Max-Planck-Institut
für
Astrophysik

Annual Report 2013

Contents

1 General Information

1.1 A brief history of the MPA

The Max-Planck-Institut für Astrophysik, usually called MPA for short, was founded in 1958 under the directorship of Ludwig Biermann. It was established as an offshoot of the Max-Planck-Institut für Physik, which at that time had just moved from Göttingen to Munich. In 1979, as part of plans to move the headquarters of the European Southern Observatory from Geneva to Garching, Biermann's successor, Rudolf Kippenhahn, relocated the MPA to its current site. The MPA became fully independent in 1991. Kippenhahn retired shortly thereafter and this led to a period of uncertainty, which ended in 1994 with the appointment of Simon White as director. The subsequent appointments of Rashid Sunyaev (1995) and Wolfgang Hillebrandt (1997) as directors at the institute, together with adoption of new set of statutes in 1997, allowed the MPA to adopt a system of collegial leadership by a Board of Directors. The Managing Directorship rotates every three years, with Simon White in post for the period 2012-2014.

In 2007 Martin Asplund arrived as a new director but, for personal reasons, decided to return to The Australian National University in 2011. He remains linked to the institute as external Scientific Member, joining the other external Scientific Members: Riccardo Giacconi, Rolf Kudritzki and Werner Tscharnuter. Eiichiro Komatsu arrived in 2012 from the University of Texas to take up a directorship, bringing new impetus to the institute's research into the early universe and the growth of structure. This generational change continued in 2013 when the MPA's own Guinevere Kauffmann was promoted to a directorship, thereby ensuring that the institute will remain a centre for studies of the formation and evolution of galaxies. Finally, a search is currently underway for another new director, active in some area of theoretical or numerical subgalactic astrophysics, to succeed Wolfgang Hillebrandt who retired in 2012.

The MPA was originally founded as an institute for theoretical astrophysics, aiming to develop the theoretical concepts and numerical algorithms needed to study the structure and evolution of stars (including the sun), the dynamics and chemistry of the interstellar medium, the interaction of hot, dilute plasmas with magnetic fields and energetic particles, and the calculation of transition probabilities and cross–sections for astrophysical processes in rarefied media. From its inception the MPA has had an internationally-recognized numerical astrophysics program that was long unparalleled by any other institution of similar size.

Over the last 20 years, activities at the MPA have diversified considerably. They now address a much broader range of topics, including a variety of data analysis and even some observing projects, although there is still a major emphasis on theory and numerics. Resources are channeled into directions where new instrumental or computational capabilities are expected to lead to rapid developments. Active areas of current research include stellar evolution, stellar atmospheres, accretion phenomena, nuclear and particle astrophysics, supernova physics, astrophysical fluid dynamics, high-energy astrophysics, radiative processes, the structure, formation and evolution of galaxies, gravitational lensing, the large-scale structure of the Universe, and physical and early universe cosmology. Several previous research themes (solar system physics, the quantum chemistry of astrophysical molecules, general relativity and gravitational wave astronomy) have been substantially reduced since 1994.

Since 2001 the MPA has been part of the International Max-Planck Research School in Astrophysics, a joint initiative between the Max Planck Society and the Ludwig-Maximilians University of Munich. About 70 PhD students participate in the school at any given time, most of them at the MPE or the MPA. This has subtantially increased and internationalised the graduate student body at MPA over the last decade and has resulted in productive social and professional links between MPA students and those at other local institutions. Currently about 25 students at MPA participate in the IMPRS.

MPA policy is effectively set by the Wissenschaftliche Institutsrat (WIR) which has met regularly about 6 times a year since 1995 to discuss all academic, social and administrative issues affecting the institute. This consists of all the permanent scientific staff, as well as elected representatives of the postdocs, doctoral students and support staff. It acts as the main formal conduit for discussion and communication within the institute, advising the directorate on all substantive issues. Ad hoc subcommittees of the WIR carry out the annual postdoc and student hiring exercises, monitor student progress, oversee the running of the computer system, and, in recent years, have carried out the searches for new directions and directorial candidates.

Other aspects of the MPA's structure have historical origins. Its administrative staff (which moved to a new extension building in early 2013) is shared with the neighboring, but substantially larger MPI für extraterrestrische Physik (MPE). The library in the MPA building also serves the two institutes jointly. All major astronomical books and periodicals are available. The MPA played an important role in founding the Max-Planck Society's Garching Computer Centre (the RZG; the principal supercomputing centre of the Society as a whole). MPA scientists have free access to the RZG and are among the top users of the facilities there. Ten posts at the computing centre, including that of its director, are formally part of the MPA's roster. This arrangement has worked well and results in a close and productive working relationship between the MPA and the RZG.

1.2 Current MPA facilities

Computational facilities

Computer and network facilities are a crucial part of everyday institute life, with different needs for theoreticians, numerical simulators and data analysts. At MPA, computing needs are satisfied both by providing extensive in-house computer power and by ensuring effective access to the supercomputers and the mass storage facilities at the Max Planck Society's Garching Computer Centre (the RZG) and the Leibniz Computer Centre of the state of Bavaria (the LRZ). Scientists at MPA are also very successful obtaining additional supercomputing time at various other supercomputer centres at both national and international level.

The design, usage and development of the MPA computer system is organized by the Computer Executive Committee. This group of scientists and system managers also evaluates user requests concerning resources or system structure, with scientific necessity being the main criterion for decisions. RZG and MPA coordinate their activities and development plans through regular meetings to ensure continuity in the working environment experienced by the users.

The most important resources provided by the RZG are parallel supercomputers, PByte mass storage facilities (also for backups), and the gateway to the German high-speed network for science and education. MPA participates actively in discussions of major investments at the RZG, and has provided several benchmark codes for the evaluation of the next generation supercomputer options. RZG also hosts a number of mid-range computers owned by MPA. Presently, two Linux-clusters (with 756 and over 2500 processor cores) are located at RZG, and are used for moderately parallel codes. In addition, a dedicated system of 156 cores, about 650 GB memory and 180 TB disk space is used, among other purposes, for data analysis of the Millenium simulations. This system also offers public web services to access and use the Millenium Databases.

MPA's computer system guarantees that every user has full access to all facilities needed, and that there is no need for users to perform maintenance or system tasks. All desks are equipped with modern PCs, running under one operating system (Linux) and a fully transparent file system, with full data security and integrity guaranteed through multiple backups, firewalls, and the choice of the operating system. With this approach MPA is achieving virtually uninterrupted service. Since desktop PCs are not personalized, hardwarefailures are quickly repaired by a complete exchange of the computer.

In addition to the desktop systems, which amount to more than 170 fully equipped workplaces, users have access to central number crunchers (about 20 machines, all 64-bit architecture; with up to 32 processor cores and 96 GB memory). The total on-line data capacity at MPA is approaching the Petabyte range; individual users control disk space ranging from a mere GB to several TB, according to scientific need.

All MPA scientists and PhD students may also get a personal laptop for the duration of their presence at the institute. These and private laptops may be connected to the in-house network through a subnet which is separated from crucial system components by a firewall. Apart from the standard wired network (Gb capacity up to floor level, and 100 Mb to the individual machine), access through a protected WLAN is provided. MPA is also a partner in the eduroam-consortium, thus allowing its members unrestricted access to WLAN at all participating institutions.

The basic operating system relies on OpenSource software and developments. One MPA system manager participates actively in the OpenSource community. The Linux system is a special distribution developed in-house, including the A(dvanced) F(ile) S(ystem), which allows completely transparent access to data and high flexibility for system maintenance. For scientific work, licensed software, e.g. for data reduction and visualization, is in use, too. Special needs requiring Microsoft or Macintosh PCs or software are satisfied by a number of public PCs and through servers and emulations.

The system manager group comprises two full-time and two part-time system administrators; users have no administrative privileges nor duties, which allows them to fully concentrate on their scientific work.

In early 2013, after completion of the new building extension, central computer facilities returned from their interim home at the computer center to a new computer room in the basement of the new wing. This room is equipped with an energy-efficient cooling system, realized as a “cold aisle”. Since energy consumption, including cooling, has become a major issue for computer center operations, this will ensure that MPA can continue to provide efficient in-house computing facilities.

Library

The library is a shared facility of the MPA and the MPE and therefore has to serve the needs of two institutes with differing research emphases – predominantly theoretical astrophysics at MPA and predominantly observational/instrumental astrophysics at MPE. At present the library holds a unique collection of about 45000 books and journals and about 7200 reports and observatory publications, as well as print subscriptions for about 149 journals and online subscriptions for about 400 periodicals. In addition the library maintains an archive of MPA and MPE publications, two slide collections (one for MPA and one for the MPE), a collection of approximately 400 CDs and videos, and it stores copies of the Palomar Observatory Sky Survey (on photographic prints) and of the ESO/SERC Sky Survey (on film). The MPA/MPE library catalogue includes books, conference proceedings, periodicals, doctoral dissertations, and habilitation theses, reports (print and online). Additional technical services such as several PCs and terminals in the library area, copy machines, a colour book-scanner, two laser printers, and a fax machine are available to serve the users’ and the librarians’ needs. The library is run by three people who share the tasks as follows: Mrs. Chmielewski (full time; head of the library, administration of books and reports), Mrs. Hardt (full time; interlending and local loans of documents, “PubMan”, and publications management for both institutes - about 1100 publications 2012), and Mrs. Blank (half time; administration of journals)

1.3 2013 at the MPA

The Planck Cosmology results

With support from the German Space Agency (DLR), the MPA has been the German partner in the European Space Agency’s Planck mission since 1998. Both Simon White and Rashid Sunyaev are co-Investigators on the satellite’s instruments, and a group of programmers has spent the last 16 years writing software for the data processing centres, initially under the responsibility of Matthias Bartelmann and more recently under that of Torsten Ensslin. 2013 was a landmark year for Planck both because the satellite finally stopped taking data after operating flawlessly for more than twice as long as its nominal mission, and also because the first cosmological results were announced on March 21 at an ESA press conference in Paris and in a series of almost 30 papers on the publication archive.

Planck has provided maps of the full sky in nine frequency bands covering almost a factor of 30 in wavelength. This allows the temperature fluctuations in the surface of last scattering to be separated from foreground emission from dust and radio plasma to an unprecedented level of accuracy, producing a high-fidelity image of almost the whole boundary of the visible universe at an age of only 400,000 years, long before any stars or galaxies had formed (see the image on the front of this report). Remarkably, the structure in this image of the early universe can be almost perfectly characterised by its power spectrum which very clearly shows the oscillatory behaviour first predicted by Rashid Sunyaev and his mentor Yakov Zeldovich in 1969. Furthermore, the detailed shape is almost perfectly fit by the ΛCDM cosmological structure formation model, which the 1985 simulations by the "Gang of Four" (Davis, Efstathiou, Frenk and Simon White) first showed to provide a good description of present-day large-scale structure. (See Fig. 1.1) The Planck data not only con-

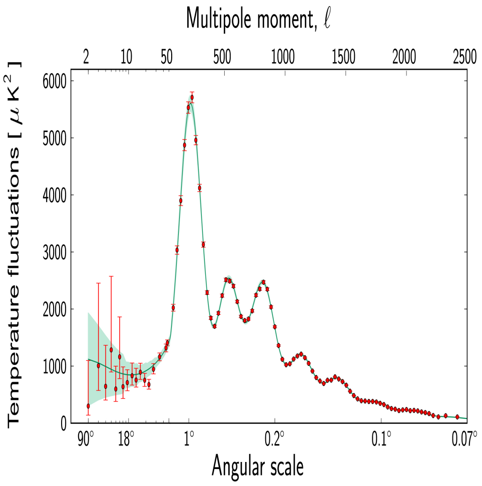

Figure 1.1: The cosmological results from Planck can be summarised by this plot which shows the amplitude of fluctuations in the microwave background radiation as a function of their angular wavelength on the sky. The data points are direct measurements from Planck while the underlying curve is the prediction of the standard ΛCDM model of cosmology which provides a perfect fit, determining the geometry and material content of our Universe as well as the process which created all cosmic structure within it.

firm these early predictions, giving precise values for the parameters which define what is now the "standard" structure formation model, they also provide strong indications that all structure originated from quantum fluctuations of a single field during a very early epoch of cosmic inflation.

So far work on the Planck data within the MPA has focussed less on the temperature fluctuation pattern on the last scattering surface than on the effects caused by material in front of this surface. This can be detected from its radio and infrared emission, from its scattering of CMB photons (the so-called Sunyaev-Zeldovich effects) and through its gravitational lensing of the CMB pattern. These effects provide quite new information on the structure of our own Milky Way, and on the large-scale distribution of distant galaxies, of intergalactic matter and of gravitating mass. The final results of Planck should be released in late 2014. These will substantially improve on the first release through improved analysis and signal-to-noise, as well as through inclusion of results from polarisation measurements, Thus 2014 should also be a good "Planck" year!

New MPA director

With effect from 1 April 2013, the Max Planck Society appointed Guinevere Kauffmann as a Scientific Member of the Society and the newest Director at the Max Planck Institute for Astrophysics. Born in California, Guinevere spent her high school and undergraduate years in South Africa before moving to the UK to do her doctorate at Cambridge University's Institute of Astronomy. After a postoctoral stay as a Miller Fellow at the University of California, Berkeley, Guinevere moved to Munich where she has been a scientist at MPA since 1995, most recently as leader of a group studying galaxy evolution.

Guinevere Kauffmann is known for her pioneering work to develop theoretical models for the formation and evolution of the galaxy population as a whole. Such semi-analytic models have become the primary method for comparing the systematic properties of galaxies in large observational surveys with expectations based on the current standard Cold Dark Matter paradigm for the growth of cosmic structure.

Over the last decade she has also played a leading role in devising analysis methods for extracting quantitative information about the physical processes driving galaxy evolution from the observational data provided by modern large-scale surveys, notably the Sloan Digital Sky Survey, but also smaller, specially designed surveys, which Dr Kauffmann and her team have carried out themselves.

Guinevere Kauffmann's research has been well recognised outside the Max Planck Society. In 2002 she was awarded the Heinz Maier-Leibnitz Prize and in 2007 she received the 2.5 million Euro Gottfried-Wilhelm-Leibniz Prize of the German Research Foundation, the most prestigious prize in German research. She was elected to the American Academy of Arts and Sciences in 2009, to the German National Academy of Science, Leopoldina, in 2010, and to the US National Academy of Science in 2012. In 2010, Bavarian Minster President Horst Seehofer awarded her the Distinguished Service Cross of the Federal Republic of Germany for her services to science.

Guinevere Kauffmann joins Eiichiro Komatsu as the second of a new generation of directors at MPA who should assure the institute's scientific future well into the coming decades.

Figure 1.2: Guinevere Kauffmann, new director at MPA

Visit of the MPA Fachbeirat

The MPA's Scientific Visiting Committee (Fachbeirat) spent three days at the institute in May 2013. The regular members (Matthias Steinmetz (chair), Lars Bildsten, Lars Hernquist, Georges Meynet, Sandy Faber and John Peacock) were joined on this visit by two additional "rapporteurs" (Gisela Anton and Mike Perryman) who had the task of attending similar Fachbeirat visits at all six institutes in the MPA's research group (the MPI's for Extraterrestial Physics, Astronomy, Radio Astronomy, Gravitational Physics, and Solar System Research in addition to MPA). Such extended evaluations take place every six years and the two rapporteurs are subsequently asked to discuss with the praesidium strategic aspects of the Society's overall programme. This took place in January 2014.

Unfortunately Lars Hernquist was unable to travel to Garching for health reasons but did participate in many of the discussions electronically. As usual the visit involved a small number of science talks selected by the directors, followed by a larger number selected by the committee themselves from a list submitted by all institute scientists. These were complemented by separate interviews with the directors (individually and as a group), with the scientific staff, and with representative groups of students and of postdocs. This formal programme was supplemented by "social" receptions and dinners which provided opportunities for more informal interactions between MPA members and the committee, who also had the chance to speak in closed session with MPS Vice-President Stratmann. As judged from the report which they later filed, the committee was generally very happy with what they saw, while still managing to come up with several helpful suggestions for improvement.

MPA scientific meetings in 2013

As usual, MPA scientists organised a number of scientific workshops in Garching or nearby in 2013. The largest of these was the annual MPA/MPE/ESO/Excellence Cluster joint conference at the end of June, for which MPA took the lead in both the SOC and the LOC. The topic was "The Physical Link between Galaxies and their Halos" which turned out to be very popular; the meeting was limited to under 200 participants by the capacity of the IPP lecture theatre and it ended up being oversubscribed by a substantial factor, requiring the organisors to make some difficult decisions. In July the Virgo Supercomputing Consortium held one of its regular semi-annual meetings at MPA, bringing about 60 collaboration scientists together to enjoy discussions within the new lecture room, which also provided the perfect venue for a cosmology workshop on "The Return of de Sitter: II" organised by the MPA's Physical Cosmology group in collaboration with scientists from the Excellence Cluster.

The MPA is currently searching for promising research areas and director candidates who would complement present activity and restore the breadth lost with the premature departure of Martin Asplund and the retirement of Wolfgang Hillebrandt. As part of this activity, six high-flying scientists were invited to the institute for a one-day symposium in November to lay out their vision for the future development of particular areas of "theoretical subgalactic astrophysics". More than 60 people attended the talks, many of them from outside the MPA, and the topics ranged from planet formation through stellar evolution and accretion disks to the properties of magnetars. As a result, the institute was exposed to a stimulating variety of possibilities which has done much to promote discussion of the ideal mix of topics for a productive future, and thus to inform the continuing search.

Biermann lectures 2013

The annual Biermann lecture series, started in 1997, aims to stimulate scientific activities across the entire Munich astronomical community and has become an MPA tradition. World-class scientists working on topics in theoretical and computational astrophysics are invited to spend one month in Garching, to give a series of prize lectures, and to interact with colleagues at MPA and in the surrounding institutes.

In 2013 the MPA was lucky to be able to attract Professor Carlos Frenk from the University of Durham as Biermann lecturer (see Figure 1.3). Professor Frenk is currently director of the Institute for Computational Cosmology at Durham University, where his group develops cosmological models and simulations. He is also co-Principal Investigator of the Virgo Consortium, which was founded in 1994 and is perhaps best known for the Millennium Simulation, carried out in Garching and first published in 2005. At the time, this N-body simulation of the dark matter distribution was the largest ever carried out, and was particularly notable because it included techniques which allowed the development of the galaxy population to be followed in detail, in addition to tracking the growth of structure in the dark matter.

Such cosmological simulations are based on the standard cold dark matter model of cosmic structure formation, which was established by the astronomical "Gang of Four": In a series of five landmark papers from 1985 to 1988, Marc Davis, George Efstathiou, Carlos Frenk, and Simon White showed that observations of galaxies, clusters, filaments, and voids were consistent with a simulated universe that had evolved under the dominant gravitational influence of cold dark matter. In 2011, the four researchers received the Gruber Cosmology Prize for this discovery and for their pioneering use of numerical simulations. In addition to this latest award, Carlos Frenk has received a number of other prizes and distinctions, such as Hoyle Medal of the Institute of Physics, the George Darwin Prize of the Royal Astronomical Society, the Daniel Chalonge medal from the Observatoire de Paris and the Gold Medal of the Royal Astronomical Society.

Figure 1.3: Carlos Frenk, the 2013 Biermann lecturer.

MPA new building officially opened

In April, the keys to the extension building of the Max Planck Institute for Astrophysics were officially handed over to its new owners. This building not only provides new offices for the administration and IT staff, but also a new, large conference room and state-of-the-art computer rooms for its IT infrastructure.

The original MPA building was built in the 1970’s and the new extension projects into a previously open area between the MPA and the adjoining MPE. It contains more than 1600 square metres of additional usable space. The staircase posed a special challenge, as three buildings with different levels had to be connected. Jokingly compared to “Escher” stairs, it will probably take some time until everybody finds their way. The open structure provides interesting perspectives since the nested architecture surrounds a high free space in the shape of an equilateral triangle that still needs to be filled. A sturdy hook on the ceiling makes it possible to suspend even a large object, extended wall areas could be filled by astronomical images.

The light-filled conference room, with a size of 200 square metres, accommodates up to 120 people. Equipped with projector, screen, and two traditional black boards, the room can be used for lectures, but can also be adapted to other events due to the variable seating plan. With the exterior areas finished during the course of the year, it is now also possible to go outside and enjoy the surrounding garden.

Above the conference room are two floors with offices, where the computer (1st floor) and the administration staff (1st & 2nd floor) of MPA and MPE are now accommodated. In the basement, there are two computer rooms with an area of 150 square metres, which are also shared by MPA and MPE. Thus the IT departments of the two neighbouring institutions have moved closer together.

The dome on the roof was installed in collaboration with the Technical University Munich and the

Excellence Cluster Universe. It contains a 60cm telescope with modern instrumentation. Among other uses, students completing their lab practical will be able to perform their own observations.

Prizes and Awards

In January, MPA director Eiichiro Komatsu received the "Lancelot M. Berkeley - New York Community Trust Prize for Meritorious Work in Astronomy" during the annual winter meeting of the American Astronomical Society in Long Beach. The prize is awarded annually for work which advances the science of astronomy; Komatsu received it for his paper presenting the cosmological results from the 7-year WMAP data on the microwave background radiation.

MPA Director Rashid Sunyaev was awarded an Einstein Professorship by the Chinese Academy of Sciences in May. CAS President Prof. Bai Chunli congratulated Rashid together with 19 other leading foreign scientists in different areas of science and technology. As Einstein professor, Rashid gave several lectures in leading CAS centres and universities which undertake active research in the fields of High Energy Astrophysics and Cosmology in China. In exchange, young CAS researcher will be invited to work at MPA for several months. The stipend and travel expenses for this researcher will be provided by CAS.

In June, Irina Zhuravleva was one of a number of young scientists to receive the Otto Hahn Medal of the Max Planck Society. The Otto Hahn Medal is awarded annually to recently graduated researchers for outstanding scientific achievements within the Society. Irina received her PhD in Astrophysics from the Max Planck Institute for Astrophysics in 2011, working with Rashid Sunyaev and Eugene Churazov. The main focus of her work is the physics of hot gas in galaxy clusters and in particular observational signatures of the gas motions. In 2012, she joined Stanford University as a postdoctoral researcher. She continues to collaborate with MPA scientists on several projects in the general area of high energy astrophysics.

Also in June, the Dutch Royal Academy of Sciences awarded the Christiaan Huygens Prize to MPA postdoctoral fellow Diederik Kruijssen for the best Dutch PhD thesis in astronomy and space sciences in the past five years. The official ceremony took place in the Great Church in The Hague, where there was also a large exhibition dedicated to father and son Huygens, since the Netherlands celebrated the Huygens Year in 2013. The prize was presented by the Dutch secretary of education Sander Dekker and the programme also included a presentation by astronaut André Kuipers. In his award-winning PhD thesis, Kruijssen studied the "Formation and evolution of star clusters and their host galaxies" using star clusters as fossils that tell the story of the formation histories of their host galaxies. The thesis consisted of two parts: the formation of stars and stellar clusters and their evolution, and the modelling of isolated and colliding galaxies including their star clusters.

In October, Massimo Gaspari was awarded the Livio Gratton Prize for the best PhD thesis in Astronomy and Astrophysics presented in Italy in the two past academic years. The Livio Gratton Prize is awarded biennially to a young researcher who has made an innovative and significant contribution to the field. In his award-winning PhD thesis, entitled "Solving the Cooling Flow Problem through Mechanical AGN Feedback", Massimo studied the intimate relationship between cooling and black hole heating in the cosmic evolution of baryons. In 2012, Massimo joined the MPA as a postdoctoral researcher in the High Energy Astrophysics group, working mainly with E. Churazov and R. Sunyaev.

Two Kippenhahn laureates this year

Two submissions for the Kippenhahn prize in 2013 were both excellent and at the same time completely different, so that the jury decided to split the prize and award it jointly to Florian Hanke and Francesco de Gasperin. In his paper *Is strong SASI activity the key to successful neutrino-driven supernova explosions?*, Florian Hanke carried out three-dimensional simulations of these violent events at the end of a star's lifetime, and compared his results to previously published two-dimensional models. Francesco de Gasperin worked on analysing radio data in the multinational LOFAR project, in which the MPA participates, and published his first science results in the paper *M87 at metre wavelengths: the LOFAR picture*.

Florian Hanke started to work on generalizing an existing core-collapse supernova simulation code to three spatial dimensions. As a code- and SN physics-learning experience, he tried to reproduce the results of a competing group, which had claimed that 3D explosions develop considerably more easily, faster, and more energetically than in two dimensions. However, despite careful and tedious tests, he was unable to confirm the earlier findings. His paper immediately received very wide attention (with nearly 70 citations at the time of the prize ceremony) and seeded a controversy, but several other groups have since confirmed Florian's results. This demonstrates that scientific progress requires not only fast and prominent publication of new findings, but also to tedious and careful verification – this kind of work should be valued much more than it often is (see Figure 1.4) .

Unlike most Kippenhahn Prize submissions, Francesco was the first author of 96 on his paper. LOFAR involves a large consortium of astronomers from many different institutions and countries. When Francesco entered the data pipeline team, the infrastructure did not yet exist, but with the help of colleagues from the Netherlands, he threw himself into the centre of the project and quickly became a knowledgeable technical expert himself. He was awarded significant time during the early commissioning phase to observe the centre of the Virgo cluster, which harbours a supermassive black hole. Francesco's observations placed important constraints on past activity of this active nucleus and his detailed spectral analysis of the extended radio-halo showed that continuous injection of relativistic electrons into the intracluster medium is required to fit the data. This was the first significant science result to emerge from the LOFAR project. As a "pioneer", Francesco was willing to face great struggles and the real possibility of failure – LOFAR is now set to produce great science (see Figure 1.5).

Regrettably, former MPA-director Rudolph Kippenhahn, the donor of the prize, could not be at the institute in person for the ceremony on 20th September but he congratulated the laureates from afar. Established in 2008, the prize recognises originality, impact on science and the quality of writing for the best scientific paper written by a student at MPA during the previous year.

Figure 1.4: Florian Hanke (laureat), Thomas Janka (supervisor), Simon White, Ewald Müller (copyright: H.-A. Arnolds, MPA)

Figure 1.5: Francesco de Gasperin (laureat), Guinevere Kauffmann (supervisor), Simon White, Ewald Müller (copyright: H.-A. Arnolds, MPA)

Public Outreach

Astronomical topics are very interesting to a broad public audience, as was demonstrated again in 2013 by the level of interest in the public outreach activities offered by the MPA. Eleven groups and school classes (about 250 people in total) visited the MPA to learn more about astronomy in general and our work in particular. For these groups, junior scientists presented a show in the MPA's digital planetarium in the form of a journey from the skies over Garching to the beginnings of the universe, touching on various aspects of MPA research along the

Figure 1.6: Even though the MPA is a theoretical institute, the girls had the chance for some observations of the Sun with our demonstration telescope on the roof and build their own spectrograph using old CDs *(copyright: H.-A. Arnolds, MPA)*

way.

In a well-established tradition, in 2013 the MPA joined again in the nationwide Girls's Day. This year, a group of junior, female MPA scientists prepared a hands-on session, in addition to a live presentation in the planetarium and a Sun-gazing session on the roof (the stars being unobservable at 10 am). While the girls were a bit shy and quiet at first, they soon started to ask questions about astronomy, career options and the possibility of internships. This direct contact was especially easy when the whole group broke up into smaller teams to work on the hands-on projects. These ranged from building a model of the solar system to visualise the enormous distances, to calculating your weight on other planets or making a star chart to orient oneself on the sky (see Figures 1.6).

Another big event for the whole institute was the Campus Open Day in October, with about 2000 people visiting the institute. The programme included hourly talks, poster presentations and Q&A-sessions with scientists, as well as the well-established "kids lab", which was again very popular. The digital planetarium and visits to the new telescope on the roof of the extension building proved to be especially attractive (See Figures 1.7).

Complementing these special events, MPA scientists were also involved in educational programmes for school teachers and gave public talks outside the institute, e.g. in the framework of Cafe & Kosmos, an event series organised together with the Excellence Cluster Universe, ESO, MPE and MPP.

They supervised undergraduates and high school students on small research projects during internships, wrote articles for popular science media and acted as interview partners for press and

Figure 1.7: More than 2000 people visited MPA during the Open Day in October. Special attractions were the traditional "Kids Corner" and the new observatory on the roof of the MPA extension building. (c) MPA

TV journalists. The Cosmology exhibition at the Deutsches Museum, which was curated partly by MPA, has been seen by more than 70.000 visitors, including about 20 guided tours.

The public outreach office issued a number of press releases about important scientific results as well as news about awards and prizes for MPA scientists. These were published on the MPA website as well, complementing the popular monthly scientific highlight series.

2 Scientific Highlights

2.1 Distances in the Galaxy: where are those metal-poor stars?

One of the major problems in modern astrophysics is to determine metallicities of stars and their kinematics. While various methods exist, most of them are not suitable for large stellar samples - these, however, are necessary in studies of Galactic structure. Scientists from MPA, Spain, and Sweden developed a novel method to accurately determine various stellar parameters as well as distances using a given stellar spectrum. Applying the new method to a sample of stars that are within 10 kpc of the Sun, they found significantly higher metallicities and shorter distances compared to previous results. This has major consequences for any study based on spectrophotometric distances to determine the stellar kinematics in our Milky Way.

Metallicities and the kinematics of low-mass stars are key parameters when studying the structure and evolution of our galaxy. The most accurate way to determine metallicity is through spectroscopy, while the most precise way to get distances is astrometry. Parallaxes from the Hipparcos mission are available for many thousands of stars, but their accuracy rapidly deteriorates beyond 0.1 - 0.2 kpc away from the Sun. For large-scale stellar surveys, such as SDSS/SEGUE, APOGEE, and RAVE, which aim to observe the Galaxy from its innermost bulge regions to the outer halo at distances larger than 50 kpc (Fig. 2.1), scientists have to find another solution.

The only alternative is to use the information in a stellar spectrum, combining the luminosity data with photometry and stellar evolution models. A prerequisite for this approach are physically realistic models of radiative transfer in stellar atmospheres. Then researchers obtain accurate physical parameters of a star when applying them to observed spectra. In the past decades, spectroscopy of low-mass stars relied on simplified models that were based on the assumptions of both local thermodynamic (LTE) and 1D hydrostatic equilibrium. Because the models are very widely used for the analysis of large datasets, including SDSS and RAVE, the principal question is whether such an 1D LTE approach is accurate.

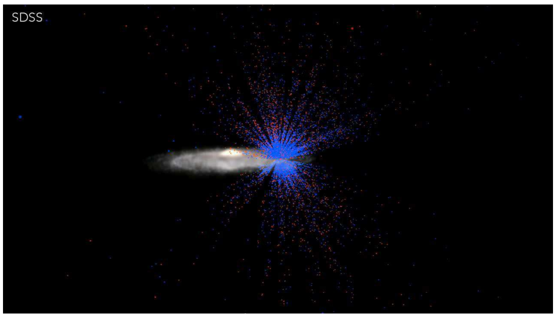

Figure 2.1: A snapshot from a fly-by movie showing the distribution of SDSS stars compared to a model of the Milky Way disk. In blue are dwarf stars. *(Credit: The RAVE Collaboration.)*

Recently, scientists at MPA worked together with researchers in Spain and Sweden to devise a new method for computing stellar parameters and distances. This method includes new physical effects (such as non-LTE radiative transfer) in stellar models, which so far have not been included in a single calculation to date.

The scientists found that with the new method, the parameters obtained from the stellar spectra change: the metal-poor stars become warmer, more metal-rich and less evolved, i.e., their surface gravities increase, accompanied by a decrease in luminosity. As a consequence, the stars become fainter and this in turn leads to much shorter distances. For most of the stars, the distance thus decreases by 10-50%. That has a major impact on the volume distribution of stars (a comparison of previous with the new accurate results is shown in Fig. 2.2).

These improvements in the physics of radiative transfer models have a large impact on the distribution functions of stellar samples. In a magnitude-limited survey (such as RAVE), where more metal-rich un-evolved stars dominate the nearby sample and metal-poor luminous giants are predominantly observed at larger distances, classical LTE analysis will systematically over-estimate distances, placing stars progressively further than they are. This would cause the unphysical smearing of the metallicity distribution function (Fig.

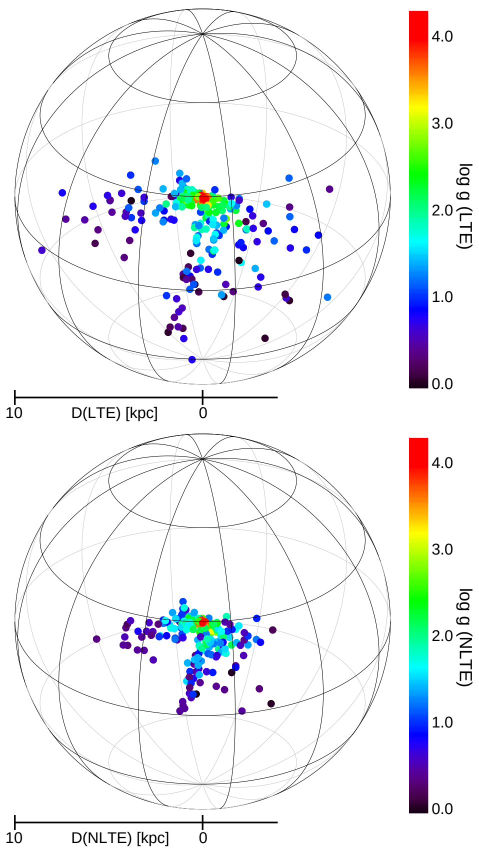

Figure 2.2: Heliocentric spatial distribution of stars in the studied sample. Left and right panels respectively show results obtained using the standard LTE and new NLTE approach. Colours depict the stellar surface gravity as indicated in the plots.

2.3, black area), as well as the stretching of the distance scale. Clearly, the effects will be more prominent in lower-metallicity stars.

Having verified the new method, the team is now ready to analyse much larger stellar samples, such as e.g., SDSS/SEGUE. These will provide radically new information about the properties of stellar populations in the Milky Way. In particular, they will shed new light on the controversy about the origin of our Galactic halo that is currently being debated.
(Maria Bergemann, Aldo Serenelli and Greg Ruchti)

References: Serenelli, A. M., Bergemann, M., Ruchti, G., and L. Casagrande: Mon. Not. R. Astron. Soc. , **429**, 3645 (2013).
Bergemann, M., Serenelli, A., and G. Ruchti: IAU Symposium, **289**, 83 (2013).
Ruchti, G. R., Bergemann, M. et al.: Mon. Not. R. Astron. Soc. , **429**, 126 (2013).

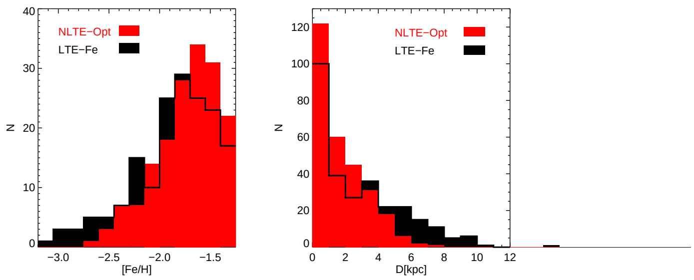

Figure 2.3: Distribution of stars in the studied sample as a function of metallicity (left) and distances. The shape of the distributions is clearly different, when more realistic models including NLTE (red) are used to determine the metallicities and distances of stars (compare to LTE black).

2.2 NIFTY: Numerical information field theory for everyone

Signal reconstruction algorithms can now be developed more elegantly because scientists at the Max Planck Institute for Astrophysics released a new software package for data analysis and imaging, NIFTy, that is useful for mapping in any number of dimensions or spherical projections without encoding the dimensional information in the algorithm itself. The advantage is that once a special method for image reconstruction has been programmed with NIFTy it can easily be applied to many other applications. Although it was originally developed with astrophysical imaging in mind, NIFTy can also be used in other areas such as medical imaging.

Behind most of the impressive telescopic images that capture events at the depths of the cosmos is a lot of work and computing power. The raw data from many instruments are not vivid enough even for experts to have a chance at understanding what they mean without the use of highly complex imaging algorithms. A simple radio telescope scans the sky and provides long series of numbers. Networks of radio telescopes act as interferometers and measure the spatial vibration modes of the brightness of the sky rather than an image directly. Space-based gamma-ray telescopes identify sources by the pattern that is generated by the shadow mask in front of the detectors. There are sophisticated algorithms necessary to generate images from the raw data in all of these examples. The same applies to medical imaging devices, such as computer tomographs and magnetic resonance scanners.

Previously each of these imaging problems needed a special computer program that is adapted to the specifications and geometry of the survey area to be represented. But many of the underlying concepts behind the software are generic and ideally would be programmed just once if only the computer could automatically take care of the geometric details.

With this in mind, the researchers in Garching have developed and now released the software package NIFTy that makes this possible. An algorithm written using NIFTy to solve a problem in one dimension can just as easily be applied, after a minor adjustment, in two or more dimensions or on spherical surfaces. NIFTy handles each situation while correctly accounting for all geometrical quantities. This allows imaging software to be developed much more efficiently because testing can be done quickly in one dimension before application to higher dimensional spaces, and code written for one application can easily be recycled for use in another.

NIFTy stands for “Numerical Information Field Theory”. The relatively young field of Information Field Theory aims to provide recipes for optimal mapping, completely exploiting the information and knowledge contained in data. NIFTy now simplifies the programming of such formulas for imaging and data analysis, regardless of whether they come from the information field theory or from somewhere else, by providing a natural language for translating mathematics into software.

The NIFTy software release is accompanied by a publication in which the mathematical principles are illustrated using examples (see Figures 2.4 and 2.5). In addition, the researchers provide an extensive online documentation. The versatility of NIFTy has already been demonstrated in an earlier scientific publication on nonlinear signal reconstruction and will certainly be helpful in developing better and more accurate imaging methods in astronomy, medical technology and earth observation.
(Marco Selig, Mike Bell, Henrik Junklewitz et al.)

References: Marco Selig, Michael R. Bell, Henrik Junklewitz, Niels Oppermann, Martin Reinecke, Maksim Greiner, Carlos Pachajoa, Torsten A. Enßlin: “NIFTy – Numerical Information Field Theory – a versatile Python library for signal inference”, Astron. Astrophys. 2013, *http://dx.doi.org/10.1051/0004-6361/201321236*

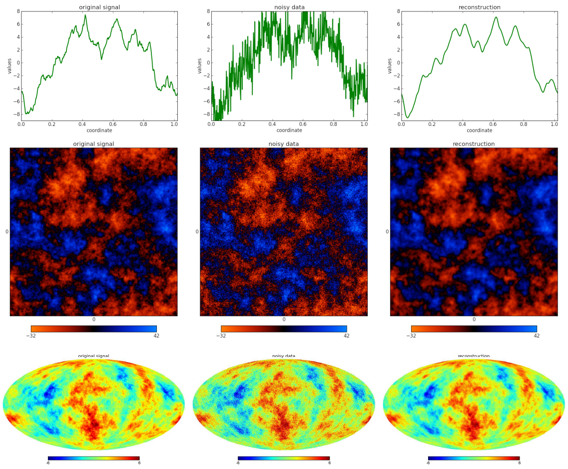

Figure 2.4: Signal reconstruction with NIFTy in one, two and spherical dimensions (upper, middle and lower rows). In each row, the original signal is shown on the left, the noisy data in the center and the signal reconstruction from the data on the right. The same NIFTy code generated all three examples.

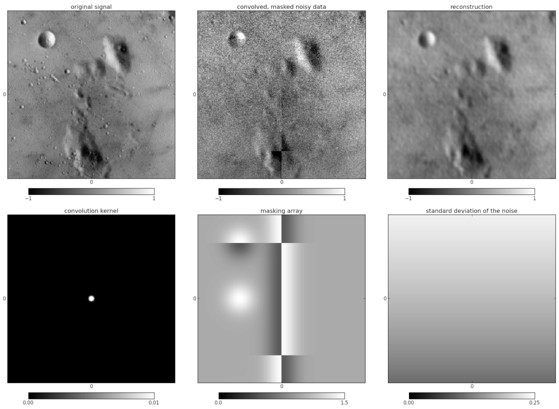

Figure 2.5: NIFTy reconstruction of a highly distorted photograph of the lunar surface. Top row from left to right: original image (Source: USC-SIPI database), data, and reconstruction. Bottom row shows disturbances in the data, from left to right: grain size of the smoothing, patterned mask and inhomogeneous structure of the noise distribution.

2.3 Asteroseismology of magnetars

Neutron stars are the remnants of the supernova explosion of massive stars (Fig. 2.6), and they are the most compact stars in the universe. Their mass of one to two solar masses is confined under the influence of their own gravity to an almost perfect sphere of about 10 km radius, i.e. the density inside a neutron star exceeds even that of an atomic nucleus. These conditions cannot be produced on Earth. If we want to improve our knowledge of the matter and the interactions between the smallest constituents of matter such as neutrons, protons, electrons, muons, but also, hyperons and quarks, we need to understand the structure of neutron stars (Fig. 2.7). In this respect a particular class of neutron stars called magnetars plays a special role.

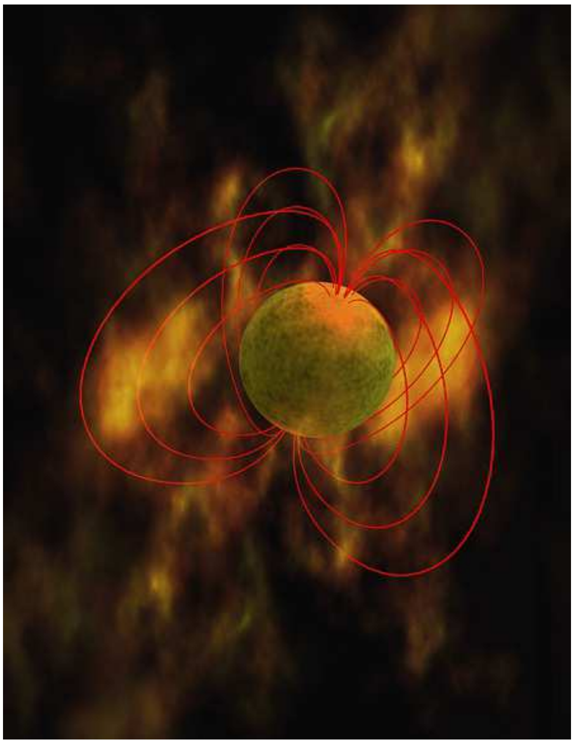

Figure 2.6: Artist's impression of a magnetar. *Credit: NASA*

Magnetars are the strongest magnets in the Universe. Estimates indicate that they could reach magnetic fields with a strength at the surface of up to some 10^{15} Gauss, which would make them about 100 billion times stronger than the strongest magnetic fields on the solar surface (to say nothing of Earth). Sometimes magnetars produce giant gamma-ray bursts, which are thought to arise from a catastrophic reorganization of their magnetic field. During these outbreaks astronomers observe a number of discrete frequencies in the associated X-ray spectrum, which should come from pulsations of the star itself according to established models. Therefore, these observations would be the first evidence of oscillations in neutron stars and one could use them to study their structure. This asteroseismology would be analogous to seismology on Earth or helioseismology on the Sun.

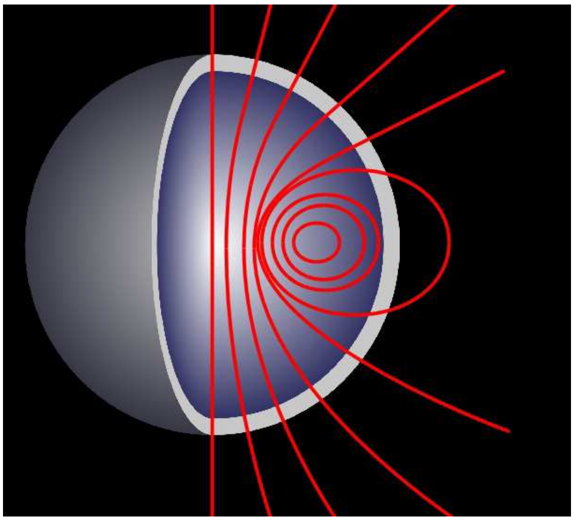

Figure 2.7: Schematic structure of a neutron star with about 1.5 solar masses and a diameter of about 20 km. A solid crust (1-2 km thick) surrounds the liquid core, which consists mainly of neutrons, protons and electrons. A magnetic field (red lines) penetrates the entire star and extends into its magnetosphere.

The magnitudes of the observed frequencies fit well with torsional, elastic shear oscillations in the crust of neutron stars. As the exact pulsation frequencies depend on the properties of the matter in the crust, these frequencies can tell us about the state of this matter. But not all pulsations can be explained as shear pulsations. The frequencies of the so-called Alfvén oscillations caused by the magnetic field are in the observed frequency range, too (for magnetic fields from 10^{14} to 10^{15} Gauss). These Alfvén oscillations are not confined to the solid crust, but provide information on the composition of the liquid core of the neutron star as well.

In his PhD thesis at the Max Planck Institute for Astrophysics, Michael Gabler together with colleagues at other institutions developed a model that combines these two types of pulsations. The properties of the coupled system can be investigated by relativistic magneto-hydrodynamic simulations. It turns out that the coupling strength and the resulting magneto-elastic oscillations depend on the magnetic field strength: For weak magnetic fields shear oscillations dominate in the crust, while for strong fields Alfvén oscillations dominate. In the interesting range of about 10^{15} Gauss, the purely elastic pulsations in the crust are absorbed very efficiently by the Alfvén oscillations of the core. Therefore, only coupled (i.e. magneto-elastic) pulsations, whose frequencies are in good agreement with the observed values, can explain the observations.

In order to observe the oscillations, they have to modulate the intensity of the electromagnetic radiation emitted by the neutron star. A model (Fig. 2.8) describes the coupling of the magnetic field inside the star to the in the field of the magnetosphere around the star. Because of the coupling, the external magnetic field oscillates as well, inducing very strong electric currents in the magnetosphere. Photons emitted by the star or in the gamma-ray burst are scattered by the electrical charge carriers (electrons and positrons) of these currents. This resonant cyclotron scattering is very effective and can explain the observed modulation of hard X-rays, as has been shown in Monte Carlo simulations. The X-ray or gamma-ray spectra, which were calculated using the core-crust-magnetosphere model, will be very useful for the design of new X-ray observatories.
(Michael Gabler and Ewald Müller)

References: PhD Thesis, Michael Gabler, TU München, Nov. 2011
Gabler, M., P. Cerda-Duran, J.A. Font et al.: Magneto-elastic oscillations of neutron stars: exploring different magnetic field configurations. Mon. Not. R. Astron. Soc. **430**, 1811-1831 (2013)
Gabler, M., P. Cerda-Duran, N. Stergioulas et al. Magnetoelastic oscillations of neutron stars with dipolar magnetic fields Mon. Not. R. Astron. Soc. **421**, 2054-2078 (2012)
Gabler, M., P. Cerda-Duran, J.A. Font et al.: Magneto-elastic oscillations and the damping of crustal shear modes in magnetars Mon. Not. R. Astron. Soc. Letters **410**, L37-L41 (2011).

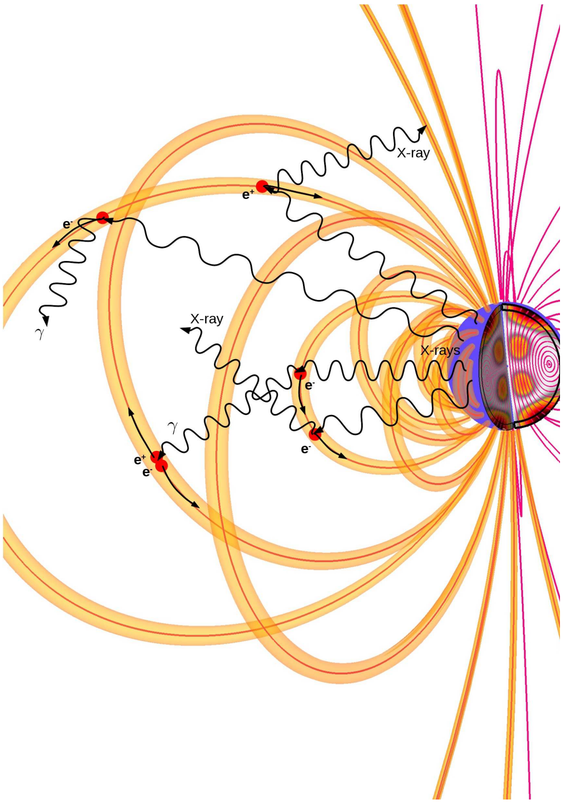

Figure 2.8: Schematic representation of the modulation of electromagnetic radiation in the magnetosphere of a neutron star. Electric currents (yellow), composed mainly of electrons and positrons, flow along the magnetic field lines (magenta). The X-rays emission from the star's surface (black) is scattered resonantly by these charge carriers. The resulting high-energy gamma rays can create further electron-positron pairs.

2.4 Magnetic fields in astrophysics: an electronic 'textbooklet'

Magnetic fields play an important role in many objects in the universe, from the Sun with its spots and the magnetically heated corona visible during a solar eclipse, to pulsars and the spectacular 'jets' from black holes and protostars. The behaviour of the magnetic field in these objects, however, is very different from experience at home or in physics class, since in astrophysical objects magnetic field lines are 'tied' to an ionized gas. The theory for such magnetic fields, called magnetohydrodynamics (MHD), is explained in a concise textbook published online. It emphasizes understanding of MHD by visualization of the flows and forces as they take place in a magnetized fluid. To this end, the text also includes a number of small video clips of basic MHD flows.

In physical processes where magnetic fields are present, one generally also has electric fields, currents and charge densities. Mathematically speaking, one has to deal with the full set of Maxwell's equations plus the equations of motion for the particles making up the plasma - the domain of plasma physics. Luckily, for most flows seen in astronomical objects, however, this complexity is rarely necessary. The electrical conductivity of an ionized gas makes MHD an extremely accurate approximation. Compared with ordinary fluid mechanics, only the magnetic field needs to be included explicitly in the theory. The other electromagnetic quantities can be evaluated afterwards; they are neither needed for a proper description, nor of much use for physical understanding. Thanks to this simplification it has become possible to include magnetic fields realistically in numerical simulations, for example of extragalactic jets (See Figure 2.9).

The price to be paid is that we have to give up some of our intuitions about the way electric and magnetic fields work. Our experience is dominated by processes taking place in the Earth's electrically insulating atmosphere (in copper wires, batteries, induction coils etc.). Most astrophysical processes on the other hand happen in an ionised gas, such as in a star, the solar wind, or the intergalactic medium.

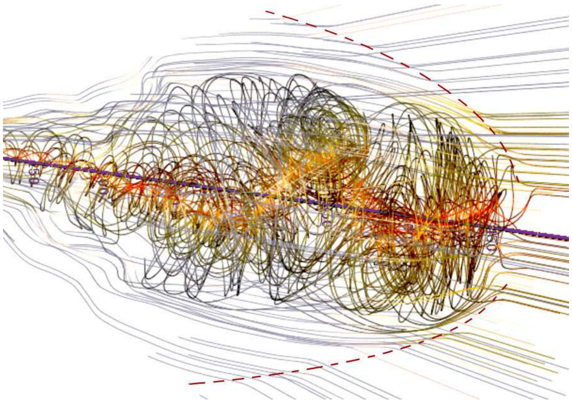

Figure 2.9: Field lines in the head of a magnetic jet.

Because of the strong coupling between the magnetic field and the electrically conducting gas, MHD flows behave more or less like visco-elastic but otherwise ordinary fluids. This makes MHD an eminently visualizable theory (see Figure 2.10), which also motivates the approach used in the textbooklet. The first chapter (only 36 pages) is a concise introduction including exercises. The exercises are important as illustrations of the points made in the text (especially the less intuitive ones). Almost all are mathematically unchallenging, though some do require a background in undergraduate physics. This is the 'essential' part. The supplement in chapter 2 contains further explanations, more specialized topics and occasional connections to topics somewhat outside the scope of MHD.
(Henk Spruit)

Reference:

H. C. Spruit: "Essential Magnetohydrodynamics for Astrophysics"
www.mpa-garching.mpg.de/ henk/mhd12.zip

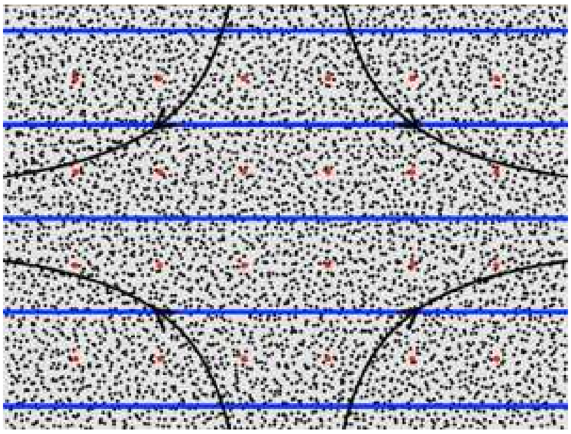

Figure 2.10: A fluid flow stretching a bundle of field lines *(copyright: Merel van't Hoff)*

2.5 Stellar lithium abundances support standard Big Bang scenario

For decades, astronomers have faced serious difficulties reconciling the amount of lithium produced in the Big Bang with the abundances measured in very old stars. Both stable lithium isotopes have been the cause of much headache by posing a difficult paradox: the stars contain too much of the lighter 6Li and not enough of the heavier 7Li. With new and improved models of spectral line formation in the atmospheres of metal-poor stars, an international group of scientists led from MPA were able to shed new light on the problem. Finally, the revised abundances of the lithium isotopes in these old stars are not incompatible with the predictions from the standard model of Big Bang nucleosynthesis.

The measurement of the lithium isotope ratio in stars is extremely challenging, both from an observational and from a theoretical perspective. Observers need the highest quality data that modern telescopes and spectrographs can provide to disentangle the weak signature of the lighter isotope from the observational noise in practice, the 6Li detection limit in metal-poor stellar spectra is only about 2% of the total lithium content. Moreover, many agents can influence the shape of spectral line profiles and hence affect the isotopic ratio, and they have to be modelled correctly.

First, thermal and convective gas motions cause Doppler shifts in the spectral lines, which call for realistic 3D radiation-hydrodynamic simulations of the atmospheres of stars, such as the Stagger models developed at MPA. Second, to correctly model the distribution of atoms in different states of excitation and ionisation one needs to account for the strong departures from local thermodynamic equilibrium (LTE). Such complex line-formation calculations are expensive and they must run for weeks on powerful multi-core machines. This is why until now, not all effects could be considered at the same time and simplifying assumptions have been made.

For the first time, a combined 3D, non-LTE technique has been be applied to model the lithium, sodium and calcium spectral lines in four very metal-poor stars. The aim was to constrain the lithium isotope ratios, while the other neutral elements serve as calibrators of the unknown projected rotational velocity of the stars. Surprisingly, the astronomers found that none of the stars displayed a significant presence of the lighter 6Li, contrary to evidence put forward in several studies over the past two decades.

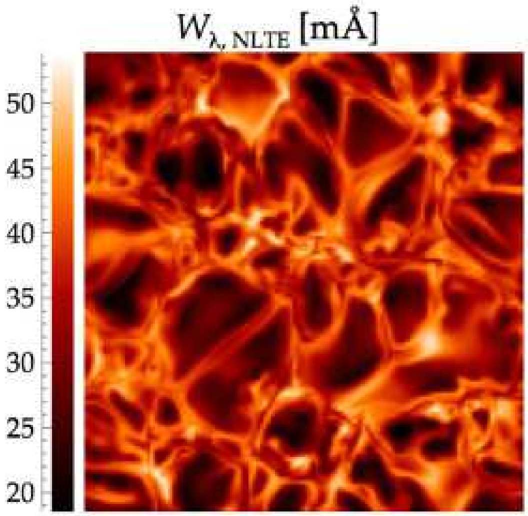

Figure 2.11: The visualisation of a radiation-hydrodynamic simulation illustrates how the lithium line strength varies across the surface of a metal-poor stellar atmosphere.

The refined models show in particular that the assumption of LTE leads to systematic overestimations, even false detections, of 6Li over a wide parameter space. The most interesting example is the metal-poor turn-off star HD84937, for which an undisputed detection has been demonstrated in at least three competing studies, while the new model shows no significant signs of 6Li.

The findings for all four stars are in gratifying agreement with the standard Big Bang nucleosynthesis model, which forges only insignificant amounts of the lighter isotope. What remains to be properly explained is why the element abundances of 7Li instead fall short of the primordial prediction. Our 3D, NLTE modelling strengthens the exciting claim that stars can act as sinks of both lithium isotopes, slowly draining their atmospheres of these and heavier elements over time. This slow diffusion process has been theoretically postulated and has the great potential to explain why the observed stellar abundances of heavy lithium are lower than expected. Thereby, both cosmological lithium problems, which have haunted particle physicists and astrophysicists since the launch of the WMAP satellite, can find their solution in improved physics of the stellar atmospheres.
(Karin Lind, Jorge Melendez and Martin Asplund).

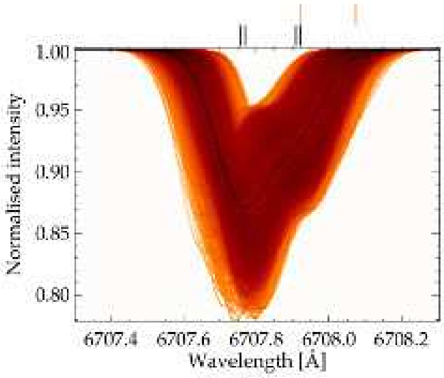

Figure 2.12: This image shows spatially resolved spectra of the lithium line, where a darker colour indicates a higher density of the line profiles. The spatially averaged profile is marked in black. The central positions of the 7Li and 6Li line components are marked at the top in black and red, respectively.

2.6 The Fine Art of Cooking an Exquisite Stellar Banquet

For stars like the Sun, the surface is literally bubbling. The energy that is produced in the stellar interior through nuclear fusion reaches the surface through convection – the same phenomenon that is seen in boiling water. The starlight observed by astronomers with their telescopes is emitted from this “stellar soup”. In order to interpret the starlight correctly in terms of for example the star’s temperature, size, mass and chemical make-up, it is paramount to understand the physical processes and convective motions occurring in the surface layers of stars: the stellar atmospheres. Now scientists at the Max Planck Institute of Astrophysics have made a major breakthrough by realistically modelling in 3D the surface layers for a very wide range of stars using powerful supercomputers. These new computer models will be very extensively used by astronomers studying stars as well as the Milky Way and planets around other stars.

The main challenge when modelling stars and their atmospheres is how to properly simulate the convective heat transfer and its interplay with the emitted stellar radiation. Traditionally, theoretical one-dimensional (1D) atmosphere models that are assumed not to change with time have been used. Such models rely on several major simplifications that are insufficient for describing the complex phenomenon that is convection, which clearly takes place in 3D and is constantly evolving. These models are therefore sometimes quite unrealistic and provide erroneous results. It is like cooking an elaborate dinner using a single basic ingredient: the basic structure is in place but something is clearly missing. A major advantage with such simplified stellar modelling, however, is that it is computationally quite cheap, making it possible to simulate many stars.

With the advent of powerful supercomputers it is now possible to compute three-dimensional (3D) stellar atmosphere models, in which the convective motions are followed in time and the interactions between the stellar plasma and the radiation is followed in detail by solving the hydrodynamical equations coupled with radiative transfer in 3D. In these sophisticated 3D models the convective motions arise from first principles, making the multiple free parameters used in 1D modelling redundant. The predictive power of such 3D models has been successfully demonstrated, especially for the Sun, which proves that the new stellar models are highly realistic. This makes them applicable to the analysis of starlight for a wide range of investigations. It is reassuring that astronomers now understand how convection works in stars and that they can compute models that enable the accurate determination of stellar properties through the radiation emitted by stars.

An international team of scientists spearheaded by Zazralt Magic at the MPA has now computed a large number of 3D stellar atmospheres, by far the largest and most ambitious undertaking in the field. It is like a splendid menu of some 250 dishes, all prepared with an elaborate attention to detail. The new 3D stellar models rely on the best possible input physics such as the equation of state of the plasma (the relationship between temperature and pressure) and opacities (how transparent is the plasma for radiation). The whole stellar surface is not modelled all at once, but rather a small representative volume in the atmosphere is followed, from which the complete picture of the star can be reconstructed in a statistical sense. Typically each computer simulation follows some 10 convective cells, so-called granules: the material flowing upwards that is heated from below.

Using the new 3D stellar models, the MPA scientists have found several new and interesting scaling relations of global properties with stellar parameters. For example the intensity contrast between the warm up-flowing material and the cold downflows is enhanced at lower metallicity, and the size of the granules scales with the pressure close to the

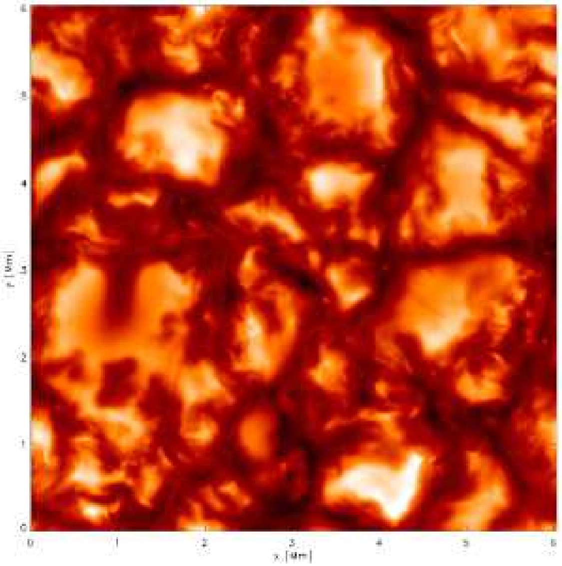

Figure 2.13: This movie shows the light emerging from the Sun with its typical granulation pattern.

surface. The entropy jump, density and vertical velocity are the components of the convective energy transport, and these properties also scale with stellar parameters in a clear and understandable way. Comparison of the spatially and temporally averaged 3D models with classical 1D models reveal distinctive systematic differences, highlighting the shortcomings of previous 1D-based analyses.

The range of the possible applications of the 3D stellar models is enormous. Currently, the team is computing a grid of predicted stellar spectra from each 3D model as a first application, enabling improved stellar parameter determination and analysis of the chemical make-up of stars. These in turn will be very beneficial for on-going and future large surveys of stars in the Milky Way to trace the formation and history of our Galaxy.

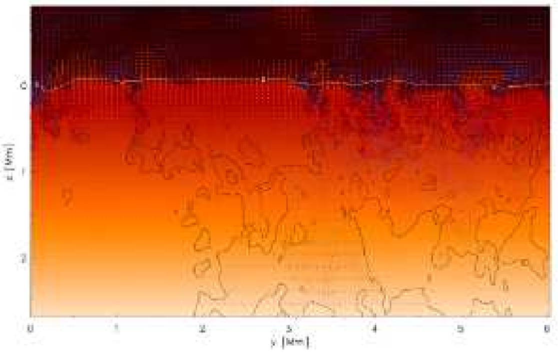

Figure 2.14: A vertical slice through the Sun (with the temperature being colour-coded) and the over-plotted velocity field (arrows).

Improved knowledge of the stellar radiation and how it varies across the stellar surface will be helpful in the determining precise parameters of exoplanets from transits – the variation in stellar brightness when a planet passes in front of its host star. The MPA group also expects major advances in asteroseismology – the ability to probe the interior of stars using their vibrations – with new stellar evolutionary models that rely on the 3D atmosphere models. The new work represents a major step in the fine art of cooking the "stellar soup", which will be appreciated by a large number of astronomers around the world.
(Zazralt Magic (MPA), Remo Collet (ANU) and Martin Asplund (ANU))

2.7 The Bluedisk project: searching for clues about how disk galaxies form

The standard paradigm for disk galaxy formation states that disk galaxies form when gas cools and condenses within a dark matter halo. Only about 20 percent of the available baryons in dark matter halos surrounding typical present-day spiral galaxies are locked up in stars. It follows that there should be a large reservoir of baryons located outside galaxies and theoretical models predict that this gas should currently be cooling and accreting to form disks. However, clear observational evidence of gas accretion and on-going disk formation has been lacking so far. Hot X-ray emitting gas has been detected around the Milky Way and other luminous spirals, and we also know that clouds of neutral hydrogen surround our Galaxy. However, estimates of the rate at which this gas accretes onto our Galaxy yield values that are too low to explain the star formation rates in galaxies like the Milky Way, which currently forms stars with a few solar masses per year on average. One possibility to explain this discrepancy is that the gas accretion is not continuous, but episodic.

Galaxies such as our own Milky Way consist of 10 percent gas and 90 percent stars. Only a minority of disk galaxies of the same total mass contain up to a factor of 10 times more gas. Nevertheless, the galaxies observed as part of the Bluedisk project were chosen to be among the most gas-rich systems in the nearby Universe. This is because previous work by the same group had revealed that such galaxies had outer disks with very

Figure 2.15: The Westerbork Synthesis Radio Telescope in the Netherlands.

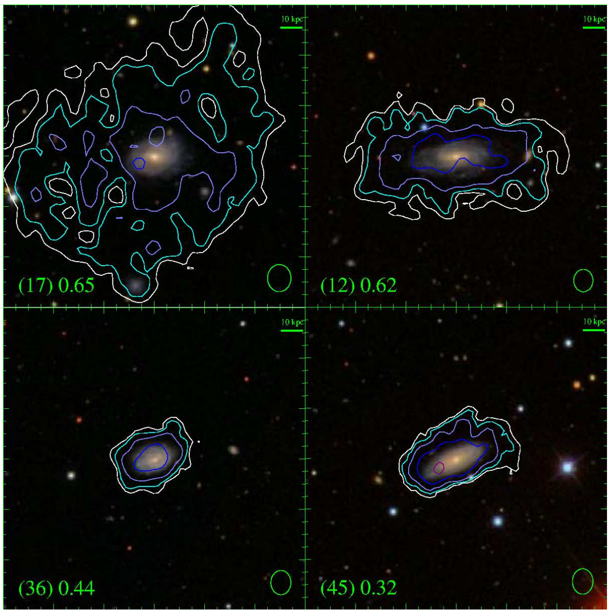

Figure 2.16: Examples of the gas-rich (top row) and control (bottom row) galaxies. The column density contours for neutral hydrogen are overlaid on optical images from the Sloan Digital Sky Survey. All the maps have a size of 140 kpc. The outermost contour has a column density equivalent to the estimated detection threshold of the total neutral hydrogen image.

blue colours, indicating active on-going formation of stars in these regions. These observations provide indirect evidence that the disks in such galaxies may be experiencing a period of renewed growth fuelled by a recent gas accretion episode.

In order to understand the gas accretion process in more detail, an international team of astronomers led by Guinevere Kauffmann and Jing Wang from the MPA, and Gyula Jozsa and Paolo Serra from ASTRON, The Netherlands used the Westerbork Synthesis Radio Telescope (WSRT, see Figure 2.15) to map hydrogen in a sample of 25 very gas-rich galaxies, along with a similar-sized sample of "control" galaxies with similar masses, sizes and redshifts. Figure 2.16 shows examples of such maps. The observations took place from December 2011 to May 2012.

One of the main results so far is that these gas-rich galaxies indeed have very large neutral hydrogen disks that extend to much larger radii than the stellar disk. In the most extreme cases, these disks even have diameters as large as 100 kiloparsecs and thus are a factor of 3-4 larger than the stellar disk. The disks of the gas-rich galaxies are also significantly clumpier than those of normal spirals (see top-left panel of Figure 2.16).

Remarkably, these enormously gas-rich galaxies have the same gas mass versus size relation as normal spiral galaxies, i.e. the gas is spread over a larger size. There is no evidence that these large gas disks are strongly out of equilibrium, because they are not lopsided or warped. In fact, the centre of the hydrogen distribution in the gas-rich galaxies corresponds more closely with the centre of the optical light than in normal spirals.

These results seem to argue against a recent major interaction, which might have been responsible for bringing in the gas. The MPA/ASTRON team suggest that the excess gas must be accreted with a broad range of angular momenta and in a relatively well-ordered way. Possibly, this "order" results from the gas initially being in equilibrium with the surrounding dark matter halo, but these questions need to be investigated in more detail by comparing the observations with hydrodynamical simulations of disk formation in a cosmological context.

The MPA/ASTRON team hopes that the results of the Bluedisk project will motivate preparations for further, future large-scale neutral hydrogen surveys with wide-field instruments like Apertif. These will obtain a wealth of data of similar quality for samples of tens of thousands of nearby galaxies.
(Jing Wang and Guinevere Kauffmann)

References:

Wang, J.; Kauffmann G.; Józsa, G. I. G.; Serra, P. et al., "The Bluedisks project, a study of unusually HI-rich galaxies: I. HI Sizes and Morphology", MNRAS, **433**, 270, (2013).

Bluedisk project webpage: *http://www.mpa-garching.mpg.de/GASS/Bluedisk/index.php*

2.8 A New Gauge of the Origin of Type Ia Supernovae: Searching for He II Recombination Lines in Elliptical Galaxies

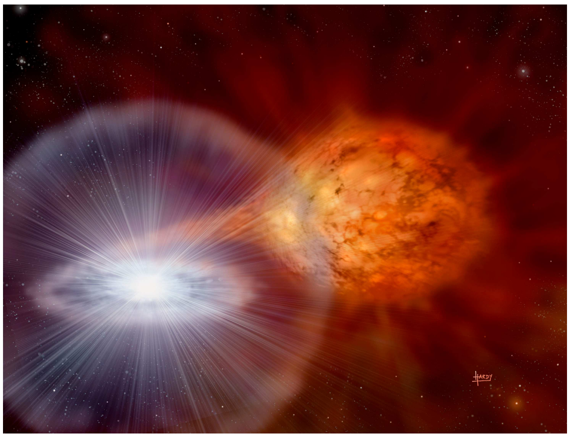

Figure 2.17: Artist's depiction of an accreting white dwarf. See http://www.astroart.org/ *(Copyright: David A. Hardy/AstroArt.org)*

Type Ia supernovae (SNe Ia) have proven invaluable as cosmic signposts, having revealed the accelerating expansion of the Universe. These tremendously energetic events occur when a white dwarf undergoes a thermonuclear explosion. But how do these explosions occur? The question remains open, despite great effort and debate. However, scientists working at the Max Planck Institute for Astrophysics have recently proposed a new test that may soon shed light on this mystery.

There are currently two "standard" models for the progenitors of SNe Ia. In the single degenerate scenario, a white dwarf accretes matter from a co-orbiting companion star until enough mass has accumulated to trigger an explosion. In the double degenerate scenario, a binary pair of white dwarfs sheds angular momentum due to gravitational radiation and merges, giving rise to a SN Ia. Observationally speaking, the clearest difference between the two is that in the single degenerate scenario, the accreting white dwarf must process a considerable amount of mass through steady nuclear burning, making it a highly luminous source of X-ray and extreme ultraviolet emission for up to a million years prior to the explosion.

Therefore, the most obvious way to distinguish between the two formation channels is to look for some evidence of the existence of such hot, luminous sources, allowing one to test the viability of the single degenerate scenario. Past work has focused on looking for X-ray emission, e.g. in the integrated X-ray luminosity of nearby galaxies. However, some type Ia supernova progenitor models predict that much of the emission from accreting white dwarfs may be radiated in the extreme ultraviolet, where it is totally absorbed by interstellar matter (see Fig. 2.17). In order to move forward, an ideal test for the presence of a significant single degenerate progenitor population would need to circumvent this issue.

Rather than looking for emission from any putative single degenerate progenitors directly, we can search instead for evidence of their effect on the interstellar medium. For example, one could attempt to find signatures of the gas ionized by such sources. In early-type galaxies without ongoing star formation, we expect only post-asymptotic giant branch stars (pAGBs) to be a significant source of ionizing radiation, at least outside of the inner galactic nuclei. These stars likely power the nebular emission-line regions now found in many ellipticals. However, in a recent paper, Tyrone Woods and Marat Gilfanov at the MPA have demonstrated that if the single degenerate hypothesis is correct, accreting white dwarfs should provide the dominant contribution to the ionizing background in such galaxies, in particular for relatively young stellar populations. This is especially true for the ionizing continuum beyond the second ionization edge of Helium at 54.4 eV.

For a given photo-ionized nebula, the total luminosity emitted in any recombination line is roughly proportional to the incident flux of ionizing photons. This suggests that one can confirm, or strongly constrain, the presence of a significant contribution of single degenerate progenitors to the SN Ia rate by searching for recombination lines of ionized helium in the spectra of early-type galaxies. Performing numerical calculations using the photoionization code MAPPINGS III, the expected luminosity of the He II 4686 Angstrom line (the strongest He II line seen in the optical) can be computed given reasonable assumptions regarding the composition and distribution of the ionized gas. For a 1 billion year old starburst galaxy, the inclusion of the accreting white dwarf population implied by a plausible single degenerate channel increases the predicted He II 4686 Angstrom line luminosity by almost 2 orders of magnitude (see Fig. 2.18)!

At present, no line at 4686 Angstroms has been detected in the extended emission-line regions of early-type galaxies. In part, this is because of the intrinsic weakness of this line (though the far-ultraviolet He II line at 1640 Angstroms is roughly 6 times stronger, and may be of use here). However, if there exists a large population of accreting, nuclear-burning white dwarfs in early-type galaxies which is consistent with the single degenerate channel, then such a line should be detectable by ongoing integral field spectroscopic surveys, such as CALIFA, or through stacking analysis of available SDSS galaxy spectra.

For young, post-starburst galaxies, an upper limit on the He II 4686 Angstrom line luminosity of roughly 10^{28} erg/s/solar mass would rule out any high temperature population consistent with the single degenerate scenario. Therefore, scientists working at the MPA hope that, in the very near future, the SN Ia community will be able to confidently detect, or place strong upper limits on, the presence of He II recombination lines in early-type galaxies.

(Tyrone Woods and Marat Gilfanov)

References Gilfanov M., Bogdan A., 2010, Nature, 463, 924.
Sarzi M., Shields J. C., Schawinski K. e. a., 2010, Monthly Notices of the Royal Astronomical Society, 402, 2187.
Woods T. E., Gilfanov M., 2013, Monthly Notices of the Royal Astronomical Society, 1254.
Groves B. A., Dopita M. A., Sutherland R. S., 2004, Astrophysical Journal Supplements, 153, 9.

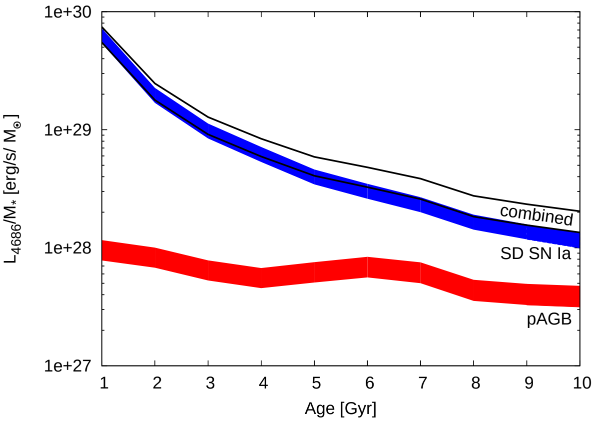

Figure 2.18: Total luminosity of the He II 4686 Angstrom recombination line predicted for a starburst galaxy per unit stellar mass given ionization by single degenerate progenitors alone (blue), and by the normal stellar population (red). For the combined case (clearly dominated by single degenerate progenitors), the predicted He II 4686 Angstrom emission is outlined in black. Width of the lines denotes the uncertainty.

2.9 Hunting for hints on galaxy formation in stellar spectra

100 000 stars is an ambitious goal for the Gaia-ESO Large Public Spectroscopic Survey, but already the first results are very promising. Since December 2011, the VLT telescope obtains high-quality spectra of Milky Way stars covering all major components of our galaxy and providing radial velocities, stellar parameters, and elemental abundances. Combined with the astrometric measurements of the Gaia satellite these data will give the first homogeneous overview of kinematics and chemical composition of stars, addressing such fundamental questions as the distinctness of stellar populations, and the dimensionality of underlying distribution functions. Preliminary results on the magnesium content of stars seem to confirm model predictions about the evolution of our galaxy that include radial migration of stars.

One of the key quests in modern astrophysics is to understand how galaxies form and evolve. Observations of their luminous constituents, the stars, provide important constraints on this problem. We can barely resolve individual stars in other galaxies, and thus have to rely on their composite, mass-function integrated, spectra. But, with the Milky Way we are in a unique position: one of the most massive members of the Local Group can be studied in great detail from the inside.

Modern telescopes are able to catch light from stars populating all galactic components: the bulge, the disk, and the halo. Using observed spectra and stellar evolution theory, we can determine the chemical composition and the ages of stars. With sufficiently large datasets, we can then reconstruct how chemical enrichment in each of the components varied over time, i.e. what nucleosynthesis processes took place and at which rate the heavy elements were injected to the interstellar medium. This information is complemented with stellar kinematics and forms the observational basis for studies of galactic chemo-dynamical evolution.

The Gaia-ESO Survey (GES) is based on this core idea. The survey is a spectroscopic extension with ground-based telescopes to the Gaia astrometric space mission (ESA). GES has been

Figure 2.19: The Gaia-ESO Survey combines spectroscopic observations from the ground (VLT) with astrometric observations from space (Gaia, 2013-2018). *(copyright ESA/ESO.)*

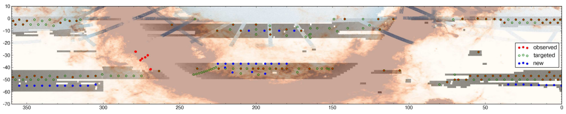

Figure 2.20: This map shows the distribution of observed and planned GES fields in the sky.

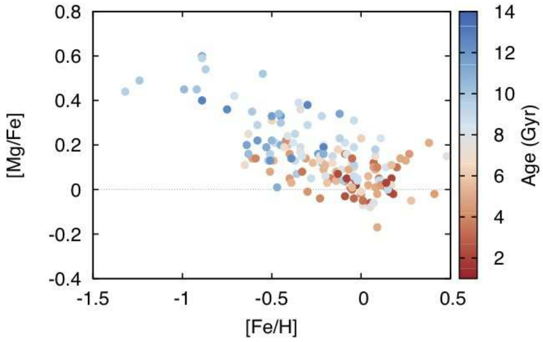

Figure 2.21: Distribution of magnesium content and metallicity for a preliminary sample of stars in the Gaia-ESO Survey. The colour of the dots indicated the ages of the stars.

awarded 300 nights on the Very Large Telescope in Chile, the largest ever allocation on a 8-10m telescope, and will acquire spectra for about 100 000 stars, probing distances as large as 15 kpc. (For comparison: The distance from the Sun to the galactic centre is about 8 kpc or 26 000 light-years.) Figure 2.20 shows the coverage map of the Milky Way field. The spectra are uniformly analysed with state-of-the-art models of stellar atmospheres and stellar evolution to complement the data. The uniqueness of the survey comes from its ability to map the detailed chemistry of all stellar populations homogeneously and with good statistics.

The complete dataset will have enormous potential, but the first interesting results have already been obtained. The preliminary analysis has yielded detailed measurements of ages and metallicities for stars in the solar neighbourhood. Contrary to most previous surveys, we are now able to add new dimensions to this data, for example, the abundances of different elements such as magnesium (Mg).

The scientists founds that in the metallicity range $-0.5 < [\mathrm{Fe/H}] < +0.5$, which is typical of the Milky Way thin disk, stars can be found with any age between 1 and 8 Gyrs. But as the metallicity decreases further, the stars become markedly older and show significantly larger abundances of alpha elements, which are synthesized in nuclear alpha-capture reactions. The elevated levels of magnesium are a clear signature that core-collapse supernovae dominate the enrichment of this older stellar population. But also stars with low, solar-like [Mg/Fe]-ratios display a large range of ages (Fig. 2.21). Does this support the current views on the formation of our galaxy? Some models are indeed bolstered by these findings, such as for example, the models with radial migration. These predict a significant spread in magnesium content and age for any given metallicity in the disk, just as observed.

This is just the beginning. In a few years, GES will have accumulated sufficiently large, statistically-significant datasets to make firm statements about stellar evolution and chemical enrichment. They will undeniably set a new point of reference in observational galactic astronomy, perhaps breaking old paradigms and bringing fresh ideas to help understand how our Milky Way came to be.
(Maria Bergemann and the Gaia-ESO Survey team)

Note: The GES team includes more than 300 co-Investigators from 90 institutes worldwide. The survey is lead by G. Gilmore (IoA, Cambridge) and S. Randich (INAF-Arcetri).

References:

Gilmore, Randich et al. ESO Messenger **147**, 2012
Randich, S., Gilmore, G., and Gaia-ESO Consortium: The Messenger, **154**, 47 (2013).
Bergemann, M., Ruchti, G., Serenelli, A., et al. arXiv:1401.4437 (2014)

2.10 Searching for Type Ia Supernovae Progenitors through Circumstellar Material

Signatures of the circumstellar material in the spectra of type Ia supernova might shed light on the progenitors of these cosmic explosions. Scientists at MPA have now analysed multi-epoch high-resolution spectra of about a dozen supernova explosion of Type Ia and come to the preliminary conclusion that only a minority show clear signatures of such material that is consistent with a single-degenerate progenitor system.

Type Ia supernovae (SNe Ia) are very luminous explosions that are used as standerdizable candles to measure distances on a cosmic scale. These measurements can then be used to reconstruct the expansion history of the Universe. Knowing the full nature of the progenitors of these events might help to standardize them more accurately, allowing for a more accurate reconstruction result. Moreover, SNe Ia are thought to be the end product of binary systems. Understanding their progenitors will help us to better understand the evolution and end product of certain binary stars. Hence, the nature of SN Ia progenitors is an important open question in need of an answer.

It is widely accepted that a SN Ia event is the explosion of a carbon-oxygen white dwarf star. For a white dwarf to explode it needs to accrete material that will trigger carbon-burning. Due to the degenerate state of the white dwarf material this burning is a runaway process that produces enough energy to unbind and totally disrupt the white dwarf. The two leading models for the progenitors of these events are the single-degenerate model (see Fig. 2.22 top) – in which material from a non-degenerate companion is transferred onto the white dwarf – and the double-degenerate model (see Fig. 2.22 bottom) – in which a degenerate companion, another white dwarf, merges with the primary.

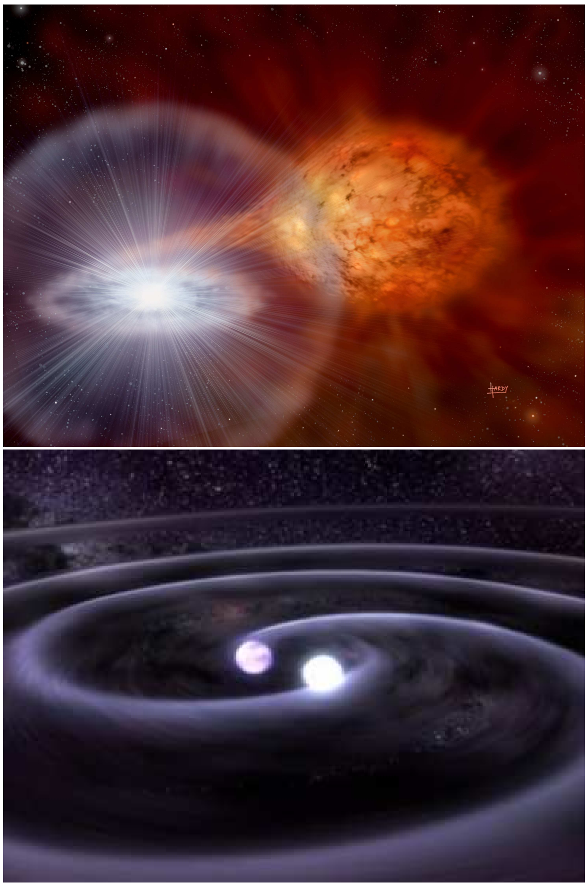

Figure 2.22: Artist impression of the two widely accepted type Ia progenitors. (Top) A white dwarf accreting material from a non-degenerate companion. Copyright: David A. Hardy/AstroArt.org. (Bottom) Two white dwarf stars spiraling in towards a merger due to gravitational wave emission. *(Copyright: GSFC/D. Berry.)*

One of the major discriminants between the different progenitor scenarios is the environment in which the white dwarf explodes. In the single-degenerate scenario the white dwarf if engulfed by circumstellar material (CSM) that was expelled from the system due to mass loss processes. This material should have relatively low outflowing velocities. In the double-degenerate scenario the white dwarf explodes in a cleaner environment. Even though some recent work suggests CSM might be present also in a certain double-degenerate progenitor, this would have different properties, namely higher velocities.

Therefore, the detection of CSM in type Ia spectra can help disentangle the different progenitor scenarios and allow us to determine the binary pathway, or pathways, that lead to them. The question then arises what the manifestation of this CSM should be. Material that is close to the exploding white dwarf should be ionized by the ultra-violet radiation emitted during the explosion. As time progresses this material should recombine and return to its previous neutral/ionization-level. Thus, in early-time spectra, not long after the explosion, we expect to see little or no features of the neutral/low-ionization-level. In later-time spectra we expect to see these features emerge and/or intensify. Material that is further away at the time of explosion will not be ionized, but given its relatively low outflowing velocity it should manifest itself as a blue-shifted absorption feature. An ideal element to use in this search is neutral sodium, as it is a strong line, even when only small amounts of sodium are present.

The first widely accepted detection of CSM in a type Ia was reported for SN 2006X by a group led by Ferdinando Patat from ESO (see Fig. 2.23). Following this detection two more events were reported to show signs of CSM – SN 2007le and PTF11kx – and three events for which such material was not detected – SN 2000cx, SN 2007af, and SN 20011fe. These mixed result might be due to (a) viewing-angle effects that will cause the CSM to be visible only in part of the SNe Ia, (b) two populations of progenitors - one with CSM and one without; or more likely a combination of both. The small size of this sample does not allow any robust conclusions to be made. A larger sample is needed to robustly conclude what the prevalence of cases like SN 2006X, SN 2007le, and PTF11kx is. Moreover, a larger sample including more cases with CSM detection will allow the study of the CSM properties. Non-detection of CSM can be used to estimate upper limits to the CSM mass. With these we can exclude implausible models and set constraints to the plausible ones.

A group led by Assaf Sternberg showed that SNe Ia exhibit an overabundance of features indicative of outflowing material. This overabundance was shown to be consistent with circumstellar material. Nevertheless, as this analysis was based on single-epoch data, it can not be used to probe the properties of the CSM, as it is not possible to tell which individual features are circumstellar and which are interstellar.

In collaboration with scientists world-wide we are leading a renewed effort to obtain a large multi-epoch high-resolution spectroscopic sample of SNe Ia in hope to shed light on the elusive progenitors of SNe Ia. So far, we have already obtained multi-epoch high-resolution spectra of 14 SNe Ia (see Fig. 2.24), more then tripling the currently published sample. This enlarged sample suggests that only ∼18% of SNe Ia exhibit time-variable absorption features that are associated with CSM. Though this result is in agreement with other previously published work, due to the size of our sample this result may still change. Moreover, in future analysis we will estimate upper limits for the CSM mass and will try to determine which binary pathways may be excluded as progenitors for the events in our sample. This is still work in progress. We hope to reach a sample size that is comparable with the Sternberg et al, single-epoch sample within the next couple of years, and that its analysis will help answer the long-standing type Ia progenitor question.

(Assaf Sternberg and Wolfgang Hillebrandt).

References

Patat, F., P. Chandra et al. (incl. A. Sternberg): Detection of circumstellar material in a normal Type Ia supernova. Science **317**, 924 (2007).

Simon, J.D., A. Gal-Yam, et al. (incl. A. Sternberg): Variable sodium absorption in a low-extinction Type Ia supernova. Astrophs. J. **702**, 1157 (2009).

Dilday, B., D.-A. Howell, et al. (incl. A. Sternberg): PTF 11kx: A Type Ia Supernova with a Symbiotic Nova Progenitor. Science **337**, 942 (2012).

Sternberg, A., A., Gal-Yam, J.-D. Simon, et al.: Circumstellar material in Type Ia supernovae via sodium absorption features. Science **333**, 856 (2011).

Sternberg, A., A. Gal-Yam, et al. (incl. W. Hillebrandt): Multi-epoch high-spectral-resolution observations of neutral sodium in 14 Type Ia supernovae. submitted to MNRAS.

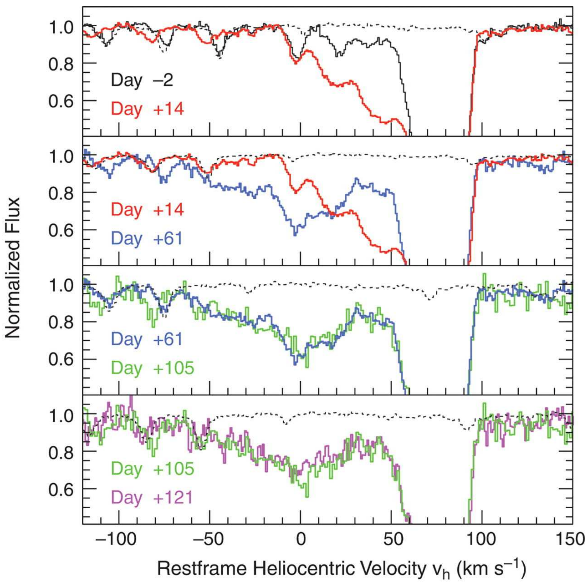

Figure 2.23: Multi-epoch spectra of SN 2006X showing the time-variable behavior interpreted as a signature of circumstellar material close to the exploding white dwarf. Image taken from Patat et al. 2007 (doi: 10.1126/science.1143005)

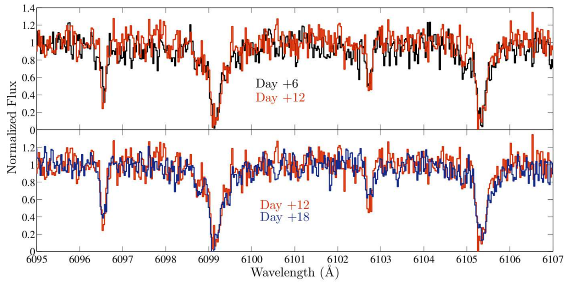

Figure 2.24: Multi-epoch spectra of SN 2008dt. The slight variability that is observed is within the noise level. These observations are consistent with a non-detection of time-variable features. Hence, there no sign of CSM along the line-of-sight to this event. Adapted from Sternberg et al.

2.11 Metals in galaxies: Is what we see what we expect?

Astronomical observations of chemical elements heavier than lithium (known simply as ‘metals’ in astrophysics) can tell us a lot about how galaxies evolve. For example, the total amount of metal in the interstellar gas of a galaxy correlates with the total number of stars that were formed. Also, the ratio of oxygen to iron abundance in stars (known as the oxygen enhancement, or simply [O/Fe]) is thought to act as a galactic clock, telling us how quickly a galaxy grew. Galaxies with high oxygen enhancement should have formed their stars rapidly, before the iron from type Ia supernovae (SNe-Ia) could pollute the star-forming gas. Galaxies with low oxygen enhancement, on the other hand, should have formed their stars over an extended period of time, with the youngest stars containing large amounts of SNe-Ia-produced iron.

However, despite this standard and straightforward theoretical framework, sophisticated galaxy evolution models have been unable to reproduce, at the same time, the complex chemical patterns seen in different types of galaxy. Specifically, the metal abundances seen in the photospheres of stars in the Milky Way and those seen in integrated populations of old stars in elliptical galaxies could only be reproduced simultaneously by invoking certain physical processes that are not part of our canonical understanding of galaxy evolution.

Starting in 2010, a team of scientists from the MPA and University of Sussex embarked on a project to reconcile the chemical properties seen in these very different regions of the cosmos. Using their latest semi-analytic model and a state-of-the-art implementation of the metal enrichment of galaxies by stars, the team could reproduce the chemical properties of the gas in nearby star-forming galaxies, of Sun-like stars in the Milky Way, and of the old stars of elliptical galaxies. Crucially, this is all done simultaneously and without any radical departure from the standard framework of galaxy formation that has seen so much success in other areas of astrophysics.

Our galaxy, the Milky Way contains around 300 billion stars with various chemical properties, ranging from old, metal-poor stars to young, metal-rich stars (see Fig. 2.25). The team found that the relation between iron abundance and oxygen enhancement for Sun-like stars in a sample of model Milky-Way-type galaxies shows good agreement

Figure 2.25: An artist's impression of what our galaxy, the Milky Way, would look like from above. Copyright by Nick Risinger.

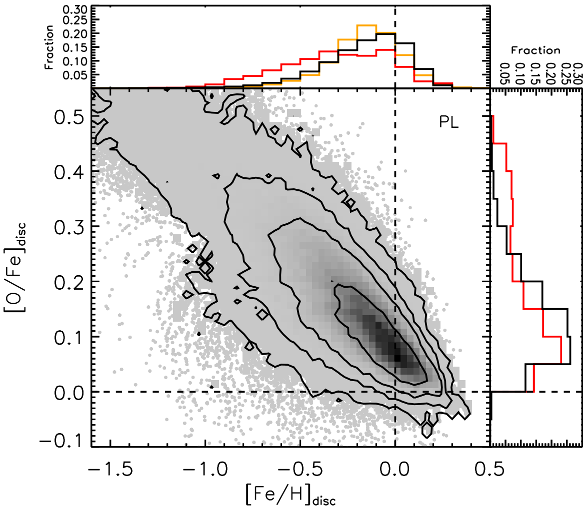

Figure 2.26: The plot in the centre gives the relation between iron abundance and oxygen enhancement in the Sun-like stars of our Milky-Way-type model galaxies. The top and right histograms show a comparison of the iron abundance and oxygen enhancement distributions, respectively, where the predictions of the model are shown in black and two samples of real Milky Way stars are shown in orange (GCS survey) and red (SEGUE survey). Figure from Yates et al. 2013.

with those observed in real Milky Way stars (see Fig. 2.26). This tells us that the model is accurately representing the chemical evolution of the Milky Way for the last thirteen billion years.

The same model, with all the same assumptions about the physical processes occurring in galaxies, also reproduces the chemical trends seen in elliptical galaxies of different masses. In the real Universe, the most massive ellipticals (see, for example, the galaxy in the centre of Fig. 2.27) are known to have a higher oxygen enhancement than lower-mass ellipticals (see, for example, the galaxy in the top right panel of Fig. 2.27). In our model, we find the same correlation between mass and oxygen enhancement.

And it's for the reason we would expect: high-mass ellipticals have formed stars rapidly (before a lot of iron is produced), whereas low-mass ellipticals formed their stars over a more extended period of time (and so contain more iron). This result is a significant achievement in itself, as it shows the relationship between the mass, age and chemistry of ellipticals predicted by the model is similar to that really observed, without requiring any major changes to the standard galaxy formation paradigm.

So what is different about this new model that allows these results to be achieved? The team believes that the key is the assumptions made about the various metals ejected by different stars and the lifetimes of SN-Ia progenitors. In their model, the simulated metal yields depend on a star's mass and metallicity, and also take account of mass loss via stellar winds prior to the final supernova explosion. In addition, no more than half of the SNe-Ia progenitor systems should explode within four hundred million years of their birth, and only about one in a thousand of all the stars formed should produce a SN-Ia. None of these conditions is particularly controversial, and when combined with the detailed semi-analytic model the group obtained the results described above.

But this is not the end of the story! The team are now working on simultaneously reproducing the chemical properties of objects that are at even more extreme ends of the galaxy spectrum. These tests will show whether the same model can reproduce both the chemical evolution of very-low-mass dwarf galaxies and the iron content of the hot gas surrounding the most massive galaxy clusters. Such tests are also crucial to validating any galaxy formation model, and should teach us even more about the true nature of galaxies in the nearby Universe. (Rob Yates and Guinevere Kauffmann).

References:

Yates R. M., Henriques B., Thomas P. A., Kauffmann G., Johansson J., White S. D. M., MNRAS, 435, 3500.

2.12 Symmetry in the Planck maps of the cosmic microwave background

Temperature anisotropies seen in maps of the cosmic microwave background (CMB) offer a test of the fundamental symmetry of space-time during a period in the very early universe called cosmic inflation. If rotational symmetry (statistical isotropy) is violated during this time, a distinct signature is imprinted on the temperature correlations of two points in the sky. Using temperature data from the Planck mission published in 2013, we impose the most stringent constraints so far on a violation of rotational symmetry in the early Universe, once the known effects of the Planck beams and Galactic foreground emission that also cause asymmetry are removed.

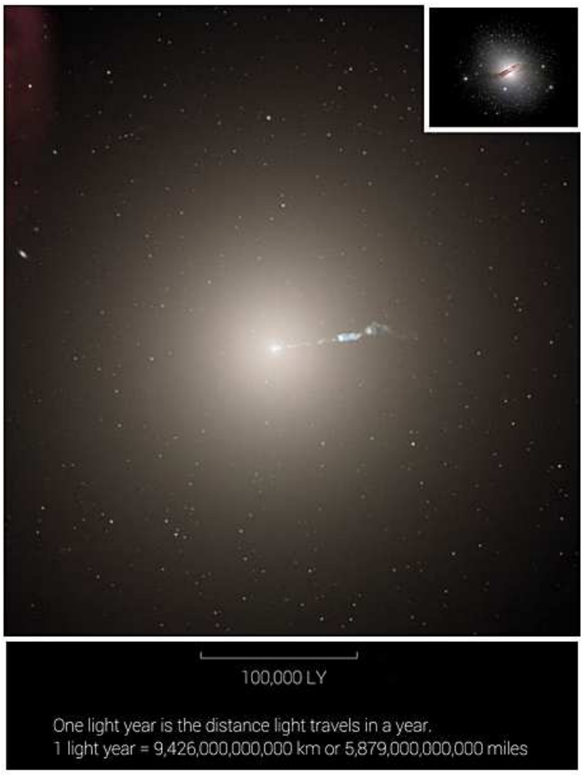

Figure 2.27: The central image shows M87, a giant elliptical galaxy at the centre of the Virgo cluster. The central supermassive black hole is emitting extended jets as it accretes material. In the top right corner is an image of Centaurus A. This is a lower-mass elliptical galaxy with a peculiar dust lane in which new stars are forming. These images are made publicly available by NASA and ESA, and are both depicted to scale, courtesy of Rhys Taylor's Galaxy Size Comparison Chart.

At the beginning of the universe, just after its birth but before the Big Bang when the universe became hot, our cosmos expanded exponentially during a very short period called cosmic inflation. This process is an indispensable building-block of the standard model of the universe; however, we do not yet know which physical mechanism caused this inflation.

The standard inflation scenario is described by a nearly de Sitter space-time. In this framework, there are ten isometric transformations, i.e. mappings that preserve distances: three spatial translations; three spatial rotations; one time translation accompanied by spatial dilation; and three additional isometries, which reduce to special conformal transformations as time approaches infinity.

As the expansion rate is necessarily time-dependent (because inflation must end) this breaks the time translation symmetry and hence the spatial dilation symmetry, limiting how much the universe deviates from dilation invariance. In terms of observations, such dilation invariance would give precisely scale-invariant initial fluctuations for the early universe, whereas a small deviation has been detected from CMB data by Planck with more than 5 sigma significance.

In the usual model of inflation, six of the ten isometries remain unbroken: translations and rotations. But why must they remain unbroken while the others are broken? In fact, slight deviations from rotation symmetry naturally arise in "anisotropic inflation" models, in which a scalar field is coupled to a vector field. A violation of rotational symmetry also occurs when very long-wavelength perturbations on super-horizon scales are coupled with short-wavelength perturbation. Finally, a pre-inflationary universe was probably very chaotic and highly anisotropic, and thus a remnant of the pre-inflationary anisotropy may still be detectable. These models lead to a quadrupolar modulation of the primordial two-point correlation function, whose fractional strength is parametrized by g_*. When g_* is different from zero, the strength of the two-point correlation function depends on the angle between the line connecting the two points and some preferred direction in space.

We tested the rotational symmetry by searching for such a preferred direction using the two-point correlation function of primordial perturbations. More precisely, we studied the CMB anisotropy, which is linearly related to the primordial perturbations. For our analysis, we used the CMB temperature data from the Planck mission released in 2013, which is publicly available at the Planck Legacy Archive. As the main "CMB channel" we use the map at 143 GHz, because at this frequency the contamination from synchrotron, free-free and dust emission of our own galaxy is weaker than in other, higher frequency channels. To further reduce the diffuse Galactic emission we fitted templates to the 143 GHz map and subsequently removed them from the observed maps. These foreground templates are created by subtracting one frequency map from the map at an adjacent frequency - similar to the "SEVEM"-method of the Planck collaboration.

From this preliminary analysis, we detect a significant quadrupolar modulation of the CMB power spectrum ($g_* = -0.116 \pm 0.014$ at 68% confidence level) with a direction close to the Ecliptic pole. This is shown in Figure 2.28.

However, there is another effect which causes asymmetry. The Planck beams at 143 GHz are not circular; the orientation of their semi-major axes is parallel to Planck's scan direction, which lies approximately along the Ecliptic longitudes. This means that the beams are "fatter" along the Ecliptic longitudes, and thus the Planck satellite measures less power along the Ecliptic north-south direction than in the east-west direction. In the data, this yields a quadrupolar power modulation (with $g_* < 0$).

After quantifying and removing the effect of this beam asymmetry, the rotation asymmetry in the CMB basically vanishes (g* = 0.002 +/- 0.016 at 68% confidence level). In Figure 1b, we show the probable locations of a preferred direction estimated with a correction for the beam asymmetry and Figure 2.29 shows the likelihood of the fractional strength of the quadrupole modulation, which peaks at zero, when the correction is added.

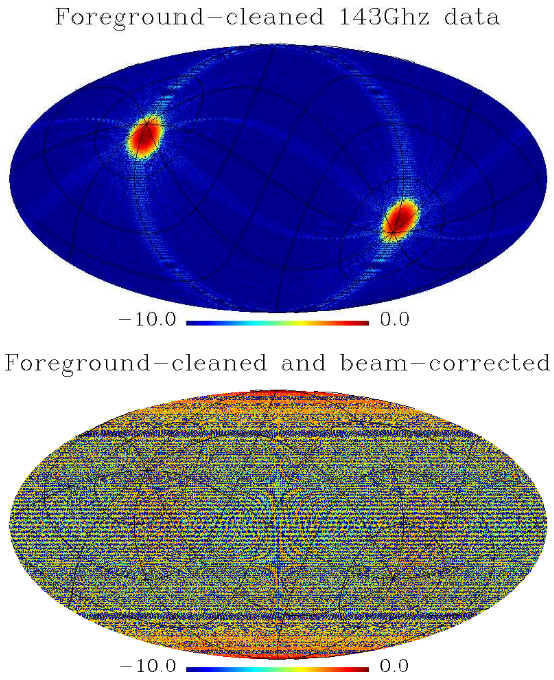

Figure 2.28: These images show the most probable locations of a preferred direction in the sky in the Galactic coordinates, estimated without beam asymmetry correction (left) and with correction (right). The left panel shows significant detection of a preferred direction toward the Ecliptic poles (marked in red), whereas the bottom panel shows no evidence for a preferred direction.

In a final step we tested the effect of the Galactic foreground emission on our estimate. When we use the raw 143 GHz map without foreground cleaning, we find significant anisotropy both before and after the beam asymmetry correction ($g_* = 0.305$ and 0.295 ± 0.015, respectively). The direction in this case lies close to the Galactic pole; the foreground reduction thus plays an important role in nulling artificial anisotropy in the data.

In a nutshell: After removing the effects of Planck's asymmetric beams and of the Galactic foreground emission, we find no evidence for any rotational asymmetry in our early Universe, which would be predicted by anisotropic inflation models. Our limit (less than 2%) provides the most stringent test of rotational symmetry during inflation so far.

(Jaiseung Kim and Eiichiro Komatsu)

References:

J. Kim and E. Komatsu: Limits on anisotropic inflation from the Planck data. Phys. Rev. D **88**,

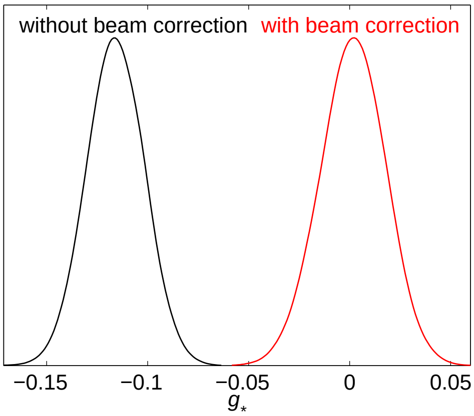

Figure 2.29: The likelihood of the fractional strength g_* of the quadrupole modulation from the Planck CMB temperature data: without the asymmetric beam correction (black) and with correction (red).

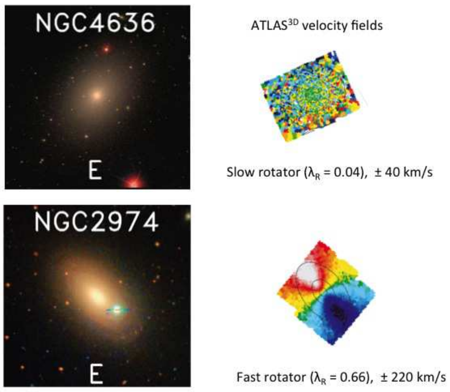

Figure 2.30: Postage stamp of a slowly rotating galaxy (top, NGC4636) and a fast rotating galaxy (bottom, NGC2974) with the corresponding observed two-dimensional ATLAS^{3D} velocity fields (right). NGC4636 has no rotation patterns and the measured velocities do not exceed 40 km/s. NGC2974 shows regular fast ($\sim$ 200 km/s) rotation (Krajnovic et al. 2011).

101301(R) (2013).

2.13 Why do the most massive galaxies in the local Universe stand still?

Within the ATLAS^{3D} project, 260 nearby early-type galaxies within a local volume of 42 Mpc have been observed at optical, radio, and millimeter wavelengths. The multi-wavelength coverage enabled the team to determine the dynamics, the star-formation histories, ages and metallicities of the stellar populations as well as a full census of the gas phase (molecular, neutral and ionised) properties. The integral-field observations of the stellar kinematics (see Fig. 2.30)) have revealed a surprising result. Whereas most early-type galaxies ($\sim$ 80 per cent) rotate quite regularly - similar to thick stellar disks - the most massive ones rotate very slowly (see Fig. 2.31) and some of them (7 out of 260) are very round and show no sign of ordered rotation at all. They stand still.

The absence of rotation is difficult to reconcile with current standard formation scenarios and has caused theorists quite a headache. Traditionally, it is assumed that early-type galaxies are burned out spiral galaxies or they formed and evolved by mergers of disk-like or even early-type galaxies of comparable mass. Many studies, however, have demonstrated that these formation paths mostly result in rotating or very elongated galaxies, inconsistent with properties of the observed non-rotating early-type galaxies.

As part of the theoretical efforts within ATLAS^{3D}, a group of MPA scientists have carried out a number of high resolution computer simulations of the formation and evolution of massive galaxies. Analysing the stellar kinematics of the simulated galaxies in the same way as the observers made it possible to identify direct links between the formation history of the galaxies - as recorded by the simulations - and the resulting kinematic properties. The study reveals a surprising wealth of formation histories which are consistent with observations and the scientists were able to demonstrate that every formation history leaves its characteristic imprint on the observable two-dimensional kinematic properties. A most valuable result to interpret the observations.

Similar to the real Universe, most simulated galaxies of lower mass are fast rotating. They either form a thick stellar disk from accreted gas or are still rotating after collisions with companion galaxies of similar size. At higher galaxy masses ($\sim 10^{11}$ M$_\odot$), however, the majority of the stars in a typical simulated galaxy do not form in the galaxy itself but formed in other galaxies that have merged with the galaxy progenitor. Some of the major collision wrecks rotate slowly but their very elongated shapes do not agree with observed non-rotators. Only galaxies with a special formation history resemble the observed round and non-rotating galaxies. They acquire about half of their stars from many mergers with much smaller galax-

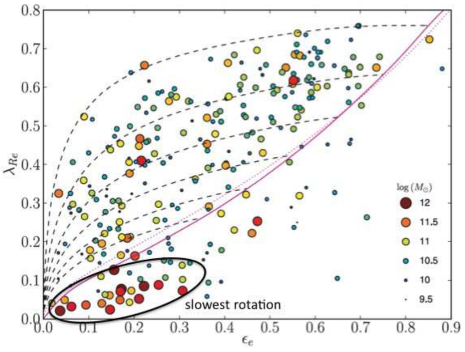

Figure 2.31: Rotation properties of all early-type galaxies in the ATLAS^{3D} sample measured by the spin parameter λR. This parameter measures the angular momentum of stellar components of the galaxies and is derived from the two-dimensional velocity fields (see Fig. 2.30). Most early-type galaxies rotate fast (high λR values) but the rare massive systems (largest symbols in the plot) are slow rotators (Emsellem et al. 2011).

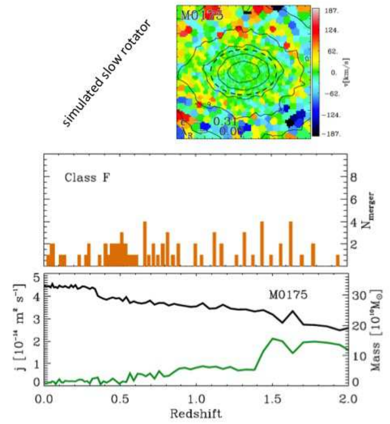

Figure 2.32: Two dimensional velocity field of a simulated non-rotating rotating-DELETE galaxy from a cosmological simulation (top panel). These galaxies have special formation histories (class F in Naab et al. 2013). Since redshift z $\sim$ 2 they have experienced repeated minor mergers ($\sim$ 100 in this case) with mass ratios larger than 4:1 (counted by the orange histogram, middle panel) and no late major mergers. During their evolution (from high redshift to z=0 today), the galaxies continuously grow in mass (black line, bottom panel) and loose angular momentum (green line) until they stand still.

ies and experience no major merger. The many repeated merger events over the last $\sim$ 10 Gyrs continuously slow the giant galaxies down so that today they stand still (Fig. 2.32).
(Thorsten Naab and Ludwig Oser).

References:

Cappellari et al., The ATLAS3D project - I. A volume-limited sample of 260 nearby early-type galaxies: science goals and selection criteria. 2011, MNRAS, **413**, 813.
Krajnovic et al., The ATLAS3D project - II. Morphologies, kinemetric features and alignment between photometric and kinematic axes of early-type galaxies. 2011, MNRAS, **414**, 2923.
Emsellem et al., The ATLAS3D project - III. A census of the stellar angular momentum within the effective radius of early-type galaxies: unveiling the distribution of fast and slow rotators, 2011, MNRAS, **414**, 888.
Naab et al., The ATLAS3D project - XXV: Two-dimensional kinematic analysis of simulated galaxies and the cosmological origin of fast and slow rotators", 2013,

2.14 D^{3}PO Denoising, Deconvolving, and Decomposing Photon Observation

A common problem for scientists analysing astronomical images is the separation of diffuse and point-like components. This analysis has now become easier: scientists at the Max Planck Institute for Astrophysics have recently published the D^{3}PO algorithm, which removes noise effects and instrumental artefacts from the observed images, while simultaneously separating diffuse and point-like contributions.

Modern observatories provide raw images of the sky with high spatial resolution. In the X-ray and gamma-ray domain, individual photons are collected and depicted in photon count images. Since the number of photons detected is random to a certain degree, the raw image suffers from granularity due to the so-called shot noise. Further, an inhomogeneous sky exposure - especially for larger area surveys - and other instrumental effects leave unwanted imprints in the observational data. Imperfect instrument optics can, for example, cause point sources to be spread out so that they appear as smeared out blobs in the raw image. Further-

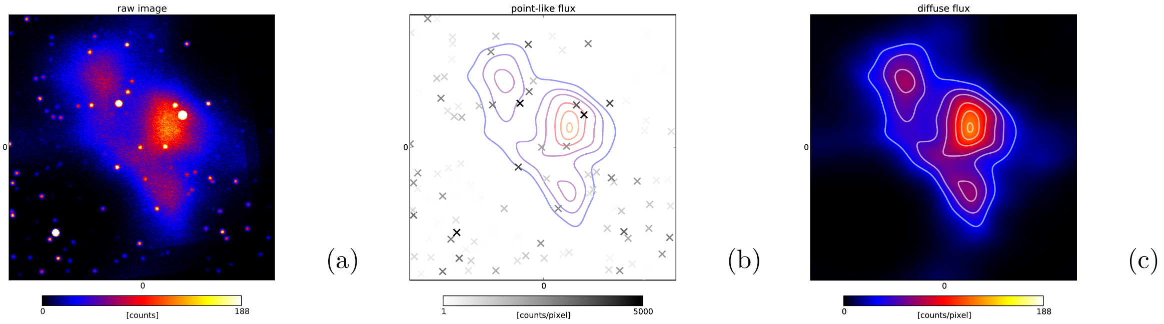

Figure 2.33: *(a)* Simulated observation showing a $32 \times 32\,\mathrm{arcmin}^2$ patch of the sky with a resolution of 0.1arcmin. *(b)* Reconstruction of the point-like photon flux, where each marker indicates a source, and its gray scale the corresponding flux. *(c)* Reconstruction of the diffuse photon flux in which noise and instrumental artefacts have been removed.

more, the sky emission is often an overlay of emission from different sources. Distinguishing between them on the image is ambiguous as it is often not clear from which of the sources a particular photon originates. It is therefore a real challenge to extract the original, astrophysical information contained in these noisy images and to sharpen them to high resolution.

To refine such raw images and reconstruct the original emission sources as reliably as possible, researchers from Garching have now developed a novel, intelligent imaging algorithm, which denoises, deconvolves, and decomposes photon observations – thus the name “D^{3}PO”. The removal or suppression of noise is commonly denoted as “denoising”. In case of photon count images, this requires that the shot noise statistics is taken fully into account. “Deconvolution” in this context denotes the rectification of instrumental artefacts such as by imperfect optics. Spread out point sources are hereby remapped and sharpened to a single position on the image. Finally, “decomposition” is the separation of the photon count image into two different images, one for the extended and one for the point-like sources. The distinction between these morphologically different components is the most difficult task since the algorithm needs to decide on how to split the observed photons into the two possible source classes.

In order to achieve all this simultaneously, the D^{3}PO algorithm relies on probabilistic inference that considers and weighs virtually all possible images of the sky while taking into account the raw photon image and all available a priori knowledge of how the sky could look like. For example, from the knowledge of how the observatory works, one has a decent idea of how a point source should look like in the raw image. Given an observation, one can judge how likely it is that a certain feature is a point source, diffuse emission, or just shot noise. This probabilistic reasoning has been designed using the framework of Information Field Theory, which provides a convenient language for the derivation of optimal imaging methods.

The images delivered by the D^{3}PO algorithm are not only cured from noise and instrumental artefacts, but also provide a separation of the photon flux into extended and point-like sources. This is crucial for analysing high energy observations with respect to the astrophysical nature of the emission. On the one hand, extended emission regions, such as galactic clouds, galaxy clusters, or unresolved cosmic background emission, can be studied in the images without blooming point sources. And on the other hand, the analysis of point sources, like neutron stars and quasi-stellar objects (so-called quasars), can be carried out in images, where the background has been removed.

The D^{3}PO algorithm is currently applied to data from the Chandra X-ray observatory and the Fermi gamma-ray space telescope at the Max Planck Institute for Astrophysics. The resulting images will hopefully provide the astrophysical community with a sharpened view on the high energy Universe.

(Marco Selig, Torsten Enßlin and Hannelore Hämmerle)

References: Marco Selig and Torsten A. Enßlin: "Denoising, Deconvolving, and Decomposing Photon Observations", Astron. Astrophys., *http://arxiv.org/abs/1311.1888*

3 Publications and Invited Talks

3.1 Publications in Journals

3.1.1 Publications that appeared in 2013 (314)

Alatalo, K., T. Davis et al. (incl. Th. Naab): The ATLAS3D project - XVIII. CARMA CO imaging survey of early-type galaxies. Mon. Not. R. Astron. Soc. **432**, 1796-1844 (2013).

Alig, C., M. Schartmann, A. Burkert and K. Dolag: Numerical Simulations of the Possible Origin of the Two Sub-parsec Scale and Counterrotating Stellar Disks around SgrA. Astrophys. J. **771**, id. 119 (2013).

Amaro-Seoane, P., P. Brem and J. Cuadra: Tidal Disruptions in Circumbinary Disks. I. Star Formation, Dynamics, and Binary Evolution. Astrophys. J. **764**, id. 14, (2013).

Ando, S. and E. Komatsu: Constraints on the annihilation cross section of dark matter particles from anisotropies in the diffuse gamma-ray background measured with Fermi-LAT. Phys. Rev. D. **87**, id. 123539 (2013).

Andrade-Santos, F., P. Nulsen et al. (incl. E. Churazov): Dark Matter Subhalos and the X-Ray Morphology of the Coma Cluster. Astrophys. J. **766**, id. 107 (2013).

Andrassy, R. and H. Spruit. Overshooting by convective settling. Astron. Astrophys. **559**, id.A122 (2013).

Angulo, R., O. Hahn and T. Abel: How closely do baryons follow dark matter on large scales? Mon. Not. R. Astron. Soc. **434**, 1756-1764 (2013).

Asgekar, A. et al. (incl. M. Bell and B. Ciardi): LOFAR detections of low-frequency radio recombination lines towards Cassiopeia A. Astron. Astrophys. **551**, id.L11 (2013).

Augustovicová, L., V. Spirko, W.P. Kraemer, and P. Soldán: Radiative association of He_2^+: the role of quartet states. Mon. Not. R. Astron. Soc. **435**, 1541–1546 (2013).

Augustovicová, L., V. Spirko, W.P. Kraemer, and P. Soldán: Radiative association of He_2^+ revisited. Astron. Astrophys. **553**, A42 (2013).

Aumer, M. and S. White: Idealized models for galactic disc formation and evolution in 'realistic' Lambda-CDM haloes. Mon. Not. R. Astron. Soc. **428**, 1055-1076 (2013).

Aumer, M., S. White, Th. Naab and C. Scannapieco: Towards a more realistic population of bright spiral galaxies in cosmological simulations. Mon. Not. R. Astron. Soc. **434**, 3142-3164 (2013).

Baldauf, T., U. Seljak, R. Smith et al.: Halo stochasticity from exclusion and nonlinear clustering. Physical Review D, **88**(8) 1-24, (2013).

Barai, P., M. Viel, et al. (incl. K. Dolag): Galactic winds in cosmological simulations of the circumgalactic medium. Mon. Not. R. Astron. Soc. **430**, 3213-3234 (2013).

Baumgarte, T., P. Montero, I. Cordero and E. Müller: Numerical relativity in spherical polar coordinates: Evolution calculations with the BSSN formulation. Phys. Rev. D. **87**, id. 044026 (2013).

Bauswein, A., S. Goriely and H.-T. Janka: Systematics of Dynamical Mass Ejection, Nucleosynthesis, and Radioactively Powered Electromagnetic Signals from Neutron-star Mergers. Astrophys. J. **773**, id. 78 (2013).

Bauswein, A., T. Baumgarte and H.-T. Janka: Prompt merger collapse and the maximum mass of neutron stars. Phys. Rev. Lett. **111**, id. 131101 (2013).

Bayet, E., M. Bureau et al. (incl. Th. Naab): The ATLAS3D project - XVI. Physical parameters and spectral line energy distributions of the molecular gas in gas-rich early-type galaxies. Mon. Not. R. Astron. Soc. **432**, 1742-1767 (2013).

Beck, A.M., K. Dolag, H. Lesch and P. Kronberg: Strong magnetic fields and large rotation measures in protogalaxies from supernova seeding. Mon. Not. R. Astron. Soc. **435**, 3575-3586 (2013).

Bell, M., N. Oppermann, A. Crai and T. Enßlin: Improved CLEAN reconstructions for rotation measure synthesis with maximum likelihood estimation. Astron. Astrophys. **551**, id.L7 (2013).

Belyaev, A.K.: Model approach for low-energy inelastic atomic collisions and application to Al+H and Al^+ H^-. Phys. Rev. A **88**, 052704 (2013).

Belyaev, A.K.: Inelastic aluminium-hydrogen collision data for non-LTE applications in stellar atmospheres. Astron. Astrophys. **560**, id. A60 (2013).

Benitez-Herrera, S., E. Ishida et al. (incl. W. Hillebrandt): Cosmological parameter estimation from SN Ia data: a model-independent approach. Mon. Not. R. Astron. Soc. **436**, 854-858 (2013).

Bennett, C.L, D. Larson et al. (incl. E. Komatsu): Nine-year Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Final Maps and Results. Astrophys. J. Suppl. **208**, id. 20, (2013).

Bergemann, M., R.P. Kudritzki B. Davies et al.: 3D NLTE line formation in the atmospheres of red supergiants. EAS Publications Series, **60**, 103-109 (2013).

Bergemann, M., R.P. Kudritzki, M. Würl et al.: Red Supergiant Stars as Cosmic Abundance Probes. II. NLTE Effects in J-band Silicon Lines. Astrophys. J. **764**, id. 115 (2013).

Biffi, V., K. Dolag and H. Böhringer: Investigating the velocity structure and X-ray observable properties of simulated galaxy clusters with PHOX. Mon. Not. R. Astron. Soc. **428**, 1395-1409 (2013).

Biffi, V., K. Dolag and H. Böhringer: Observing simulated galaxy clusters: The prospects of ICM velocity diagnostics. Astron. Nachrichten **334**, 317-320 (2013).

Bogdan, A., et al. (incl. M. Gilfanov and E. Churazov): Hot X-Ray Coronae around Massive Spiral Galaxies: A Unique Probe of Structure Formation Models. Astrophys. J. **772**, id. 97 (2013).

Brinchmann, J., S. Charlot, G. Kauffmann et al.: Estimating gas masses and dust-to-gas ratios from optical spectroscopy. Mon. Not. R. Astron. Soc. **432**, 2112-2140 (2013).

Burigana, C., D. Rodney et al. (incl. R. Khatri): Recent Developments in Astrophysical and Cosmological Exploitation of Microwave Surveys. Int. J. of Modern Phys. D. **22**, id. 1330011 (2013).

Burke, M., et al. (incl. M. Gilfanov and Z. Zhang): Spectral Properties of X-Ray Binaries in Centaurus A. Astrophys. J. **766**, id. 88 (2013).

Cao, X. and H. Spruit: The Large-scale Magnetic Fields of Thin Accretion Disks. Astrophys. J. **765**, id. 149 (2013).

Cao, Yi, M. Kaliwal et al. (incl. P. Mazzali): Discovery, Progenitor and Early Evolution of a Stripped Envelope Supernova iPTF13bvn. Astrophys. J. Lett. **775**, id. L7, (2013).

Cappellari, M., N. Scott et al. (incl. Th. Naab): The ATLAS3D project - XV. Benchmark for early-type galaxies scaling relations from 260 dynamical models: mass-to-light ratio, dark matter, Fundamental Plane and Mass Plane. Mon. Not. R. Astron. Soc. **432**, 1709-1741 (2013).

Cappellari, M., R. McDermid et al. (incl. Th. Naab)': The ATLAS3D project - XX. Mass-size and mass-omega distributions of early-type galaxies: Mon. Not. R. Astron. Soc. **432**, 1862-1893 (2013).

Cassano, R., S. Ettori, et al. (incl. K. Dolag): Revisiting scaling relations for giant radio halos in galaxy clusters. Astrophys. J. **777**, id. 141 (2013).

Cassaraá, L.P., L. Piovan, A. Weiss et al.: The role of dust in models of population synthesis. Mon. Not. R. Astron. Soc. **436**, 2824-2851 (2013).

Catinella, B., D. Schiminovich et al. (incl. J. Wang): The GALEX Arecibo SDSS Survey. VIII. Final Data Release – The Effect of Group Environment on the Gas Content of Massive Galaxies. Mon. Not. R. Astron. Soc. **436**, 34-70 (2013).

Cenko, S.B., S. Kulkarni et al. (incl. A. Sternberg): Discovery of a cosmological, relativistic outburst via its rapidly fading optical emission. Astrophys. J. **769**, 130 (2013)

Chen, Y.M., G. Kauffmann et al. (incl. S. White): Evolution of the most massive galaxies to z $\sim$ 0.6 - II. The link between radio AGN activity and star formation. Mon. Not. R. Astron. Soc. **429**, 2643-2654 (2013).

Chen, X., J. Rachen, M. Lopez-Caniego et al.: Long-term variability of extragalactic radio sources in the Planck Early Release Compact Source Catalogue. Astron. Astrophys. **553**, 107 (2013).

Chen, X.G., H. Firouzjahi, E. Komatsu et al.: In-in and ΩN calculations of the bispectrum from non-attractor single-field inflation. J. of Cosmology and Astrop. Phys. **12**, id. 039 (2013).

Chiang, C.-T., P. Wullstein et al. (incl. E. Komatsu): Galaxy redshift surveys with sparse sampling. J. Cosmology and Astroparticle Phys. **Issue 12**, id. 030 (2013).

Childress, M., A. Scalzo et al. (incl. P. Mazzali): Spectroscopic Observations of SN 2012fr: A Luminous, Normal Type Ia Supernova with Early High-velocity Features and a Late Velocity Plateau. Astrophys. J. **770**, id. 29 (2013).

Churazov, E., M. Ruszkowski and A. Schekochihin: Powering of cool filaments in cluster cores by buoyant bubbles. I. Qualitative model. Mon. Not. R. Astron. Soc. **436**, 526-530 (2013).

Ciambur, B., G. Kauffmann and S. Wuyts: On the evolution of the bi-modal distribution of galaxies in the plane of specific star formation rate versus stellar mass. Mon. Not. R. Astron. Soc. **432**, 2488-2495 (2013).

Ciaraldi-Schoolmann, I. Seitenzahl and F. Röpke: A Subgrid-scale Model for Deflagration-to-Detonation Transitions in Type Ia Supernova Explosion Simulations - Numerical implementation. Astron. Astrophys. **559**, id. A117 (2013).

Ciardi, B., P. Labropoulos, A. Maselli et al.: Prospects for detecting the 21 cm forest from the diffuse intergalactic medium with LOFAR. Mon. Not. R. Astron. Soc. **428**, 1755-1765 (2013).

Cooper, A., R. D'Souza, G. Kauffmann et al.: Galactic accretion and the outer structure of galaxies in the CDM model. Mon. Not. R. Astron. Soc. **434**, 3348-3367 (2013).

Cruz, M.A., A. Serenelli and A. Weiss: S-process in extremely metal-poor, low-mass stars Astron. Astrophys. **559**, id. A4 (2013).

D'Souza, R. and H.-W. Rix: Mass estimates from stellar proper motions: the mass of omega Centauri. Mon. Not. R. Astron. Soc. **429**, 1887-190 (2013).

Davis, T., K. Alatalo et al. (incl. Th. Naab): The ATLAS3D Project - XIV. The extent and kinematics of the molecular gas in early-type galaxies. Mon. Not. R. Astron. Soc. **429**, 534-555 (2013).

Davies, B., R.-P. Kudritzki et al. (incl. M. Bergemann): The Temperatures of Red Supergiants. Astrophys. J. **767**, id. 3 (2013).

Dawson, K.S., D. Schlegel et al. (incl. G. Kauffmann): The baryon oscillation spectroscopic survey of SDSS-III. Astron. J. **145**, i1 (2013).

Dayal, P., J. Dunlop, U. Maio and B. Ciardi: Simulating the assembly of galaxies at redshifts z = 6-12. Mon. Not. R. Astron. Soc. **434**, 1486-1504 (2013).

De Boni, C. S. Ettori, K. Dolag and L. Moscardini: Hydrodynamical simulations of galaxy clusters in dark energy cosmologies - II. c-M relation. Mon. Not. R. Astron. Soc. **428**, 2921-2938 (2013).

Delabrouille, J., M. Betoule et al. (incl. K. Dolag): The pre-launch Planck Sky Model: of sky emission at submillimetre to centimetre wavelengths. Astron. Astrophys. **553**, A96 (2013).

Diener, C., S. Lilly et al. (incl. G. Lemson): Proto-groups at $1.8 < z < 3$ in the zCOSMOS-deep Sample. Astrophys. J. **765**, id. 109 (2013).

de Souza, R. S., B. Ciardi, U. Maio and A. Ferrara: Dark matter halo environment for primordial star formation. Mon. Not. R. Astron. Soc. **428**, 2109-2117 (2013).

Deming, D., A. Wilkins et al. (incl. Z. Magic): Infrared Transmission Spectroscopy of the Exoplanets HD209458b and XO-1b Using the Wide Field Camera-3 on the Hubble Space Telescope. Astrophys. J. **774**, id. 95 (2013).

Dijkstra, M. and A. Jeeson-Daniel: Empirical Constraints on the Star Formation and Redshift Dependence of the Lyman Alpha 'Effective' Escape Fraction. Mon. Not. R. Astron. Soc. **435**, 3333-3341 (2013).

Dolag, K., A.D. Dolgov and I.I. Tkachev: Resolving infall caustics in dark matter halos. JETP Lett. **96**, 754-758 (2013).

Dolag, K. and R. Sunyaev: Relative velocity of dark matter and baryons in clusters of galaxies and measurements of their peculiar velocities. Monthly Notices of the Royal Astronomical Society, **432**, 1600-1615 (2013).

Donnert, J., K. Dolag, G. Brunetti and R. Cassano: Rise and fall of radio haloes in simulated merging galaxy clusters. Mon. Not. R. Astron. Soc. **429**, 3564-3569 (2013).

Dorn, S., N. Oppermann and T. Enßlin: DIP – Diagnostics for Insufficiencies of Posterior calculations in Bayesian signal inference. Phys. Rev. E **88**, id. 053303 (2013).

Dorn, S., N. Oppermann, R. Khatri et al.: Fast and precise way to calculate the posterior for the local non-Gaussianity parameter f_{nl} from cosmic microwave background observations. Phys. Rev. D **88** 103 (2013).

Drout, M. R., A.M. Soderberg, P. Mazzali et al.: The fast and furious decay of the peculiar type Ic supernova 2005ek. Astrophys. J. **774**, 1-18 (2013).

Dünner, R., Hasselfield, et al. (incl. C. Hernandez-Monteagudo): The Atacama Cosmology Telescope: data characterization and mapmaking. The Astrophys. J., **762**, 1-19 (2013).

Enßlin, T.: Information field dynamics for simulation scheme construction. Physical Review E. **Vol.87**, No.1 (2013).

Ettori, S., F. Gastaldello et al. (incl. M. Gaspari): Cold fronts and metal anisotropies in the X-ray cool core of the galaxy cluster Zw 1742+3306. Astron. Astrophys. **555**, id.A93 (2013).

Forero-Romero, J., and M. Dijkstra: Effects of star-formation stochasticity on the Ly alpha and Lyman continuum emission from dwarf galaxies during reionization. Mon. Not. R. Astron. Soc. **428**, 2163-2170 (2013).

Fraser, M., C. Inserra et al. (incl. A. Sternberg): SN 2009ip a la PESSTO: no evidence for core collapse yet. Mon. Not. R. Astron. Soc. **433**, 1312-1337 (2013).

Freundlich, J., F. Combes et al. (incl. Th. Naab): Towards a resolved Kennicutt-Schmidt law at high redshift. Astron. Astrophys. **553**, id.A130 (2013).

Fu, J., G. Kauffmann, M.L. Huang et al.: Star formation and metallicity gradients in semi-analytic models of disc galaxy formation. Mon. Not. R. Astron. Soc. **434**, 1531-1548 (2013).

Gabler, M., P. Cerda-Duran, et al. (incl. E. Müller): Magneto-elastic oscillations of neutron stars: exploring different magnetic field configurations. Mon. Not. R. Astron. Soc. **430**, 1811-1831 (2013).

Gabler, M., P. Cerda-Duran, et al (incl. E. Müller): Imprints of superfluidity on magnetoelastic quasiperiodic oscillations of soft gamma-ray repeaters. Phys. Rev. Lett. **111**, 1-5 (2013).

Gal-Yam, A., P. Mazzali, I. Manulis and D. Bishop: Supernova discoveries 2010–2011: statistics and trends. Publ. of the Astron. Soc. of the Pac. **125**, 749-752 (2013).

Gaspari, M. and E. Churazov: Constraining turbulence and conduction in the hot ICM through density perturbations. Astron. Astrophys. **559**, id. A78 (2013).

Gaspari, M., M. Ruszkowski and Oh Peng: Chaotic cold accretion on to black holes. Mon. Not. R. Astron. Soc. **432**, 3401-3422 (2013).

Gatto, A., F. Fraternali, et al. (incl. S. Walch): Unveiling the corona of the Milky Way via ram-pressure stripping of dwarf satellites. Mon. Not. R. Astron. Soc. **433**, 2749-2763 (2013).

Gazak, J.Z., N. Bastian, R.-P. Kudritzki et al.: Age dating stellar populations in the near infrared: an absolute age indicator from the presence/absence of red supergiants. Mon. Not. R. Astron. Soc. Lett. **430**, L35-L39 (2013).

Genzel, R., L. Tacconi et al. (incl. Th. Naab): Phibss: Molecular Gas, Extinction, Star Formation, and Kinematics in the z = 1.5 Star-forming Galaxy EGS13011166. Astrophys. J. **773**, id. 68 (2013).

Giannios, D.: Reconnection-driven plasmoids in blazars: fast flares on a slow envelope. Mon. Not. R. Astron. Soc. **431**, 355-363 (2013).

Gómez, F. A., Helmi, et al. (incl. S. White): Streams in the Aquarius stellar haloes. Mon. Not. R. Astron. Soc. **436**, 3602-3613 (2013).

Goudfrooij, P., and D. Kruijssen: The optical colors of giant elliptical galaxies and their metal-rich globular clusters indicate a bottom-heavy initial mass function. Astrophys. J. **762**, 1-11 (2013).

Graziani, L., A. Maselli and B.Ciardi: CRASH3: cosmological radiative transfer through metals. Mon. Not. R. Astron. Soc. **431**, 722-740 (2013).

Grebenev, S. A., A.V. Prosvetov and R. Sunyaev: Second outburst of the black hole candidate MAXI J1836-194 from SWIFT and INTEGRAL observationshard X-ray sources from Chandra and XMM-Newton data. Astron. Lett. **39**, 367-374 (2013).

Greene, Z. S., S. Suyu, et al. (incl. S. Hilbert): Improving the precision of time-delay cosmography with observations of galaxies along the line of sight. Astrophys. J. **768**, 1-11 (2013).

Greif, T., V. Springel and V. Bromm: On the operation of the chemothermal instability in primordial star-forming clouds. Mon. Not. R. Astron. Soc. **434**, 3408-3422 (2013).

Greig, B., E. Komatsu, and J.S.B. Wyithe: Cosmology from clustering of Lyα galaxies: breaking non-gravitational Lyα radiative transfer degeneracies using the bispectrum. Mon. Not. R. Astron. Soc. **431**, 1777-1794. (2013).

Gunar, S., D. H. Mackay, U. Anzer and P. Heinzel: Non-linear force-free magnetic dip models of quiescent prominence fine structures. Astron. Astrophys. **551**, id. A3 (2013).

Guo, Qi, S. White, R. Angulo et al.: Galaxy formation in WMAP1 and WMAP7 cosmologies. Mon. Not. R. Astron. Soc. **428**, 1351-1365 (2013).

Greene, Z., S. Suyu et al. (incl. S. Hilbert): Improving the Precision of Time-delay Cosmography with Observations of Galaxies along the Line of Sight. Astrophys. J. **768**, id. 39 (2013).

Greig, B., E. Komatsu and S. Wyithe: Cosmology from clustering of Ly alpha galaxies: breaking non-gravitational Ly-alpha radiative transfer degeneracies using the bispectrum. Mon. Not. R. Astron. Soc. **431**, 1777-1794 (2013).

Hachinger, S., P. Mazzali, M. Sullivan et al.: The UV/optical spectra of the Type Ia supernova SN 2010jn: a bright supernova with outer layers rich in iron-group elements. Mon. Not. R. Astron. Soc. **429**, 2228-2248 (2013).

Hanasz, M., Lesch, H., Th. Naab, et al.: Cosmic rays can drive strong outflows from gas-rich high-redshift disk galaxies. Astrophys. J. Lett. **777** 1-6 (2013).

Hanke, F., B. Müller, A. Wongwathanarat: SASI Activity in Three-dimensional Neutrino-hydrodynamics Simulations of Supernova Cores. Astrophys. J. **770**, 66 (2013).

Hansen, C.J., M. Bergemann, C. Cescutti et al.: LTE or non-LTE, that is the question. The NLTE chemical evolution of strontium in extremely metal-poor stars. Astron. Astrophys. **551**, id.A57 (2013).

Hao, W., M.B. Kouwenhoven, and R. Spurzem: The dynamical evolution of multiplanet systems in open clusters. Mon. Not. R. Astron. Soc. **433**, 867-877 (2013).

Happenhofer, N., H. Grimm-Strele, F. Kupka et al.: A low Mach number solver: enhancing applicability. J. of Comp. Phys. **236**, 96-118 (2013).

Hassall, T. E., et al. (incl. B. Ciardi and F. de Gasperin): Differential frequency-dependent delay from the pulsar magnetosphere. Astron. Astrophys. **552**, 1-9 (2013).

Henriques, B., S. White, P. Thomas et al.: Simulations of the galaxy population constrained by observations from z = 3 to the present day: implications for galactic winds and the fate of their ejecta. Mon. Not. R. Astron. Soc. **431**, 3373-3395 (2013).

Hermsen, W. et al. (incl. M. Bell and B. Ciardi): Synchronous X-ray and radio mode switches: a rapid global transformation of the pulsar magnetosphere. Science, **339**, 436-439 (2013).

Hernandez-Monteagudo, C. and R. Smith: On the signature of z 0.6 superclusters and voids in the Integrated Sachs-Wolfe effect. Mon. Not. R. Astron. Soc. **435**, 1094-1107 (2013).

Hilditch, D, et al. (incl. T. Baumgarte, P. Montero and E. Müller): Collapse of nonlinear gravitational waves in moving-puncture coordinates. Phys. Rev. D, **88** 1-12 (2013).

Hillebrandt, W., M. Kromer, F. Röpke and A. Ruiter: Towards an understanding of Type Ia supernovae from a synthesis of theory and observations. Frontiers of Phys. **8**, 116-143 (2013).

Hilz, M., Th. Naab and J. Ostriker: How do minor mergers promote inside-out growth of ellipticals, transforming the size, density profile and dark matter fraction? Mon. Not. R. Astron. Soc. **429**, 2924-2933 (2013).

Hinshaw, G., D. Larson, E. Komatsu, et al.: Nine-year Wilkinson Microwave Anisotropy Probe (WMAP) observations: cosmological parameter results. The Astrophys. J. Suppl. Series **208**, 1-25 (2013).

Hirschmann, M., T. Naab, R. Dave et al.: The effect of metal enrichment and galactic winds on galaxy formation in cosmological zoom simulations. Mon. Not. R. Astron. Soc. **436**, 2929-2949 (2013).

Holman, K., S. Walch, S.P. Goodwin and A.P. Whitworth: Mapping the core mass function on to the stellar initial mass function: multiplicity matters. Mon. Not. R. Astron. Soc. **432**, 3534-3543 (2013).

Hopkins, A. M., S. Driver, et al. (incl. J. Johansson): Galaxy And Mass Assembly (GAMA): spectroscopic analysis. Mon. Not. R. Astron. Soc. **430**, 2047-2066 (2013).

Hsiao, E., G.H. Marion et al. (incl. M. Kromer): The Earliest Near-infrared Time-series Spectroscopy of a Type Ia Supernova. Astrophys. J. **766**, id 72 (2013).

Huang, M.L., G. Kauffmann, Y.M. Chen et al.: Spatially resolved star formation histories of nearby galaxies: evidence for episodic star formation in discs. Mon. Not. R. Astron. Soc. **431**, 2622-2633 (2013).

Hubber, D.A., S. Walch and A.P. Whitworth: An improved sink particle algorithm for SPH simulations. Mon. Not. R. Astron. Soc. **430**, 3261-3275 (2013).

Iacobelli, M., et al. (incl. M. Bell, T. Enßlin): Studying galactic interstellar turbulence through fluctuations in synchrotron emission - First LOFAR galactic foreground detection. Astron. Astrophys. **558**, 1-13 (2013).

Ibanez, J. M., I. Cordero-Carrion, J.M. Marti and Miralles: On the convexity of relativistic hydrodynamics. Classical and Quantum Gravity, **30**, 1-8 (2013).

Inserra, C., S. Smartt et al. (incl. S. Taubenberger): Super-luminous Type Ic Supernovae: Catching a Magnetar by the Tail. Astrophys. J. **770**, id. 128 (2013).

Inserra, C., A. Pastorello, et al. (incl. S. Taubenberger): Moderately luminous Type II supernovae. Astron. Astrophys. **555**, id.A142 (2013).

Ishida, E., and R. de Souza: Kernel PCA for Type Ia supernovae photometric classification. Mon. Not. R. Astron. Soc. **430**, 509-532 (2013).

Janka, Th.: Natal kicks of stellar mass black holes by asymmetric mass ejection in fallback supernovae. Mon. Not. R. Astron. Soc. **434**, 1355-1361 (2013).

Jensen, H., Datta, K. K., et al. (incl. B. Ciardi): Probing reionization with LOFAR using 21-cm redshift space distortions. Mon. Not. R. Astron. Soc. **435**, 460-474 (2013).

Jin, Z.-P., S. Covino, et al. (incl. P. Mazzali): GRB 081007 and GRB 090424: the surrounding medium, outflows, and supernovae. Astrophys. J. **774**, 1-9 (2013).

Joachimi, B., E. Semboloni, S. Hilbert et al.: Intrinsic galaxy shapes and alignments II: Modelling the intrinsic alignment contamination of weak lensing surveys. Mon. Not. R. Astron. Soc. **436**, 819-838 (2013).

Joachimi, B., E. Sembolini et al. (incl. S. Hilbert): Intrinsic galaxy shapes and alignments - I. Measuring and modelling COSMOS intrinsic galaxy ellipticities. Mon. Not. R. Astron. Soc. **431**, 477-492 (2013).

Johansson, J., D. Thomas et al.: SN Ia host galaxy properties from sloan digital sky survey-II spectroscopy. Mon. Not. R. Astron. Soc. **435**, 1680-1700 (2013).

Kanak, S. and Th. Naab: Spinning dark matter haloes promote bar formation. Mon. Not. R. Astron. Soc. **434**, 1287-1299 (2013).

Karl, S.J., T. Lunttila, Th. Naab et al.: Constrained simulations of the Antennae galaxies: comparison with Herschel-PACS observations. Mon. Not. R. Astron. Soc. **434**, 696-709 (2013).

Kauffmann, G., Ch. Li, W. Zhang and S. Weinmann: A re-examination of galactic conformity and a comparison with semi-analytic models of galaxy formation. Mon. Not. R. Astron. Soc. **430**, 1447-1456 (2013).

Khabibullin, I., S. Sazonov and R. Sunyaev: SRG/eROSITA prospects for the detection of stellar tidal disruption flares. Mon. Not. R. Astron. Soc. **437**, 327-337 (2013).

Khatri, R. and R. Sunyaev: Forecasts for CMB and i-type spectral distortion constraints on the primordial power spectrum. J. of Cosmology and Astropart. Phys., id. 026 (2013).

Khedekar, S., E. Churazov, A. Kravtsov et al.: Bias from gas inhomogeneities in the pressure profiles as measured from X-ray and Sunyaev-Zeldovich observations. Mon. Not. R. Astron. Soc. **431**, 954-965 (2013).

Khedekar, S. and S. Majumdar: Cosmology with the largest galaxy cluster surveys: going beyond Fisher matrix forecasts. J. Cosmology and Astroparticle Phys. id. **030** (2013).

Kim, J., A. Rotti and E. Komatsu: Removing the ISW-lensing bias from the local-form primordial non-Gaussianity estimation. J. of Cosmology and Astropart. Phys. **4**, 1-19 (2013).

Kim, J. and E. Komatsu: Limits on anisotropic inflation from the Planck data. Physical Review D, **88**, 101301(R) (2013).

Knebe, A., N. Liebeskind et al. (incl. K. Dolag): Galaxies going MAD: the Galaxy-Finder Comparison Project. Mon. Not. R. Astron. Soc. **428**, 2039-2052 (2013).

Knebe, A., F. Pearce et al. (incl. K. Dolag): Structure finding in cosmological simulations: the state of affairs. Mon. Not. R. Astron. Soc. **435**, 1618-1658 (2013).

Koliopanos, F., M. Gilfanov and L. Bildsten: X-ray diagnostics of chemical composition of the accretion disk and donor star in ultra-compact X-ray binaries. Mon. Not. R. Astron. Soc. **432**, 1264-1273 (2013).

Kolodzig, A., M. Gilfanov, R. Sunyaev et al.: AGN and QSOs in the eROSITA all-sky survey - I. Statistical properties. Astron. Astrophys. **558**, id A84 (2013).

Kolodzig, A., M. Gilfanov, G. Hütsi and R. Sunyaev: AGN and QSOs in the eROSITA All-Sky Survey – Part II: Studies of large-scale structure. Astron. Astrophys. **558**, id. A90 (2013).

Krajnovic, D., K. Alatalo et al. (incl. Th. Naab): The ATLAS3D project - XVII. Linking photometric and kinematic signatures of stellar discs in early-type galaxies. Mon. Not. R. Astron. Soc. **432**, 1768-1795 (2013).

Krajnovic, D., A. Karick et al. (incl. Th. Naab): The ATLAS3D Project - XXIII. Angular momentum and nuclear surface brightness profiles. Mon. Not. R. Astron. Soc. **433**, 2812-2839 (2013).

Kromer, M. et al. (incl. S. Taubenberger and W. Hillebrandt): 3D deflagration simulations leaving bound remnants: a model for 2002cx-like type Ia supernovae Mon. Not. R. Astron. Soc. **429**, 2287-2297 (2013).

Kromer, M., R. Pakmor, S. Taubenberger et al. : SN 2010lp-a Type Ia Supernova from a Violent Merger of Two Carbon-Oxygen White Dwarfs. Astrophys. J. Lett. **778**, id. L18 (2013).

Kruijssen, J. M. D. and S. Longmore: Comparing molecular gas across cosmic time-scales: the Milky Way as both a typical spiral galaxy and a high-redshift galaxy analogue. Mon. Not. R. Astron. Soc. **435**, 2598-2603 (2013).

Kruijssen, J. M. D. and N. Lützgendorf: Did massive black holes in globular clusters initially satisfy galactic scaling relations? Mon. Not. R. Astron. Soc. Lett. **434**, L41-L45 (2013).

Kudritzki, R.-P., M.A. Urbaneja, Z. Gazak et al.: A direct stellar metallicity determination in the disk of the maser galaxy NGC 4258. Astrophys. J. Lett. **779**, 1-6 (2013).

Lam, T.Y., F. Schmidt, T., Nishimichi and M. Takada: Modeling the phase-space distribution around massive halos. Phys. Rev. D. **88**, id. 023012 (2013).

Laporte, Ch., M. Walker and J. Penarrubia: Measuring the slopes of mass profiles for dwarf spheroidals in triaxial cold dark matter potentials. Mon. Not. R. Astron. Soc. Lett. **433**, L54-L58 (2013).

Laporte, Ch., S. White, Th. Naab and L. Gao: The Growth in Size and Mass of Cluster Galaxies since z=2. Mon. Not. R. Astron. Soc. **435**, 901-909 (2013).

Lee J. and G. Lemson: On the spin bias of satellite galaxies in the local group-like environment. JCAP **05**, id. 022 (2013).

Lemasle, B., P. Francois et al. (incl. M. Bergemann): Galactic abundance gradients from Cepheids. Alpha and heavy elements in the outer disk. Astron. and Astrophys. **558**, id. A31 (2013).

Lemonias, J. J., D. Schiminovich, B. Catinella et al: The GALEX Arecibo SDSS Survey - VII. The bivariate neutral hydrogen-stellar mass function for massive galaxies. Astrophys. J. **776**, 1-25 (2013).

Li, Shao, G. Kauffmann, Li Cheng et al. The nature of obscuration in AGN - I. Insights from host galaxies. Mon. Not. R. Astron. Soc. **436**, 3451-3463 (2013).

Li, J., J. Ostriker and R. Sunyaev: Rotating Accretion Flows: From Infinity to the Black Hole. Astrophys. J. **767**, id. 105 (2013).

Lind, K., J. Melendez, M. Asplund et al.: The lithium isotopic ratio in very metal-poor stars. Astron. Astrophys. **554**, id.A96 (2013).

Liu, Z.-W., R. Pakmor et al. (incl. W. Hillebrandt): Rotation of surviving companion stars after type Ia supernova explosions in the WD+MS scenario. Astron. Astrophys. **554**, 1-12 (2013).

Liu, Z.W., R. Pakmor, I. Seitenzahl et al.: The impact of Type Ia supernova explosions on helium companions in the Chandrasekhar-mass explosion scenario. Astrophys. J. **774**, id. 37 (2013).

Liu, Z.-W., M. Kromer, M. Fink et al.: Predicting the amount of hydrogen stripped by the SN explosion for SN 2002cx-like SNe Ia. Astrophys. J. **778**, 1-7 (2013).

Longmore, S. N., Bally et al. (incl. D. Kruijssen): Variations in the galactic star formation rate and density thresholds for star formation. Mon. Not. R. Astron. Soc. **429**, 987-1000 (2013).

Longmore, S. N., D. Kruijssen, J. Bally: Candidate super star cluster progenitor gas clouds possibly triggered by close passage to Sgr A*. Mon. Not. R. Astron. Soc. Lett. **433**, L15-L19 (2013).

Lützendorf, N., H. Baumgardt and D. Kruijssen: N-body simulations of globular clusters in tidal fields: effects of intermediate-mass black holes. Astron. Astrophys. **558**, 1-10 (2013).

Ludlow, A.D., et al. (incl. Li Ming and S. White): The mass profile and accretion history of cold dark matter haloes. Mon. Not. R. Astron. Soc. **432**, 1103-1113 (2013).

Lyskova, N.: A simple recipe for estimating masses of elliptical galaxies and clusters of galaxies. Astron. Nachrichten, **334**, 360-363 (2013).

Mädler, T. and W. Müller: The Bondi–Sachs metric at the vertex of a null cone: axially symmetric vacuum solutions. Classical and Quantum Gravity, **30**, 1-29 (2013).

Magic, Z., R. Collet, M. Asplund et al.: The Stagger-grid: A Grid of 3D Stellar Atmosphere Models - I. Methods and General Properties. Astron. Astrophys. **557**, id. A26 (2013).

Magic, Z., R. Collet and M. Asplund: The Stagger-grid: A Grid of 3D Stellar Atmosphere Models - II. Horizontal and Temporal Averaging and Spectral Line Formation. Astron. Astrophys. **560**, id. A8 (2013).

Maguire, K., et al. (incl. P. Mazzali and A. Sternberg): A statistical analysis of circumstellar material in Type Ia supernovae. Mon. Not. R. Astron. Soc. **436**, 222-240 (2013).

Maio, U., B. Ciardi and V. Müller: Simulating extremely metal-poor gas and DLA metal content at redshift z=7. Mon. Not. R. Astron. Soc **435**, 1443-1450 (2013).

Maio, U., M. Dotti, M. Petkova, et al.: Effects of circumnuclear disk gas evolution on the spin of central black holes. Astrophys. J. **767**, 1-14 (2013).

Mana, A., T. Giannantonio et al. (incl. G. Hütsi): Combining clustering and abundances of galaxy clusters to test cosmology and primordial non-Gaussianity. Mon. Not. R. Astron. Soc. **434**, 684-695 (2013).

Maraston, C., J. Pforr, B. Henriques et al.: Stellar masses of SDSS-III/BOSS galaxies at $z \sim 0.5$ and constraints to galaxy formation models. Mon. Not. R. Astron. Soc. **434**, 2764-2792 (2013).

Marian, L., R. Smith, S. Hilbert and P. Schneider: The cosmological information of shear peaks: beyond the abundance. Mon. Not. R. Astron. Soc. **432**, 1338-1350 (2013).

Marino, A., A. Milone et al. (incl. M. Bergemann): Helium enhanced stars and multiple populations along the horizontal branch of NGC 2808: direct spectroscopic measurements. Mon. Not. R. Astron. Soc. **437**, 1609-1627 (2013).

Marino, A. F., A. Milone and K. Lind: Horizontal branch morphology and multiple stellar populations in the anomalous globular cluster M22. Astrophys. J. **768**, 1-8 (2013).

Martig, M., A. Crocker, et al. (incl. Th. Naab): The ATLAS3D project - XXII. Low-efficiency star formation in early-type galaxies: hydrodynamic models and observations. Mon. Not. R. Astron. Soc. **432**, 1914-1927 (2013).

Mazzali, P. A., S. Walker, E. Pian et al.: The very energetic, broad-lined type Ic supernova 2010ah (PTF10bzf) in the context of GRB/SNe. Mon. Not. R. Astron. Soc. **432**, 2463-2473. (2013).

Mellema, G., L.V. Koopmans et al. (incl. B. Ciardi): Reionization and the cosmic dawn with the square kilometre array. Exp. Astron. **36**, 235-318 (2013).

Milisavljevic, D., R. Margutti et al. (incl. P. Mazzali): Multi-wavelength observations of supernova 2011ei: time-dependent classification of type IIb and Ib supernovae and implications for their progenitors. Astrophys. J. **767**, 1-19 (2013).

Miller Bertolami, M. M., L.G. Althaus, and E. Garcia-Berro: Quiescent nuclear burning in low-metallicity white dwarfs. Astrophys. J. Lett. **775**, 1-4 (2013).

Milone, A. P., A. Marino, G. Piotto et al.: A WFC3/HST view of the three stellar populations in the globular cluster NGC 6752. Astrophys. J. **767**, 1-20 (2013).

Mineo, S., S. Rappaport et al. (incl. M. Gilfanov): Spatially Resolved Star Formation Image and the Ultraluminous X-Ray Source Population in NGC 2207/IC 216. Astrophys. J. **771**, id. 133 (2013).

Monelli, M., et al. (incl. A. Marino and A. Weiss): The SUMO project I. A survey of multiple populations in globular clusters. Mon. Not. R. Astron. Soc. **431**, 2126-2149 (2013).

Monroe T.R., J. Melendez et al. (incl. M. Bergemann): High Precision Abundances of the Old Solar Twin HIP 102152: Insights on Li Depletion from the Oldest Sun.. Astrophys. J. Lett. **774**, id. L32 (2013).

Moreno, J., A. Bluck, et al. (incl. B. Moster): The dynamics of galaxy pairs in a cosmological setting. Mon. Not. R. Astron. Soc. **431**, 1765-1786 (2013).

Moster, B., Th. Naab and S. White: Galactic star formation and accretion histories from matching galaxies to dark matter haloes. Mon. Not. R. Astron. Soc. **428**, 3121-3138 (2013).

Mrugala, F., W.P. Kraemer: Radiative charge transfer in He^+ + H2 collisions at energies in the milli- to nano-electron-volt range. J. Chem. Phys. **138**, 104315 (2013).

Müller, B., H.-Th. Janka and A. Marek: A New Multi-dimensional General Relativistic Neutrino Hydrodynamics Code of Core-collapse Supernovae. III. Gravitational Wave Signals from Supernova Explosion Models. Astrophys. J. **766**, id. 43 (2013).

Munshi, F., F. Governato et al. (incl. B. Moster) : Reproducing the Stellar Mass/Halo Mass Relation in Simulated Lambda-CDM Galaxies: Theory versus Observational Estimates. Astrophys. J. **766**, id. 56 (2013).

Newman, S., R. Genzel et al. (incl. Th. Naab): The SINS/zC-SINF Survey of z$\sim$2Galaxy Kinematics: The Nature of Dispersion-dominated Galaxies. Astrophys. J. **767**, id. 104 (2013).

Newman, S., P. Buschkamp et al. (incl. Th. Naab): Nebular Excitation in $z \sim 2$ Star-forming Galaxies from the SINS and LUCI Surveys: The Influence of Shocks and AGN. Astrophys. J. **781**, 21 (2013).

Nicholl, M., S. J. Smartt, et al.(incl. S. Taubenberger): Slowly fading super-luminous supernovae that are not pair-instability explosions. Nature, **502**, 346-349 (2013).

Nieva, M.-F.: Temperature, gravity, and bolometric correction scales for non-supergiant OB stars . Astron. Astrophys. **550**, 1-14 (2013).

Norris, J. E., M.S. Bessell, et al.(incl. M. Asplund): The most metal-poor stars - I. Discovery, data, and atmospheric parameters. Astrophys. J. **762**, 1-16 (2013).

Nulsen, P., et al. (incl. I. Zhuravleva and E. Churazov): Deep Chandra Observations of Abell 2199: the Interplay between Merger-Induced Gas Motions and Nuclear Outbursts in a Cool Core Cluster. Astrophys. J. **775**, id. 117 (2013).

Nuza, S. E., A.G. Sanchez et al. (incl. R. Angulo): The clustering of galaxies at $z \approx 0.5$ in the SDSS-III data release 9 BOSS-CMASS sample: a test for the ΛCDM cosmology. Mon. Not. R. Astron. Soc. **432**, 743-760 (2013).

Offringa, A.R., A.G. de Bruyn et al. (incl. B. Ciardi): The LOFAR radio environment. Astron. Astrophys. **549**, id. A11 (2013).

Offringa, A.R., (incl. M. Bell and B. Ciardi): The brightness and spatial distributions of terrestrial radio sources. Mon. Not. R. Astron. Soc. **435**, 584-596 (2013).

Oppermann, N., M. Selig, M. Bell, and T. Enßlin: Reconstruction of Gaussian and log-normal fields with spectral smoothness. Phys.Rev. E. **87** 1-16 (2013).

Overzier, R.A., N.P. Nesvadba, M. Dijkstra et al.: Resolving the Optical Emission Lines of Ly alpha Blob B1 at z=2.38: Another Hidden Quasa. Astrophys. J. **771**, id. 89 (2013).

Overzier, R., G. Lemson, et al. (incl. S. White): The Millennium Run Observatory: first light. Mon. Not. R. Astron. Soc. **428**, 778-803 (2013).

Pakmor, R., M. Kromer, S. Taubenberger and V. Springel: Helium-ignited Violent Mergers as a Unified Model for Normal and Rapidly Declining Type Ia Supernovae. Astrophys. J. Lett. **770**, id. L8 (2013).

Pandey, B.: A method for testing the cosmic homogeneity with Shannon entropy. Mon. Not. R. Astron. Soc. **430**, 3376-3382 (2013).

Pandey, B., S. White, V. Springel and R. Angulo: Exploring the non-linear density field in the Millennium simulations with tessellations - I. The probability distribution function. Mon. Not. R. Astron. Soc. **435**, 2968-2981 (2013).

Parikh, A., J. Jose, I. Seitenzahl, and F. Röpke: The effects of variations in nuclear interactions on nucleosynthesis in thermonuclear supernovae. Astron. Astrophys. **557**, A3, 1-11 (2013).

Park, H., P. Shapiro, E. Komatsu et al.: The Kinetic Sunyaev-Zel'dovich Effect as a Probe of the Physics of Cosmic Reionization: The Effect of Self-regulated Reionization. Astrophys. J. **769**, id. 93 (2013).

Pastorello, A. et al. (incl. S. Benitez and S. Taubenberger): Interacting Supernovae and Supernova Impostors: SN 2009ip, is this the End? Astrophys. J. **767**, id. 1, 19 (2013).

Pawlik, A., M. Milosavljevic and. V. Bromm: The First Galaxies: Assembly under Radiative Feedback from the First Stars. Astrophys. J. **767**, id. 59 (2013).

Pereira, T.M., M. Asplund, et al. (incl. I. Thaler): How realistic are solar model atmospheres? Astron. Astrophys. **554**, id. A118 (2013).

Pereira, R., et al. (incl. M. Kromer and S. Taubenberger): Spectrophotometric time series of SN 2011fe from the Nearby Supernova Factory. Astron. Astrophys. **554**, id. A27 (2013).

Perez-Montero, E., Contini et al. (incl. K. Kovac): The cosmic evolution of oxygen and nitrogen abundances in star-forming galaxies over the past 10 Gyr. Astron. Astrophys. **549**, A52 (2013).

Planck Collaboration (incl. MPA group): Planck intermediate results. II. Comparison of Sunyaev-Zeldovich measurements from Planck and from the Arcminute Microkelvin Imager for 11 galaxy clusters. Astron. Astrophys. **550**, id.A128 (2013).

Planck Collaboration (incl. MPA group): Planck intermediate results. III. The relation between galaxy cluster mass and Sunyaev-Zeldovich signal Astron. Astrophys. **550**, id.A129 (2013).

Planck Collaboration (incl. MPA group): Planck intermediate results. IV. The XMM-Newton validation programme for new Planck galaxy clusters. Astron. Astrophys. **550**, id.A130 (2013).

Planck Collaboration (incl. MPA group): Planck intermediate results. V. Pressure profiles of galaxy clusters from the Sunyaev-Zeldovich effect. Astron. Astrophys. **550**, id.A131 (2013).

Planck Collaboration (incl. MPA group): Planck intermediate results (Corrigendum). V. Pressure profiles of galaxy clusters from the Sunyaev-Zeldovich effect. Astron. Astrophys. **558**, id.C2 (2013).

Planck Collaboration (incl. MPA group): Planck intermediate results. VI. The dynamical structure of PLCKG214.6+37.0, a Planck discovered triple system of galaxy clusters. Astron. Astrophys. **550**, id.A132 (2013).

Planck Collaboration (incl. MPA group): Planck intermediate results. VII. Statistical properties of infrared and radio extragalactic source from the Planck Early Release compacts source catalogue at frequencies between 100 adn 857 GHz. Astron. Astrophys. **550**, A133 (2013).

Planck Collaboration (incl. MPA group): Planck intermediate results. VIII. Filaments between interacting clusters. Astron. Astrophys. **550**, id.A134 (2013).

Planck Collaboration (incl. MPA group): Planck intermediate results. X. Physics of the hot gas in the Coma cluster. Astron. Astrophys. **554**, id.A140 (2013).

Planck Collaboration (incl. MPA group): Planck intermediate results. IX. Detection of the Galactic haze with Planck. Astron. Astrophys. **554**, A139 (2013).

Planck Collaboration (incl. MPA group): Planck intermediate results. XI. The gas content of dark matter halos. Astron. Astrophys. **557**, A52 (2013).

Planelles, S., S. Borgani, K. Dolag et al.: Baryon census in hydrodynamical simulations of galaxy clusters. Mon. Not. R. Astron. Soc. **431**, 1487-1502 (2013).

Radice, D., E. Abdikamalov, et al. (incl. C. Ott): A New Spherical Harmonics Scheme for Multi-Dimensional Radiation Transport I: Static Matter Configurations. Journal of Comp. Phys. **242**, 648-669 (2013).

Rahmati, A., J. Schaye, A. Pawlik and M. Raicevic: The impact of local stellar radiation on the H I column density distribution. Mon. Not. R. Astron. Soc. **431**, 2261-2277 (2013).

Rahmati, A., A. Pawlik, M. Raicevic and J. Schaye: On the evolution of the H I column density distribution in cosmological simulations. Mon. Not. R. Astron. Soc. **430**, 2427-2445 (2013).

Ramalho, T., M. Selig, U. Gerland and T. Enßlin: Simulation of stochastic network dynamics via entropic matching. Phys. Rev. E. **87**, pp. 1-9 (2013).

Rau, S., S. Vegetti and S. White: The effect of particle noise in N-body simulations of gravitational lensing. Mon. Not. R. Astron. Soc. **430**, 2232-2248 (2013).

Reinecke, M. and D.S. Seljebotn: Libsharp – spherical harmonic transforms revisited. Astron. Astrophys. **554**, A112 (2013).

Remus, R.S., et al. (incl. Th. Naab and L. Oser): The Dark Halo-Spheroid Conspiracy and the Origin of Elliptical Galaxies. Astrophys. J. **766**, id. 71 (2013).

Riebe, K., A. M. Partl, et al. (incl. G. Lemson): The MultiDark Database: release of the Bolshoi and MultiDark cosmological simulations. Astronomische Nachrichten, **334**, 691-708 (2013).

Roediger, E., R. Kraft et al. (incl. E. Churazov): Kelvin-Helmholtz Instabilities at the Sloshing Cold Fronts in the Virgo Cluster as a Measure for the Effective Intracluster Medium Viscosity. Astrophys. J. **764**, id. 60 (2013).

Roediger, E., R. Kraft et al. (incl. E. Churazov): Viscous Kelvin–Helmholtz instabilities in highly ionized plasmas. Mon. Not. R. Astron. Soc. **436**, 1721-1740 (2013).

Roncarelli, M., S. Ettori et al. (incl. K. Dolag): Large-scale inhomogeneities of the intracluster medium: improving mass estimates using the observed azimuthal scatter. Mon. Not. R. Astron. Soc. **432**, 3030-3046 (2013).

Ruchti, G., M. Bergemann, A. Serenelli et al.: Unveiling systematic biases in the 1D LTE excitation-ionization balance of Fe for FGK stars: a novel approach to determination of stellar parameters. Mon. Not. R. Astron. Soc. **429**, 126-134 (2013).

Ruiter, A., S. Sim, R. Pakmor et al.: On the brightness distribution of Type Ia supernovae from violent white dwarf mergers. Mon. Not. R. Astron. Soc. **429**, 1425-1436 (2013).

Saha, K., and T. Naab: Spinning dark matter haloes promote bar formation. Mon. Not. R. Astron. Soc. **434**, 1287-1299 (2013).

Sales, L., W. Wang, S. White and J. Navarro: Satellites and haloes of dwarf galaxies. Mon. Not. R. Astron. Soc. **428**, 573-578 (2013).

Salvaterra, R., U. Maio, B. Ciardi, et al.: Simulating high-z gamma-ray burst host galaxies. Mon. Not. R. Astron. Soc. **429**, 2718-2726 (2013).

Sanders, J. S., A.C. Fabian, E. Churazov et al.: Linear structures in the core of the Coma cluster of galaxies. Science, **341**, 1365-1368 (2013).

Saro, A., J. Mohr, G. Bazin and K. Dolag: Toward Unbiased Galaxy Cluster Masses from Line-of-sight Velocity Dispersions. Astrophys. J. **772**, id. 47 (2013).

Sarzi, M., K. Alatalo, et al. (incl. Th. Naab): The ATLAS3D project - XIX. The hot gas content of early-type galaxies: fast versus slow rotators. Mon. Not. R. Astron. Soc. **432**, 1845-1861 (2013).

Schellart, P., Nelles, A. et al. (incl. B. Ciardi): Detecting cosmic rays with the LOFAR radio telescope Astron. Astrophys. **560**, A98 1-14 (2013).

Schneider, A., R. Smith, and D. Reed: Halo mass function and the free streaming scale. Mon. Not. R. Astron. Soc. **432**, 1573-1587 (2013).

Scott, N., M. Cappellari et al. (incl. Th. Naab): The ATLAS3D project - XXI. Correlations between gradients of local escape velocity and stellar populations in early-type galaxies. Mon. Not. R. Astron. Soc. **432**, 1894-1913 (2013).

Scoville, N., S. Arnouts and Guo Qi: Evolution of galaxies and their environments at z = 0.1-3 in COSMOS. Astrophys. J. Suppl. **206**, 1-26 (2013).

Seitenzahl, I. R., Cescutti, et al. (incl. A. Ruiter): Solar abundance of manganese: a case for near Chandrasekhar-mass type Ia supernova progenitors. Astron. Astrophys. **559**, L5, 1-4 (2013).

Seitenzahl, I., F. Ciaraldi-Schoolmann, F. Röpke et al.: Three-dimensional delayed-detonation models with nucleosynthesis for Type Ia supernovae. Mon. Not. R. Astron. Soc. **429**, 1156-1172 (2013).

Selig, M., M. Bell, H. Junklewitz et al.: NIFTY - Numerical Information Field Theory. A versatile PYTHON library for signal inference. Astron. Astrophys. **554**, id. A26 (2013).

Serenelli, A., M. Bergemann, G. Ruchti and L. Casagrande: Bayesian analysis of ages, masses and distances to cool stars with non-LTE spectroscopic parameters. Mon. Not. R. Astron. Soc. **429**, 3645-3657 (2013).

Serra, P., B. Koribalski et al. (incl. Th. Naab): Discovery of a giant HI tail in the galaxy group HCG 44. Mon. Not. R. Astron. Soc. **428**, 370-380 (2013).

Shankar, F., D. Weinberg, and Miralda-Escude J.: Accretion-driven evolution of black holes: Eddington ratios, duty cycles and active galaxy fractions. Mon. Not. R. Astron. Soc. **428**, 421-446 (2013).

Shankar, F., F. Marulli, M. Bernardi, et al.: Size evolution of spheroids in a hierarchical universe. Mon. Not. R. Astron. Soc. **428**, 109-128 (2013).

Shao, L., G. Kauffmann, Ch. Li et al.: The Nature of Obscuration in AGN: I. Insights from Host Galaxies. Mon. Not. R. Astron. Soc. **436**, 3451-3463 (2013).

Shiraishi, M., E. Komatsu, M. Peloso, and N. Barnaby: Signatures of anisotropic sources in the squeezed-limit bispectrum of the cosmic microwave background. J. of Cosmology and Astroph. Phys. **5**, 1-32 (2013).

Shivvers, I., P. Mazzali, J.M. Silverman et al.: Nebular spectroscopy of the nearby type IIb supernova 2011dh. Mon. Not. R. Astron. Soc. **436**, 3614-3625 (2013).

Siess, L., R. Izzard, P. Davis, and R. Deschamps: BINSTAR: a new binary stellar evolution code - tidal interactions. Astron. Astrophys. **550**, A100, 1-13 (2013).

Sievers, J. L., R. A. Hlozek et al. (incl. C. Hernandez-Monteagudo): The Atacama Cosmology Telescope: cosmological parameters from three seasons of data. J. of Cosmology and Astrop. Phys., **10** 1-48 (2013).

Silva Aguirre, V., S. Basu et al. (incl. A. Weiss): Stellar ages and convective cores in field main-sequence stars: first asteroseismic application to two Kepler targets. Astrophys. J., **769**, 1-17 (2013).

Silva Aguirre, V., L. Casagrande, S. Basu et al.: Determining distances using asteroseismic methods. Astron. Nachrichten **334**, 22-25 (2013).

Silverman, J. M., P.E. Nugent et al. (incl. A. Sternberg): Type Ia supernovae strongly interacting with their circumstellar medium. Astrophys. J. Suppl. **207**, 1-15 (2013).

Sim, S.A., et al. (incl. W. Hillebrandt and S. Taubenberger): Synthetic light curves and spectra for three-dimensional delayed-detonation models of Type Ia supernovae. Mon. Not. R. Astron. Soc. **436**, 333-347 (2013).

Soffitta P., et al. (incl. R. Sunyaev and E. Churazov): XIPE: the X-ray imaging polarimetry explorer. Exp. Astron. **36**, 523-567 (2013).

Sotomayor-Beltran, C. et al. (incl. M. Bell and B. Ciardi): Calibrating high-precision Faraday rotation measurements for LOFAR and the next generation of low-frequency radio telescopes. Astron. Astrophys. **552**, id. A58, 1-13 (2013).

Sousa, S., N. Santos et al. (incl. M. Bergemann): A new procedure for defining a homogenous line-list for solar-type stars. Astron. Astrophys. **561**, id. A21 (2013).

Spruit, H.: Semiconvection: theory Astron. Astrophys. **552**, id.A76 (2013).

Srisawat, Ch., A. Knebe et al. (incl. K. Dolag): Sussing Merger Trees: The Merger Trees Comparison Project. Mon. Not. R. Astron. Soc. **436**, 150-162 (2013).

Stacy, A., T. Greif, R. Klessen, et al.: Rotation and internal structure of Population III protostars Mon. Not. R. Astron. Soc. **431**, 1470-1486 (2013).

Starkenburg, E., A. Helmi et al. (incl. S. White): The satellites of the Milky Way – insights from semi-analytic modelling in a ΛCDM cosmology. Mon. Not. R. Astron. Soc. **429**, 725-743 (2013).

Stasyszyn, F. A., K. Dolag, and A.M. Beck: divergence-cleaning scheme for cosmological SPMHD simulations. Mon. Not. R. Astron. Soc. **428**, 13-17 (2013).

Kazuyuki S. and E. Komatsu: Bispectrum from open inflation. Journal of Cosmology and Astrop. Phys. **11**, 065 (2013).

Sugiyama, N. S., E. Komatsu, and T. Futamase: δ N formalism. Phys. Review D., **87** 1-10 (2013).

Summa, A., A. Ulyanov, M. Kromer et al.: Gamma-ray diagnostics of Type Ia supernovae. Predictions of observables from three-dimensional modeling. Astron. Astrophys. **554**, id. A67 (2013).

Sunyaev, R. and R. Khatri: Motion induced second order temperature and y-type anisotropies after the subtraction of linear dipole in the CMB maps. J. of Cosmology and Astrop. Phys. **3** 1-8 (2013).

Sunyaev, R. and R. Khatri: Unavoidable CMB Spectral Features and Blackbody Photosphere of Our Universe. Int. J. of Modern Phys.D. **22**, id. 1330014 (2013).

Suyu, S.H., M. Auger, S. Hilbert et al.: Two Accurate Time-delay Distances from Strong Lensing: Implications for Cosmology. Mon. Not. R. Astron. Soc. **766**, id. 70 (2013).

Tacconi, L, R. Neri et al. (incl. Th. Naab): PHIBSS: molecular gas content and scaling relations in z $\sim$ 1-3 normal star forming galaxies. Astrophys. J. **768**, id. 74 (2013).

Tamborra, I., F. Hanke, et al. (incl. Th. Janka): Neutrino signature of supernova hydrodynamical instabilities in three dimensions. Phys. Rev. Lett. **111**, 1-5 (2013).

Tanaka, T. L.: Recurring flares from supermassive black hole binaries: implications for tidal disruption candidates and OJ 287. Mon. Not. R. Astron. Soc. **434**, 2275-2288 (2013).

Tanaka, T. L., M. Li and Z. Haiman: The effect of baryonic streaming motions on the formation of the first supermassive black holes. Mon. Not. R. Astron. Soc. **435**, 3559-3567 (2013).

Tanaka, T. L., and Z. Haiman: Electromagnetic signatures of supermassive black hole binaries resolved by PTAs. Classical and Quantum Gravity, **30** 1-16 (2013).

Taubenberger, S., M. Kromer, S. Hachinger et al.: Super-Chandrasekhar Type Ia Supernovae at nebular epochs. Mon. Not. R. Astron. Soc. **432**, 3117-313 (2013).

Taubenberger, S., M. Kromer, et al. (incl. W. Hillebrandt): 6364 in the Nebular Spectrum of a Subluminous Type Ia Supernova. Astrophys. J. Lett. **775**, id. L43 (2013).

Thomas, D., O. Steele et al. (incl. J. Johansson): Stellar velocity dispersions and emission line properties of SDSS-III/BOSS galaxies. Mon. Not. R. Astron. Soc. **431**, 1383-1397 (2013).

Tomasella, L., E. Cappellaro et al. (incl. S. Taubenberger): Comparison of progenitor mass estimates for the Type IIP SN 2012A. Mon. Not. R. Astron. Soc. **434**, 1636-1657 (2013).

Tombesi, F., Cappi, et al. (incl. M. Gaspari): Unification of X-ray winds in Seyfert galaxies: from ultra-fast outflows to warm absorbers. Mon. Not. R. Astron. Soc. **430**, 1102-1117 (2013).

Utrobin, V. P., and N.N. Chugai: Type IIP supernova 2008in: the explosion of a normal red supergiant. Astron. Astrophys. **555**, 1-6 (2013).

van Haarlem, M.P. et al. (incl. M. Bell and B. Ciardi): LOFAR: The LOw-Frequency ARray. Astron. Astrophys. **556**, id. A2, 1-53 (2013).

Viallet M., I. Baraffe and R. Walder: Comparison of different nonlinear solvers for 2D time-implicit stellar hydrodynamics. Astron. Astrophys. **555**, id. A81 (2013).

Viallet, M., C. Meakin, D. Arnet and M. Mocak: Turbulent Convection in Stellar Interiors. III. Mean-field Analysis and Stratification Effects. Astrophys. J. **769**, id. 1 (2013).

Viaux, N., M. Catelan et al. (incl. A. Weiss): Particle-physics constraints from the globular cluster M5: neutrino dipole moments. Astron. Astrophys. **558**, id. A12 (2013).

Viaux, N., M. Catelan et al. (incl. A. Weiss): Neutrino and axion bounds from the globular cluster M5 (NGC 5904). Phys. Rev. Lett. **111**, 1-5 (2013).

Walch, S., A.P. Whitworth, T.G. Bisbas et al.: Clumps and triggered star formation in ionised molecular clouds. Mon. Not. R. Astron. Soc. **435**, 917-927 (2013).

Wanajo, Sh., H.-Th. Janka and B. Müller: Electron-capture Supernovae as Origin of 48Ca. Astrophys. J. Lett. **767**, id. L26 (2013).

Wanajo, Sh., H.-Th. Janka and B. Müller: Electron-capture supernovae as sources of 60Fe. Astrophys. J. Lett. **774**, id. L6 (2013).

Wang, J., G. Kauffmann, J. Gyula et al.: The Bluedisks project, a study of unusually H I-rich galaxies - I. H I sizes and morphology. Mon. Not. R. Astron. Soc. **433**, 270-294 (2013).

Wang, J., C. Frenk and A. Cooper: The spatial distribution of galactic satellites in the Λ cold dark matter cosmology. Mon. Not. R. Astron. Soc. **429**, 1502-1513 (2013).

Wang, L., G. De Lucia and S. Weinmann: On the scatter in the relation between stellar mass and halo mass: random or halo formation time dependent? Mon. Not. R. Astron. Soc. **431**, 600-608 (2013).

Wiersma, R., B. Ciardi, R. Thomas et al.: LOFAR insights into the epoch of reionization from the cross-power spectrum of 21 cm emission and galaxies. Mon. Not. R. Astron. Soc. **432**, 2615-2624 (2013).

Wongwathanarat, A., T.-H. Janka and E. Müller: Three-dimensional neutrino-driven supernovae: neutron star kicks, spins, and asymmetric ejection of nucleosynthesis products. Astron. Astrophys. **552**, id. A126 (2013).

Woods, T.E. and M. Gilfanov: He II recombination lines as a test of the nature of SN Ia progenitors in elliptical galaxies. Mon. Not. R. Astron. Soc. **432**, 1640-1650 (2013).

Wu, H.Y., O. Hahn, et al. (incl. K. Dolag): Virial scaling of galaxies in clusters: bright to faint is cool to hot. Mon. Not. R. Astron. Soc. **436**, 460-469 (2013).

Yan, H., Z. Fan and S. White: The dependence of galaxy properties on the large-scale tidal environment. Mon. Not. R. Astron. Soc. **430**, 3432-3444 (2013).

Yatawatta, S., et al. (incl. B. Ciardi and M. Bell): Initial deep LOFAR observations of epoch of reionization windows - I. The north celestial pole. Astron. Astrophys. **550**, id. A136, 1-17 (2013).

Yates, R., B. Henriques, P. Thomas et al.: Modelling Element Abundances in Semi-analytic Models of Galaxy Formation. Mon. Not. R. Astron. Soc. **435**, 3500-3520 (2013).

Yong, D., J. Norris et al. (incl. M. Asplund): The most metal-poor stars - II. Chemical abundances of 190 metal-poor stars including 10 new stars. Astrophys. J. **762**, 1-49 (2013).

Zahid, H., R. Yates, L. Kewley and R.P. Kudritzki: The Observed Relation between Stellar Mass, Dust Extinction, and Star Formation Rate in Local Galaxies. Astrophys. J. **763**, id. 92 (2013).

Zahid, H., P. Torrey, R.-P. Kudritzki et al.: The Slow Flow Model of Dust Efflux in Local Star-Forming Galaxies. Mon. Not. R. Astron. Soc. **436**, 1852-1866 (2013).

Zaussinger, F. and H. Spruit: Semiconvection: numerical simulations. Astron. Astrophys. **554**, id.A119 (2013).

Zhang, W., Ch. Li, G. Kauffmann and T. Xiao: Gas depletion in cluster galaxies depends strongly on their internal structure. Mon. Not. R. Astron. Soc. **429**, 2191-2198 (2013).

Zhang, Z., M. Gilfanov and A. Bogdan: Low-mass X-ray binary populations in galaxy outskirts: Globular clusters and supernova kicks. Astron. Astrophys. **556**, id. A9 (2013).

Zhuravleva, I., E. Churazov, R. Sunyaev et al.: Resonant scattering in the Perseus Cluster: spectral model for constraining gas motions with Astro-H. Mon. Not. R. Astron. Soc. **435**, 3111-3121 (2013).

Zhuravleva I., E. Churazov, A. Kravtsov et al.: Quantifying properties of ICM inhomogeneities. Mon. Not. R. Astron. Soc. **428**, 3274-3287 (2013).

Zubovas, K., S. Nayakshin, S. Sazonov and R. Sunyaev: Outflows of stars due to quasar feedback. Mon. Not. R. Astron. Soc. **431**, 793-798 (2013).

3.1.2 Publications accepted in 2013 (44)

Augustovicova, L., P. Soldan, W.P. Kraemer, and V. Spirko: Potential microwave probes of the proton-to-electron mass ratio at higher redshifts. Mon. Not. R. Astron. Soc.

Augustovicova, L., W.P. Kraemer, and P. Soldan: Depopulation of metastable helium by radiative association with hydrogen and lithium ions. Astrophys. J.

Barai, P., M. Viel, et al. (incl. M. Gaspari): Kinetic or thermal AGN feedback in simulations of isolated and merging disc galaxies calibrated by the M relation. Mon. Not. R. Astron. Soc.

Bedin, L.R., Ruiz-Lapuente, P., Gonzakez et al.: Improved Hubble Space Telescope Proper Motions for Tycho-G and Other Stars in the Remnant of Tycho's Supernova 1572. Mon. Not. R. Astron. Soc.

Benetti, S., M. Nicholl et al.(incl. S. Taubenberger): The supernova CSS121015:004244+132827: a clue for understanding super-luminous supernovae. Mon. Not. R. Astron. Soc.

Dunkel, J. and S. Hilbert: Consistent thermostatistics and negative absolute temperatures. Nature Physics.

Ergon, M., J. Sollerman, et al. (incl. S. Taubenberger): Optical and near-infrared observations of SN 2011dh - The first 100 days. Astron. Astrophys.

Girichidis, P., L. Konstandin, A. Whitworth and R. Klessen: On the Evolution of the Density Probability Density Function in Strongly Self-gravitating Systems. Astrophys. J.

Grimm-Strele, H., F. Kupka and H. J. Muthsam: Curvilinear Grids for WENO Methods in Astrophysical Simulations Comp. Phys. Communications.

Grimm-Strele, H., F. Kupka, B. Loew-Baselli et al.: Realistic Simulations of Stellar Surface Convection with ANTARES: I. Boundary Conditions and Model Relaxation. New Astronomy.

Hütsi, G., M. Gilfanov and R. Sunyaev: Linking X-ray AGN with dark matter halos: a model compatible with AGN luminosity function and large-scale clustering properties. Astron. Astrophys.

Jofre, P., U. Heiter et al. (incl. M. Bergemann): FGK Benchmark Stars A new metallicity scale. accepted by Astron. Astrophys.

Khabibullin, I., S. Sazonov and R. Sunyaev: SRG/eROSITA prospects for the detection of stellar tidal disruption flares. Mon. Not. R. Astron. Soc.

Komarov, S., E. Churazov and A. Schekochihin: Suppression of local heat flux in a turbulent magnetized intracluster medium. Mon. Not. R. Astron. Soc.

Meyer-Hofmeister, E. and F. Meyer: The relation between radio and X-ray luminosity of black hole binaries: affected by inner cool disks? Astron. Astrophys.

Obergaulinger, M., A. Iyudin, E. Müller and G.F. Smoot: Hydrodynamic simulations of the interaction of supernova shock waves with a clumpy environment: the case of the RX J0852.0-4622 (Vela Jr) supernova remnant. Mon. Not. R. Astron. Soc.

Paldus, J., T. Sako, X. Li, and G.H.F. Diercksen: Symmetry-breaking in the independent particle model: Nature of a singular behavior of Hartree-Fock potentials. accepted by J. Math. Chem.

Planck Collaboration (incl. MPA group): Planck 2013 results. I. Overview of products and scientific results. accepted by Astron. Astrophys.

Planck Collaboration (incl. MPA group): Planck 2013 results. XVI. Cosmological parameters. accepted by Astron. Astrophys.

Planck Collaboration (incl. MPA group): Planck 2013 results. VIII. HFI photometric calibration and mapmaking. Astron. Astrophys.

Planck Collaboration (incl. MPA group): Planck 2013 results. XII. Component separation. Astron. Astrophys.

Planck Collaboration (incl. MPA group): Planck 2013 results. XIII. Galactic CO emission. accepted by Astron. Astrophys.

Planck Collaboration (incl. MPA group): Planck intermediate results. XIII. Constraints on peculiar velocities. accepted by Astron. Astrophys.

Planck Collaboration (incl. MPA group): Planck 2013 results. XVII. Gravitational lensing by large-scale structure. Astron. Astrophys.

Planck Collaboration (incl. MPA group): Planck 2013 results. XVIII. Gravitational lensing-infrared background correlation. Astron. Astrophys.

Planck Collaboration (incl. MPA group): Planck 2013 results. XIX. The integrated Sachs-Wolfe effect. Astron. Astrophys.

Planck Collaboration (incl. MPA group): Planck 2013 results. XX. Cosmology from Sunyaev-Zeldovich cluster counts. Astron. Astrophys.

Planck Collaboration (incl. MPA group): Planck 2013 results. XXI. Cosmology with the all-sky Planck Compton parameter y-map. Astron. Astrophys.

Planck Collaboration (incl. MPA group): Planck 2013 results. XXII. Constraints on inflation. Astron. Astrophys

Planck Collaboration: 250 authors (the authors ordered alphabetically) Planck 2013 results. XXIII. Isotropy and Statistics of the CMB. Astron. Astrophys.

Planck Collaboration (incl. MPA group): Planck 2013 Results. XXIV. Constraints on primordial non-Gaussianity. Astron. Astrophys.

Planck Collaboration (incl. MPA group): Planck 2013 results. XXVII. Doppler boosting of the CMB: Eppur si muove. Astron. Astrophys.

Planck Collaboration (incl. MPA group): Planck 2013 results. XXVIII. The Planck Catalogue of Compact Sources. Astron. Astrophys.

Planck Collaboration (incl. MPA group): Planck 2013 results. XXIX. Planck catalogue of Sunyaev-Zeldovich sources. Astron. Astrophys.

Suyu, S.H., T. Treu, S. Hilbert et al.: Cosmology from gravitational lens time delays and Planck data. Astrophys. J. Lett.

Prokhorov, D.A. and E. Churazov: Counting gamma rays in the directions of galaxy clusters. Astron. and Astrophys.

Schoenrich, R. and M. Bergemann: Fundamental stellar parameters and metallicities from Bayesian spectroscopy. Application to low- and high-resolution spectra. Mon. Not. R. Astron. Soc.

Selig, M. and T. Enßlin: Denoising, Deconvolving, and Decomposing, Photon Observations. Astron. Astrophys.

Shirazi, M., S. Vegetti, N. Nesvadba et al.: The physical nature of the 8 o'clock arc based on near-IR IFU spectroscopy with SINFONI. Mon. Not. R. Astron. Soc.

Spiniello, C, S.C. Trager, L.V.E. Koopmans and C.Conroy: The stellar IMF in early-type galaxies from a non-degenerate set of optical line indices. Mon. Not. R. Astron. Soc.

de Souza, R., U. Maio, V. Biffi and B. Ciardi: Robust PCA and MIC statistics of baryons in early mini-haloes. Mon. Not. R. Astron. Soc.

Surman, R., et al. (incl. O. Just, and H.-Th. Janka): Production of Nickel-56 in black hole-neutron star merger accretion disk outflows. Journal of Physics G.

Valenti, S., F. Yuan, S. Taubenberger et al.: PESSTO monitoring of SN 2012hn: further heterogeneity among faint Type I supernovae. Mon. Not. R. Astron. Soc.

Yates, R. and G. Kauffmann: Dilution in elliptical galaxies: Implications for the relation between metallicity, stellar mass and star formation rate. Mon. Not. R. Astron. Soc.

3.2 Publications in proceedings

3.2.1 Publications in proceedings appeared in 2013 (36)

Alatalo, K., K. Nyland et al. (incl. T. Naab): AGN feedback driven molecular outflow in NGC 1266. In: Feeding Compact Objects: Accretion on All Scales Eds. C. Zhang, T. Belloni, M. Mendez, and S. Zhang. IAU Symposium 290, Cambridge, UK: Cambridge University Press, 175-176.

Aloy, M. A., Cuesta-Martinez et al. (incl. H.-Th. Janka): Interpreting observations of GRBs with numerical simulations. In: Numerical Modeling of Space Plasma Flows. ASTRONUM-2012, Eds.: N. V. Pogorelov, E. Audit, and G. P. Zank, 33-40.

Bergemann, M., R.P. Kudritzki, B. Davies et al.: NLTE line formation in the atmospheres of red supergiants. In: The Physics of Red Supergiants: Recent Advances and Open Questions Eds.: P. Kervella, T. Le Bertre, and G. Perrin. Betelgeuse Workshop 2013, 103-109.

Bergemann, M., A. Serenelli, and G. Ruchti: Spectroscopic distances to late-type stars. In: Advancing the Physics of Cosmic Distances (IAU Symposium 289) Ed.: R. De Grijs Cambridge, UK: Cambridge University Press, 83-86.

Bois, M., Emsellem et al. (incl. T. Naab): Simulations of binary galaxy mergers and the link with fast rotators, slow rotators, and kinematically distinct cores. Eds. In: Galaxy Mergers in an Evolving Universe. Eds. W.-H. Sun, K. C. Xu, et al. 97-100.

Cherepashchuk, A., R. Sunyaev, S. Molkov et al.: Peculiarities in the orbital and precessional variability of SS433 from INTEGRAL observations. In An INTEGRAL view of the high-energy sky (the first 10 years) - 9th INTEGRAL Workshop and celebration of the 10th anniversary of the launch - INTEGRAL 2012, 1-6).

Cooper, A. P., G. Kauffmann, J. Wang, and S. White: Using the Millennium II simulation to test CDM predictions for the structure of massive galaxies. In: The Intriguing Life of Massive Galaxies (IAU Symposium 295) Eds. D. Thomas, A. Pasquali, and I. Ferreras. Cambridge, UK: Cambridge University Press, 95-98.

Davies, B., R.-P. Kudritzki et al. (incl. M. Bergemann): The temperatures of red supergiants: how cool are the coolest massive stars? In: The Physics of Red Supergiants: Recent Advances and Open Questions. Eds. P. Kervella, T. Le Bertre, and G. Perrin, Betelgeuse Workshop 2012, 69-76.

Davies, B., R.-P. Kudritzki et al. (incl. M. Bergemann): Red supergiants as cosmic abundance probes. In: The Physics of Red Supergiants: Recent Advances and Open Questions. Eds. P. Kervella, T. Le Bertre, and G. Perrin, Betelgeuse Workshop 2012, 287-292.

Davis, T. A., Alatalo et al. (incl. T. Naab): Revealing the origin of the cold ISM in massive early-type galaxies. In: The Intriguing Life of Massive Galaxies (IAU Symposium 295) Eds. D. Thomas, A. Pasquali, and I. Ferreras. Cambridge, UK: Cambridge University Press, 324-327.

Duc, P., Cuillandre, J.-C et al. (incl. T. Naab): Probing the mass assembly of massive nearby galaxies with deep imaging In: The Intriguing Life of Massive Galaxies (IAU Symposium 295) Eds. D. Thomas, A. Pasquali, and I. Ferreras. Cambridge, UK: Cambridge University Press, 358-361.

Enßlin, T.: Information field theory. In: Bayesian Inference and Maximum Entropy Methods in Science and Engineering, Ed. U. VonToussaint, 184-191.

Forman, W., C. Jones, and C. Churazov: Chandra and VLA observations of supermassive black hole outbursts in M87. In: The Intriguing Life of Massive Galaxies (IAU Symposium 295) Eds. D. Thomas, A. Pasquali, and I. Ferreras. Cambridge, UK: Cambridge University Press, 261-264.

Fu, J., and G. Kauffmann: The roles of atomic and molecular gas on the redshift evolution of star formation and metallicity in galaxy formation models. In: Molecular Gas, Dust, and Star Formation in Galaxies, IAU Symposium 292. Eds. T. Wong, and J. Ott. Cambridge, UK: Cambridge University Press, 245-245.

Gheller, C., Rivi, M., et al. (incl. M. Reinecke): CUDA-Splotch: GPU aisualization of astrophysical data. In: Astronomical Data Analysis Software and Systems XXII Ed.: D. N. Friedel, 103-106.

Hanke, F., Marek, A., B. Müller and H.-Th. Janka: The SuperN-Project: porting and optimizing VERTEX-PROMETHEUS on the cray XE6 at HLRS for three-dimensional simulations of core-collapse supernova explosions of massive stars. In: High Performance Computing in Science and Engineering: Transactions of the High Performance Computing Center Stuttgart (HLRS) 2011, Eds.: W. E. Nagel, D. B. Kröner and M. M. Resch, Heidelberg, Germany: Springer, 81-93.

Johansson, J., G. Kauffmann, and S. Morana: Stellar population gradients in GASS. In: The Intriguing Life of Massive Galaxies (IAU Symposium 295) Eds. D. Thomas, A. Pasquali, and I. Ferreras. Cambridge, UK: Cambridge University Press, 304-307.

Jones, C., W. Forman et al. (incl. C. Churazov): Hot gas and AGN feedback in galaxies and nearby groups. In: The Intriguing Life of Massive Galaxies (IAU Symposium 295) Eds. D. Thomas, A. Pasquali, and I. Ferreras. Cambridge, UK: Cambridge University Press, 257-260.

Krajnovic, D., K. Alatalo et al. (incl. T. Naab): Stellar discs in massive galaxies. In: The Intriguing Life of Massive Galaxies (IAU Symposium 295) Eds. D. Thomas, A. Pasquali, and I. Ferreras. Cambridge, UK: Cambridge University Press, 314-314.

Kruijssen, J. M. D. (2013). Collateral damage: the implications of Utrecht star cluster astrophysics for galaxy evolution. In: 370 Years of Astronomy in Utrecht. Eds. G. Pugliese, A. de Koter and M. Wijburg, 347-351.

Marino, A. F. (2013). Anomalous globular clusters: insights from neutron capture elements abundances. In: Reading the book of globular clusters with the lens of stellar evolution - Eds. P. Ventura, and C. Charbonnel, Honour of Franca D'Antona, 29-33.

Melendez, B., M. Miller Bertolami and L. Althaus: Revisiting the impact of axions in the cooling of white dwarfs. In: 18th European White Dwarf Workshop (EUROWD12) Eds. J. Krzesinski, G. Stachowski, P. Moskalik, and K. Bajan. 18th European White Dwarf Workshop (EUROWD12), 189-192.

Miller Bertolami, M. M. and R. Rohrmann: Synthetic light curves for born again events: preliminary results. In: 18th European White Dwarf Workshop (EUROWD12) Eds. J. Krzesinski, G. Stachowski, P. Moskalik, and K. Bajan. 18th European White Dwarf Workshop (EUROWD12), 185-188.

Monelli, M. et al. (incl. A. Marino and A. Weiss): The SUMO project: a SUrvey of Multiple pOpulations in globular clusters. In: Reading the book of globular clusters with the lens of stellar evolution. Eds. P. Ventura, and C. Charbonnel, Honour of Franca D'Antona, 71-74.

Montero, P. J., and I. Cordero-Carrion:. BSSN equations in spherical coordinates without regularization: spherically symmetric spacetimes. Journal of Physics: Conference Series, 454, 1-10.

Moster, B. P. (2013). Simulated galaxy merger trees: a new numerical tool to study galaxy evolution. In: Galaxy Mergers in an Evolving Universe. Eds. W.-H. Sun, K. C. Xu, N. Z. Scoville, and D. B. Sanders, 115-118.

Naab, T.: Modelling the formation of today's massive ellipticals. In: The Intriguing Life of Massive Galaxies (IAU Symposium 295) Eds. D. Thomas, A. Pasquali, and I. Ferreras. Cambridge, UK: Cambridge University Press, 340-349.

Oppermann, N., G. Robbers, and T. Enßlin: Reconstructing signals from noisy data with unknown signal and noise covariance. In: Bayesian Inference and Maximum Entropy Methods in Science and Engineering, Ed. U. VonToussaint, 122-129.

Oser, L., T. Naab, J. Ostriker, and P. Johansson, P. H. (2013). Structural evolution of massive early-type galaxies. In: The Intriguing Life of Massive Galaxies (IAU Symposium 295) Eds. D. Thomas, A. Pasquali, and I. Ferreras. Cambridge, UK: Cambridge University Press, 204-207.

Rachen, J. P. (2013). Bayesian classification of astronomical objects - and what is behind it. In: Bayesian Inference and Maximum Entropy Methods in Science and Engineering, Ed. U. VonToussaint, 254-261.

Remus, R.-S., Burkert et al. (incl. T. Naab): The dark halo âĂŞ spheroid conspiracy. In: The Intriguing Life of Massive Galaxies (IAU Symposium 295) Eds. D. Thomas, A. Pasquali, and I. Ferreras. Cambridge, UK: Cambridge University Press, 208-208.

Röpke, F. K. et al. (incl. M. Kromer and I. Seitenzahl): Thermonuclear supernova explosions from white dwarfs in different progenitor systems. In: Binary Paths to Type Ia Supernovae Explosions (IAU Symposium 281) Eds. R. Di Stefano, M. Orio, and M. Moe. Cambridge, UK: Cambridge University Press, 261-266.

Sim, S. et al. (incl. F. Röpke and M. Kromer): Type Ia supernovae from sub-Chandrasekhar mass white dwarfs. In: Binary Paths to Type Ia Supernovae Explosions (IAU Symposium 281) Eds. R. Di Stefano, M. Orio, and M. Moe. Cambridge, UK: Cambridge University Press, 267-274.

Thomas, D., O. Steele et al. (incl. J. Johansson): Stellar velocity dispersions and emission line properties of SDSS-III/BOSS galaxies. In: The Intriguing Life of Massive Galaxies (IAU Symposium 295) Eds. D. Thomas, A. Pasquali, and I. Ferreras. Cambridge, UK: Cambridge University Press, 129-132.

Toonen, S., Nelemans et al. (incl. A. Ruiter): Progenitors of supernovae type Ia. In: 18th European White Dwarf Workshop (EUROWD12) Eds. J. Krzesinski, G. Stachowski, P. Moskalik, and K. Bajan. 18th European White Dwarf Workshop (EUROWD12), 329-334.

Weiss, A., and N. Heners: Low-mass stars: open problems all along their evolution. In: 40th Liege International Astrophysical Colloquium Ageing Low Mass Stars: From Red Giants to White Dwarfs. Eds. J. Montalban, A. Noels, and V. Van Groote. 1-10.

3.2.2 Publications available as electronic file only

Bauer, W., M. Baumann, L. Scheck et al. Simulation of tropical-cyclone-like vortices in shallow-water ICON-hex using goal-oriented r-adaptivity. Theoretical and Computational Fluid Dynamics.
`doi:10.1007/s00162-013-0303-4`

Cerdá-Durán, P., M. Gabler, E. Müller: The CoCoNuT code: from neutron star oscillations to supernova explosions. Highlights of Spanish Astrophysics VII, Proceedings of the X Scientific Meeting of the Spanish Astronomical Society (SEA).

Jeon M., Pawlik A. H., Bromm V., Milosavljevic M.: Radiative Feedback from high mass X-ray binaries on the formation of the first galaxies and early reionization.
`http://arxiv.org/abs/1310.7944`

Ritter, H. and U. Kolb: Catalogue of cataclysmic binaries, low-mass X-ray binaries and related objects (Editions 7.19 and 7.20).
`http://www.mpa-garching.mpg.de/RKcat/`
`http://physics.open.ac.uk/RKcat/`
`http://vizier.cfa.harvard.edu/viz-bin/VizieR?-source=B/cb`
`http://vizier.u-strasbg.fr/viz-bin/VizieR?-source=B/cb`

Schmidt, F, E. Pajer and M. Zaldarriaga: Large-Scale Structure and Gravitational Waves III: Tidal Effects.
`arXiv e-prints arXiv:1312.5616`

Selig, M. and T. A. Enßlin: Denoising, Deconvolving, and Decomposing Photon Observations.
`http://arxiv.org/abs/1311.1888`

Spruit, H.C.: Essential Magnetohydrodynamics for Astrophysics.
`http://www.mpa-garching.mpg.de/ henk/mhd12.zip`
`http://arxiv.org/abs/1301.5572`

Stacy A., Pawlik A. H., Bromm V., Loeb A.: The Mutual Interaction Between Population III Stars and Self-Annihilating Dark Matter `http://arxiv.org/abs/1312.3117`

3.3 Invited review talks at international meetings

E. Churazov:
– Cold fronts in Galaxy Clusters, (Sesto, 14.1.-18.1)
– Multi-Scale Structure Formation and Dynamics in Cosmic Plasmas, (Bern, 15.4.-19.4)
– Physics of Galaxy Clusters, (Snowbird, UT, 24.3-29.3)

B. Ciardi: “The Radio Universe at Ger’s (wave)-length” (Groningen, The Netherlands, 04.11–07.11).

T.A. Enßlin: CASPAR Conference (Hamburg, 10.9-19.9)

M.Gilfanov: Frontiers of Non-linear Physics (Nizhnii Novgorod, Russia, 28.7.-2.8.)
– Multifaceted Universe (St.Petersburg, Russia, 22.9-25.9)

W. Hillebrandt:
– 10th Russbach School on Nuclear Astrophysics, (Russbach, Austria, 10.3.-16.3.)
– Leibniz-Kolleg Potsdam, (AIP Potsdam, 2.5.-3.5.)
– Supernovae and Gamma-Ray Bursts, (Kyoto, 28.10.-2.11.)
– INT Physics Days, (KIT, Karlsruhe, 14.11.-15.11.)

H.-Th. Janka: Realtime Astroparticle Physics, (Bonn, 4.2.–6.2.)
- International Francqui Symposium: What Asteroseismology has to offer to Astrophysics, (Bonn, 2.12.–4.12.)
- ESO Workshop: The Deaths of Stars and the Lives of Galaxies, (Santiago de Chile, 8.4.–12.4.)
- NAVI Annual Meeting, (Darmstadt, 16.12.–17.12.)
- Observational Constraints on Sources of Nucleosynthesis, (Garching, 25.3.–27.3.)
- XLI International Workshop on Gross Properties of Nuclei and Nuclear Excitations, (Hirschegg, 27.1.–31.1.)
- Max Planck/Princeton Center for Plasma Physics, General Meeting, (Garching, 14.1.–16.1.)
- Nuclear Physics in Astrophysics VI (NPA-VI) Conference, (Lisbon, 19.5.–24.5.)
- Fifty-One Ergs, (Raleigh, 13.5.–17.5.)
- 10th Russbach School on Nuclear Astrophysics, (Russbach, 10.3.–16.3.)
- Neutron Stars: Nuclear Physics, Gravitational Waves and Astronomy, (Surrey, 29.7.–30.7.)
- TAUP 2013, (Asilomar, 8.9.–13.9.)

H. Junklewitz: “Faraday Synthesis: The synergy of aperture and rotation measure synthesis” (Stockholm, Sweden, 23.9.–27.9.)

G. Kauffmann:
- The Physical Link Between Galaxies and their Halos, (Munich, 24.6.-28.6.)
- Super JEDI, (Mauritius 30.6.-9.7.)
- LSST at Europe: The Path to Science, (Cambridge, 9.9.-12.9.)

E. Komatsu: The 221st American Astronomical Society Meeting (Long Beach, CA, 6.1.-10.1.)
- KITP Conference on “Observational and Theoretical Challenges in Primordial Cosmology” (Santa Barbara, CA, 22.4.-26.4.)
- International Conference on “Cosmic Microwave Background” (Okinawa, 10.6.-14.6.)
- The 17th Paris Cosmology Colloquium (Paris, 24.7.-26.7.)
- Lorentz Center Conference on “New Challenges for Early Universe Cosmologists” (Leiden, 5.8.-9.8.)
- GRAPPA Conference on “Anisotropic Universe: from microwaves to ultra high energies” (Amsterdam, 25.9.-27.9.)
- The 19th International Symposium on Particles, Strings and Cosmology, PASCOS 2013 (Taipei, 20.11.-26.11.)

B. Müller: Supernovae and Gamma-Ray Bursts (Kyoto, 14.10.-15.11.)

T. Naab:
- Lorentz Center workshop (25.2. - 1.3.)
- Ringberg meeting on galactic nuclei (18.3. - 22.3.)
- Lorentz Center workshop: What regulates galaxy formation 22.4. - 26.4.
- Origin of the Hubble sequence conference, (Paris, 24.6. - 28.6.)
- Mind the Gap, (Cambridge, 8.7. - 12.7.)
- Phases of the ISM, (Heidelberg, 29.7. - 2.8.)
- Physical processes in the ISM, (21.10. - 01.11.)

H. Ritter: The Golden Age of Cataclysmic Variables and Related Objects II, (Palermo, 9.9.-14.9.)

S. Vegetti: Interdisciplinary Cluster Workshop on Dark Matter, Excellence Cluster Universe, (Garching, 24.6 – 28.6)

A. Weiss: The World of Clusters, (Rome, 23.9.–26.9)

S. White:
- 47th ESLAB Symposium (the Planck Mission) (Nordwijk, 2.4.-5.4.)

– Conference on Galaxy Halos (Garching, 24.6.-28.6.)
– Conference, Mind The Gap, (Cambridge, 8.7.-11.7.)
– Cosmo13 Conference, (Cambridge, 8.7.-11.7.)
– UV Astronomy, (ESO Garching, 7.10.-11.10.)
– Conference on Scientific Computing: CSC2013, (Paphos, Cyprus. 3.12.-5.12.)

R. Yates: EWASS 2013, Turku: Symposium 4: Mystery of Ellipticals: (Turku 9.6.)

3.4 Colloquia talks

E. Churazov: Astrophysics Colloquium (Stanford, 5.4)

S. Dorn: Bayes Forum, (Garching, 13.12)

T.A. Enßlin:
– Universe Cluster LMU; 4.12.; – University Kaiserslautern; 13.11.; – University Siegen; 24.10.; – Max-Planck-Institut für Radioastronmie, Bonn; 12.7.; – PRISMA Cluster of Excellence, University Mainz; 5.6.; – Universe Cluster LMU Munich 20.6.; – Institute for Particle Physics, University Bonn; 18.4.; – University Heidelberg; 18.2.

M. Gaspari:
– SnowCluster conference talk (Utah, USA - 29.03.); – 4th HydroSim meeting talk (Trieste, USA - 23.09.)

M.Gilfanov:
– Invited talk at the Scientific session of the General Physics and Astronomy Division of RAS (Lebedev Institute, Moscow; 27.2.); – Invited talk at the meeting of the Academy of Sciences (Kazan, Russia; 18.3.); – Invited seminar at the Anton Pannekoek Institute (Amsterdam university; 5.12.)

H.-Th. Janka:
– Invited Colloquium (Univ. Dresden; 25.6.); – Invited Colloquium (Univ. Giessen; 13.6.); – Invited Colloquium (MPIA Heidelberg; 11.6.); – Invited Colloquium (ITC, CfA Harvard; 10.10.); – Invited Seminar (CEA Saclay; 5.11.); – Invited Colloquium (Univ. Thessaloniki; 24.4.); – Invited Colloquium (Univ. Würzburg; 6.6.);

E. Komatsu:
–Invited Colloquium (ESO; 10.1.); – (University of Cambridge; 30.1.); – (University of Oxford; 4.2.); – (Cardiff University; 6.2.); – (Mullard Space Science Laboratory; 8.2.); – (University College London; 11.2.); – (University of Geneva; 25.2.); – (University Catholique de Louvain; 1.3.); – (SISSA; 5.3.); – (Münchner Physik Kolloquium; 15.7.); – (Scuola Normale Superiore; 6.11.)

Tsz Yan LAM:
– National Tsing Hua University Astronomy Colloquium (22.11)

E. Müller:
– Institute colloquium, Univ. Basel (18.04.)

Th. Naab:
– invited colloquium IoA, Cambridge (29.01.13)

M. Selig:
– Bayes Forum Garching/München (22.03.)

S. White:
– IAS colloquium (15.4.); – UCL Colloquium London (6.-7.3.); – Trieste (20.3.);
– Colloquium Bonn (26.4.); –

3.5 Public talks and popular articles

E. Churazov:
– Moscow State University (Moscow, 12.10)

T.A. Enßlin:
– Reihe Physik Modern, Munich, (25.4.); – 100 Jahre Schloß Ringberg, (20.7.);
– MPA Open House (19.10.)

W. Hillebrandt:
– Astronomisches Institut Potsdam (10.8.)

H.-Th. Janka:
– Planetarium Münster (5.3.); – Planetarium Stuttgart (21.3.); – MPA Open House (19.10.)

Alexander Kolodzig:
"Wie werde ich Forscher? Jugend forscht. Ein Beispiel aus der Astrophysik" Treffen der Preisträgerinnen und Preisträger im Fachgebiet Physik, MPG MPE, Garching, (13.12.)

E. Komatsu:
– Tohoku University, Sendai, Japan (12.3.); – Mukaiyama Nursery School, Sendai, Japan (13.3.); – Okinawa Institute of Science and Technology Graduate University (OIST), Okinawa, Japan (13.6.);
– Institute for the Physics and Mathematics of the Universe (IPMU), Kashiwa, Japan (17.11.)

B. Müller:
– Volkssternwarte Winzer (20.4.); – VHS Deggendorf (26.4.)

E. Müller:
– Lehrerakademie Dillingen (24.06.); – MPA Open House (19.10.)

H. Spruit:
– Lehrerfortbilding Dillingen (23.6.); – MPA Open House (19.10.);
– Volkssternwarte Darmstadt (26.10)

A. Weiss:
– MPA Open House (19.10.)

S. White:
– Deutsches Museum "PLANCK Mission" (14.5.); – Rosenheim (10.6.);
– MPA Open House (19.10.); – Göttingen (29.10.) – Madrid (18.11.)

3.6 Lectures and lecture courses

Lectures at LMU and TUM

T. Enßlin, SS 2013, LMU München

W. Hillebrandt, WS 2013/2014, TU München

H.-Th. Janka, WS 2012/2013 and SS 2013, TU München

G. Kauffmann, "Structure Formation in the Universe" , WS 2013/2014, TU München

E. Müller, WS 2012/2013 and SS 2013, TU München

H. Ritter, WS 12/13, LMU München

A. Weiss, SS 2013, LMU München

Lecture courses

H.-Th. Janka: “The violent deaths of massive stars” (L’INAF - Osservatorio Astronomico di Brera, Milan, 19.11.–20.11.)

E. Komatsu: “Cosmic Microwave Background” (IMPRS on Astrophysics, Garching, 21.1.–25.1.)

H. Spruit: “Magnetically Powered Jets” (Cargèse summer school “Cosmic Accelerators”, Cargèse, 29.4.–8.5.)

C. Wagner: “Neutrinos in Cosmology” (Postdoc/Staff Lecture Series on Cosmology MPA, Garching, 19.6.; two sessions)

S. White: – IMPRS Lectures Garching (11.11.-15.11.)

4 Personnel

4.1 Scientific staff members

Directors

E. Komatsu, G. Kauffmann (since 1.4.), R. Sunyaev, S.D.M. White (managing director)

Research Group Leaders

E. Churazov, B. Ciardi, T. Enßlin, M. Gilfanov, H.-Th. Janka, G. Kauffmann (until 31.3.), T. Naab, E. Müller.

External Scientific Members

M. Asplund, R. Giacconi, R.-P. Kudritzki, W. Tscharnuter.

Emeriti

H. Billing, W. Hillebrandt, R. Kippenhahn, F. Meyer, H.U. Schmidt, E. Trefftz.

Staff

M. Anderson (since 1.9.), Y. Bahe (since 1.9.), A. Bauswein (until 31.7.), M. Bell (until 31.5.), M. Bergemann (until 31.7.), B. Catinella (until 31.5.), M. Dijkstra (until 31.10.), J. Fu (until 21.9.), M. Gabler, M. Gaspari, P. Girichidis, L. Graziani (until 31.10.), J. Guilet (since 1.10.), H. Hämmerle, B. Henriques, S. Hilbert, G. Hütsi, J. Johansson, O. Just, R. Khatri, S. Khedekar, Jaiwon Kim, Jaiseung Kim, M. Kromer (until 30.9.), D. Kruijssen, T.Y. Lam, K. Lind (until 31.3.), G. Lemson, P. Mazzali (until 30.4.), M. Miller-Bertolami (since 1.7.), R. Moll (since 1.11.), P. Montero, B. Moster (until 30.11.), B. Müller, M. Nielsen (since 15.8.), N. Oppermann (1.3.-30.9.), B. Pandey (until 31.1.), A. Pawlik, V. Prat (since 1.10.), D. Prokhorov, A. Rahmati (since 1.9.), M. Reinecke, S. Roychowdhury (since 1.8.), A. Ruiter (until 31.12.), L. Sales (until 31.8.), F. Schmidt (since 1.10.), X. Shi, R. Smith, C. Spiniello (since 15.11.), H.C. Spruit, A. Sternberg, T. Tanaka, S. Taubenberger, S. Vegetti (since 1.1.), M. Viallet, C. Wagner, S. Walch (until 31.10.), J. Wang, A. Weiss, A. Wongwathanarat.

Ph.D. Students

[1] R. Andrassy*, H. Andresen* (since 1.9.), A. Arth* (since 1.11.), M. Aumer*, P. Baumann (until 14.4.) S. Benitez* (till 30.11.), V. Böhm* (since 1.10.), R. Bollig (since 1.12.), M. Bugli* (since 1.9.), H.L. Chen (since 4.1.), C.T. Chiang, A. Chung*, B. Ciambur*, D. D'Souza* (since 1.9.), R. D'Souza*, S. Dorn (since 15.10.), P. Edelmann, T. Ertl (since 1.2.), A. Gatto*, M. Greiner (since 1.5.), F. Hanke, W. Hao*, N. Hariharan*, L. Hüdepohl (until 15.5.), C.H. Hu*, M.L. Huang, I. Jee (since 1.9.), A. Jendreieck*, H. Junklewitz (until 14.10.), K. Kakiichi*, F. Koliopanos*, A. Kolodzig*, S. Komarov*, C. Laporte*, Ming Li (until 31.12.), Z.W. Liu (until 17.1.), N. Lyskova*, Q. Ma (since 10.9.), Z. Magic*, T. Melson (since 1.3.), M. Molaro*, U. Nöbauer, D. Oliveira*, N. Oppermann (until 28.2.), A. Pardi* (since 1.9.), E. Pllumbi*, L. Porter* (until 30.9.), S. Rau, T. Rembiasz* (until 30.11.), B. Röttgers (since 15.11.), M. Rybak* (since 1.9.), M. Sasdelli*, M. Selig, Li Shao (until 31.12.), Shi Shao, M. Soraism*, I. Thaler*, J. von Groote, D. Vrbanec* (since 1.10.), M. Wadepuhl, T. Woods*, P. Wullstein*, R. Yates, Luo Yu (since 20.4.)

---

[1] *IMPRS Ph.D. Students

Diploma students

A. Agrawal (since 1.9.), R. Ardevol (since 1.4.), T. Denk (since 1.3.), S. Dorn (until 30.9.), M. Eisenreich (since 14.10.), A. Gessner (since 1.3.), M. Greiner (until 30.4.), T. Pangerl (since 1.10.), B. Röttgers (until 30.10.), V. Rozov (since 1.10.), A. Schmidt (since 1.10.), A. Schnell (until 30.10.), H. Übler (until 30.8.), A. Voth (until 30.3.).

Technical staff

Computational Support: H.-A. Arnolds, B. Christandl, N. Grüner, H.-W. Paulsen (head of the computational support).
PLANCK group: U. Dörl, W. Hovest, J. Knoche, M. Reinecke.
MPDL: J.W. Kim; *Galformod:* M. Egger.
Press Officer: H. Hämmerle (MPA/MPE).
Secretaries: M. Depner, S. Gründl, G. Kratschmann, K. O'Shea, C. Rickl (secretary of the management).
Library: E. Blank, E. Chmielewski (head of the library), C. Hardt.

Associated Scientists:

U. Anzer, H. Arp, G. Börner, G. Diercksen, W. Kraemer, E. Meyer–Hofmeister, H. Ritter, J. Schäfer, R. Wegmann.

4.1.1 Staff news

Torsten Enßlin: Habilitation (postdoctoral lecture qualification) at Ludwig-Maximilians-Universität Munich.

Massimo Gaspari received the *Livio Gratton Prize* for the best PhD thesis in Astronomy and Astrophysics presented in Italy in the two past academic years.

Florian Hanke and Francesco de Gasperin: received the *Rudolf-Kippenhahn Prize* for the best MPA student publication 2012.

Hans-Thomas Janka: received *ERC Advanced Grant* for supernova research.

Guinevere Kauffmann: appointed Scientific Director at the Max Planck Institute for Astrophysics.

Eiichiro Komatsu received the *Lancelot M. Berkeley - New York Community Trust Prize* for Meritorious Work in Astronomy.

Diederik Kruijssen received the *Christiaan Huygens Prize* for the best Dutch PhD thesis in astronomy and space sciences in the past five years.

Bernhard Müller: awarded a *Feodor Lynen Fellowship* by the Alexander von Humboldt Foundation.

Chiara Spiniello received a *PhD cum Laude* from the Kapteyn Astronomical Institute in Groningen, NL

Rashid Sunyaev has been awarded an Einstein Professorship by the Chinese Academy of Sciences.

Irina Zhuravleva received the *Otto Hahn Medal* of the Max Planck Society for outstanding scientific achievements.

4.2 PhD Thesis 2013/Diploma thesis 2013

4.2.1 Ph.D. theses 2013

Michael Aumer: Simulations of Disk Galaxy Evolution. Ludwig-Maximilians-Universität München.

Patrick Baumann: The chemical composition of solar-type stars and its impact on the presence of planets. Ludwig-Maximilians-Universität München.

Sandra Benitez-Herrera: Model-Independent Approach to Reconstruct the Expansion History of the Universe with Type Ia Supernovae. Technische Universität München.

Philipp Edelmann: Coupling of Nuclear Reaction Networks and Hydrodynamics for Application in Stellar Astrophysics. Technische Universität München (submitted).

Lorenz Hüdepohl: Neutrino cooling evolution of newly formed proto neutron stars. Technische Universität München.

Henrik Junklewitz: Magnetic Field Statistics and Information field theory. Ludwig-Maximilians-Universität München (submitted).

Natalya Lyskova: Physics of hot gas in elliptical galaxies. Ludwig-Maximilians-Universität München.

Niels Oppermann: Signal inference in galactic astrophysics. Ludwig-Maximilians-Universität München.

Stefan Rau: Gravitational lensing studies of dark matter halos. Ludwig-Maximilians-Universität München (submitted).

Tomasz Piotr Rembiasz: Numerical Studies of the Magnetorotational Instability in Core Collapse Supernovae. Technische Universität München.

4.2.2 Diploma theses 2013

Bernhard Röttgers: Stellar Orbits in Cosmological Simulations of Galaxy Formation. Ludwig-Maximilians-Universität, München.

Sebastian Dorn: Non-Gaussianities of the Cosmic Microwave Background anisotropies. Ludwig-Maximilians-Universität, München.

Maksim Greiner: Rekonstruktion der Dichte freier Elektronen in der Milchstrasse. Ludwig-Maximilians-Universität, München.

Andre Schnell: Stellar Orbit Analysis in Simulated Galaxy Merger Remnants. Ludwig-Maximilians-Universität, München.

Hannah Übler: The assembly history of gas and stars in simulated galaxies. Ludwig-Maximilians-Universität, München.

Andreas Voth: Verschmelzung von Doppelneutronensternen mit exzentrischen Orbits. Technische Universität München.

4.2.3 PhD Thesis (work being undertaken)

Robert Andrassy: Convective overshooting in stars by 3-D simulations. University of Amsterdam.

Haakon Andresen: Gravitational waves from core collapse supernova. Ludwig-Maximilians-Universität München.

Alexander Arth: Simulations of the formation of individual galaxies. Ludwig-Maximilians-Universität München.

Vanessa Böhm: Gravitational Lensing of the Cosmic Microwave Background: Reconstruction of Deflection Potential and unlensed Temperature Map using Information Field Theory. Ludwig-Maximilians-Universität München.

Robert Bollig: Long term cooling studies of proto-neutronstars with full neutrino flavour treatment and muonisation. Technische Universität München.

Matteo Bugli: Study of viscous accretion disks around Kerr black holes. Technische Universität München.

Chi-Ting, Chiang: Sparse sampling and position-dependent power spectrum: new and efficient approaches to galaxy redshift surveys and searches for non-Gaussianity. Ludwig-Maximilians-Universität München.

Andrew Chung: High-redshift Lyman-α945; Emitters. Ludwig-Maximilians-Universität München.

Durand D'Souza: Radiative levitation and other processes in massive stars. Ludwig-Maximilians-Universität München.

Richard D'Souza: Stellar Halos of Galaxies. Ludwig-Maximilians-Universität München.

Thomas Ertl: Progenitor-remnant connection of core-collapse supernovae. Technische Universität München.

Sebastian Dorn: Non-Gaussianity and inflationary models. Technische Universität München.

Andrea Gatto: The impact of stellar feedback on the formation and evolution of molecular clouds. Ludwig-Maximilians-Universität München.

Mahsa Ghaempanah: Information field theory for INTEGRAL gamma ray data. Ludwig-Maximilians-Universität München.

Maksim Greiner: Galactic tomography. Ludwig-Maximilians-Universität München.

Florian Hanke: Three-dimensional simulations of core-collapse supernovae using a detailed neutrino transport description. Technische Universität München.

Wei Hao: Supermassive black hole binaries in Galaxy centres. Ludwig-Maximilians-Universität München.

Nitya Hariharan: Numerical Developments of the Radiative Transfer code CRASH. Technische Universität München.

Chia-Yu, Hu: A new star formation recipe for large-scale SPH simulations. Ludwig-Maximilians-Universität München.

Mei-Ling Huang: Radially resolved star formation histories of disk galaxies. Ludwig-Maximilians-Universität München.

Inh Jee: Measuring angular diameter distances of strong gravitational lenses. Ludwig-Maximilians-Universität München.

Andressa Jendreieck: Stellar Parameter Estimation for Kepler Stars. Ludwig-Maximilians-Universität München.

Kakiichi Koki: The high redshift universe: galaxy formation and the IGM. Ludwig-Maximilians-Universität München.

Filippos Koliopanos: Radiation processes in compact X-ray sources. Ludwig-Maximilians-Universität München.

Alexander Kolodzig: AGN in the eROSITA all-sky survey: Statistics and correlation properties. Ludwig-Maximilians-Universität München.

Sergey Komarov: Physics of Intracluster Medium. Ludwig-Maximilians-Universität München.

Chervin Laporte: Galaxies in clusters. Ludwig-Maximilians-Universität München.

Zazralt Magic: Theoretical models for cool stars including multidimensional atmospheres. Ludwig-Maximilians-Universität München.

Tobias Melson: Implementation of a two-moment closure scheme for neutrino transport into the Yin-Yang grid environment for three-dimensional simulations of core-collapse supernovae with the Prometheus-Vertex code. Technische Universität München.

Margherita Molaro: X-ray binaries' contribution to the Galactic ridge X-ray emission. Ludwig-Maximilians-Universität München.

Ulrich Nöbauer: A Monte Carlo Approach to Radiation Hydrodynamics in Astrophysical Environments. Technische Universität München.

David Oliveira: Cosmology and Dark Matter Dynamics with a GPU accelerated Tree Code. Ludwig-Maximilians-Universität München.

Anabele Pardi: The Dynamics and Evolution of the Interstellar Medium Ludwig-Maximilians-Universität München.

Else Pllumbi: Nucleosynthesis studies for supernova and binary merger ejecta. Technische Universität München.

Laura Porter: Modelling dust in cool stellar and substellar atmospheres. Ludwig-Maximilians-Universität München.

Bernhard Röttgers: AGN feedback in cosmological simulations and the comparison to observations. Ludwig-Maximilians-Universität München.

Michele Sasdelli: Principal Components Analysis of type Ia supernova spectra. Ludwig-Maximilians-Universität München.

Marco Selig: Information Theory Based High Energy Photon Imaging. Ludwig-Maximilians-Universität München.

Shao Li: Understanding the connection between AGNs and their host galaxies. Ludwig-Maximilians-Universität München.

Shao Shi: Disk dynamics in live halos. NAOC, China

Monika Soraism: Progenitors of Type Ia Supernovae. Ludwig-Maximilians-Universität München.

Irina Thaler: Solar magnetohydrodynamics. University of Amsterdam.

Marcel van Daalen: Correlation functions from the Millennium XXL simulation. Ludwig-Maximilians-Universität München.

Janina von Groote: Hydrodynamic modelling of the accretion-induced collapse of white dwarfs with detailed neutrino transport. Technische Universität München.

Dijana Vrbanec: Cross-correlation of Lyman Alpha Emitters & 21-cm signal from the Epoch of Reionization. Ludwig-Maximilians-Universität München.

Tyrone Woods: The Progenitors of Type Ia Supernovae. Ludwig-Maximilians-Universität München.

Philipp Wullstein: How does gas follow dark matter? Galaxy-Lyman-alpha-forest cross-correlation as a probe of a coupling between dark matter and dark energy. Ludwig-Maximilians-Universität München.

Rob Yates: Metal enrichment in galaxy formation models. Ludwig-Maximilians-Universität München.

4.3 Visiting scientists

Name	home institution	Duration of stay at MPA
Aniket Agrawal	(LMU München, Germany)	since 6.9.
Eliana Amazo-Gomez	(Univ. Nacional Columbia)	since 4.12.
Patricia Arevalo	(Univ. Cat. de Chile)	3.7.–31.7.
Anthony Banday	(IRAP, Toulouse, FR)	26.7.–11.8.
Isabelle Baraffe	(Univ. of Exeter UK)	1.7.–31.7.
Thomas W. Baumgarte	(Bowdoin Coll. Brunswick USA)	1.1.–31.7.
Derek Baugh	(Tsinghua Univ., China)	14.10.-14.11.
Chiara Enrico Bena	(University of Turin)	8.4 – 21.4.
Gilles Chabrier	(Univ. of Exeter UK)	1.7.–31.7.
Hailiang Cheng	(Shanghai Obs. China)	since 4.1.
Juncheng Chen	(Tsinghua Univ., China)	14.10.-14.11.
Jorge Cuadra	(Univ. Cat. de Chile)	3.7.-31.7.
Carlos Frenk	(Durham Univ., UK)	1.6.–30.6.
Hannes Grimm-Strele	(TU Wien Austria)	1.3.–30.4., and 1.12.–31.12.
Santosh Harish	(DAAD exchange)	1.9.–30.11.
Petr Heinzel	(Astron. Inst. Ondrejov)	22.4.-21.5.
Nail Inogamov	(Landau Inst. Moscow, Russia)	17.7.–20.8.
Emille Ishida	(Sao Paulo, Brazil)	9.1.–30.4.
Anatoli Iyudin	(Moscow Russia)	22.7.–3.8.
Bhavya Joshi	(Gujrat, India)	since 15.10.
Shi Jia	(CAS, Shanghai, China)	since 19.12.
Xi Kang	(CAS, Nanjing, China)	20.4.–20.5.
Ildar Khabibullin	(IKI Moscow, Russia)	14.1.–2.3. and 17.6.–3.8.
Rolf-Peter Kudritzki	(Hawaii University)	1.1.-30.9.
Craig Lage	(Yeshiva Univ. New York, USA)	5.11.–18.11.
Cheng Li	(Shanghai Obs. China)	26.1.–15.2. 19.6.–26.8.
Ming Li	(CAS, Shanghai, China)	till 31.12.
Yu Luo	(CAS, Nanjing, China)	since 20.4.
Quingbo Ma	(CAS, Nanjing, China)	since 20.9.
Azadeh Maleknejad	(IPM Iran)	12.10.–30.11.
Shude Mao	(Univ. of Manchester)	1.8.–24.8.
Antonio Marquina	(Univ. Valencia Spain)	15.4.–3.5.
Pavel Medvedev	(IKI Moscow, Russia)	17.6.–3.8.
Atsushi Naruko	(Kyoto University Japan)	30.7.–30.9.
Julio Navarro	(Victoria, Canada)	9.6.–29.6.
Martin Obergaulinger	(Univ. Valencia Spain)	24.7.–30.8.
Ludwig Oser	(New York, USA)	2.9.–31.10.

Name	home institution	Duration of stay at MPA
Nelson Padilla	(PUC, Santiago, Chile)	since 1.8.
Maya Padivattathumana	IPP Garching	1.1.–30.6.
Taras Panamarev	(Almaty Kazakhstan)	5.7.–24.7.
Konstantin Postnov	(Sternberg Astron. Inst. Moscow)	1.11.–30.11.
Mikhail Revnivtsev	(IKI, Moscow, Russia)	27.7.–25.8.
Sergei Sazonov	(IKI, Moscow, Russia)	4.1.–5.2. and 28.6.–30.7.
Nikolai Shakura	(Sternberg Astron. Inst. Moscow)	1.11.–30.11.
Li Shao	(Shanghai Obs., China)	until 31.12.
Ashmeet Singh	(New Delhi, India)	15.5.–16.7.
Gerald Skinner	(Univ. of Birmingham, U.K.)	1.11.–30.11.
Rafael de Souza	(KASS, Korea)	4.3.–27.4. and 16.11.–8.12.
Kazuyuki Sugimura	(Kyoto University Japan)	13.7.–9.9.
Lian Tao	(Beijing, China)	14.6.–14.7.
Patricia Tissera	(Univ. of Cordoba, Argentina)	17.6.–28.6.
Scott Tremaine	(IfA, Princeton USA)	4.6.–21.9.
Victor Utrobin	(ITEP, Moscow, Russia)	15.10.–14.12.
Enci Wang	(Shanghai Obs., China)	1.8–30.8
Long Wang	(Beijing, China)	5.7.–24.7.
Zhang Wei	(NAOC, Beijing, China)	15.6.15.7.
Qingwen Wu	(Huazhong Univ. Wuhan, China)	15.7.–25.8.
Lev Yungelson	(RAS, Moscow, Russia)	25.03.-24.04. and 15.10.–14.11.
Irina Zhuravleva	(Menlo Park, USA)	2.6.–5.7.