Dust Particle Tracking at Comet 67P/Churyumov-Gerasimenko

General Idea & Current Approach

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General Idea

Background

Figure 1: My SWT talk two weeks ago

General Idea

Background

Figure 2: 67P's active surface landru79

General Idea

Background

Figure 3: Image sequence taken on Jan 6th, 2016 @ $\sim 2\,\mathrm{AU}$ outbound

General Idea

Background

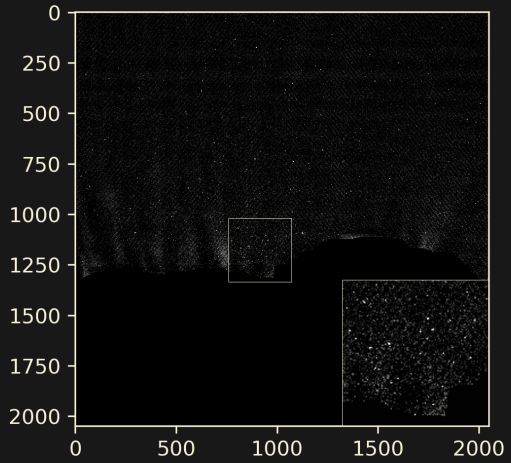

Figure 4: Modified image sequence

General Idea

Background

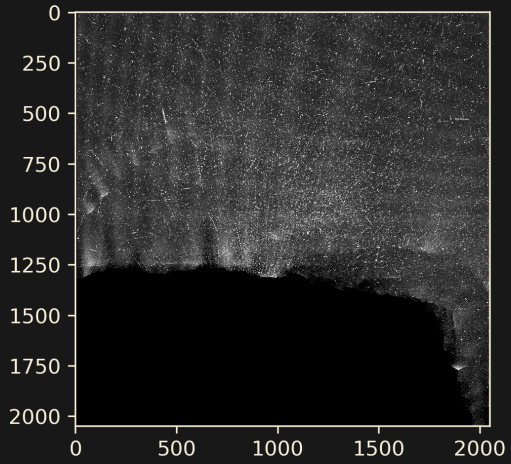

Figure 5: Stacked image sequence

General Idea

Background

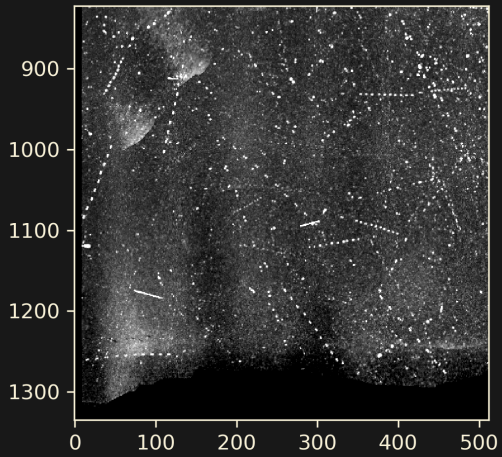

Figure 6: Zoomed-in area of stacked image sequence

General Idea

Previous work

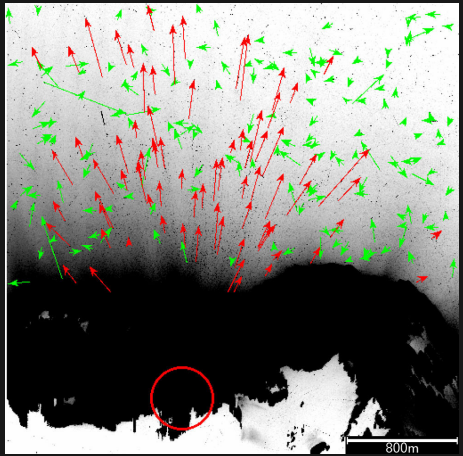

Figure 7: Manually tracked particles (Agarwal et al., 2016)

Step I: Particle Detection

Identifying point sources

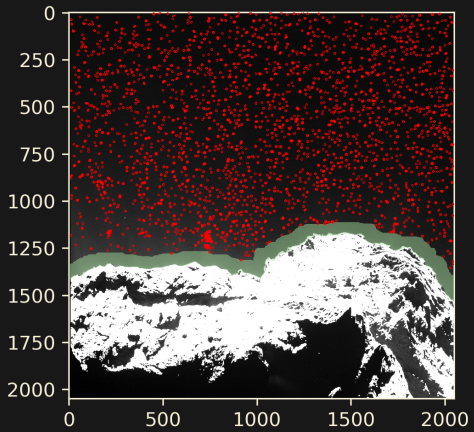

Figure 8: Particle detection with SExtractor software

Step II: Particle Tracking

Utilizing different time intervals

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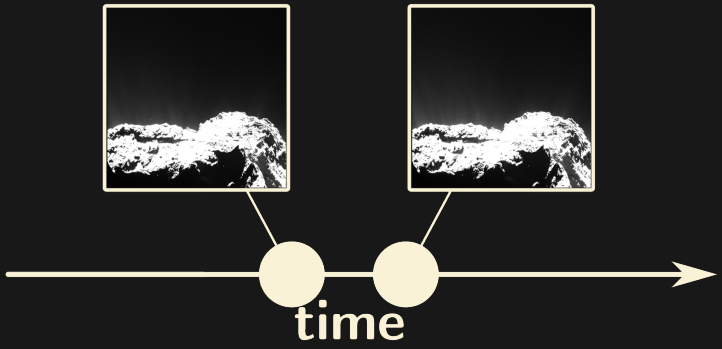
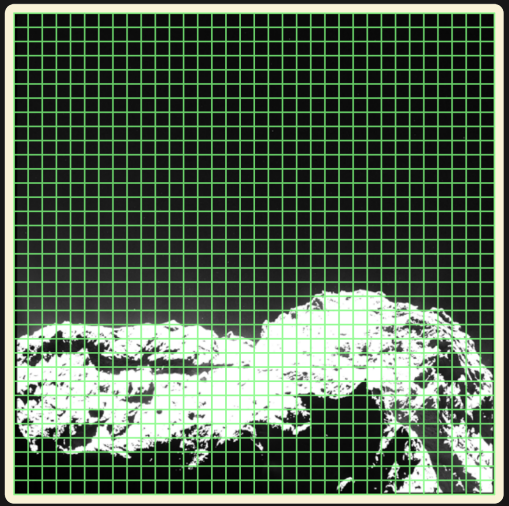
Utilizing different time intervals



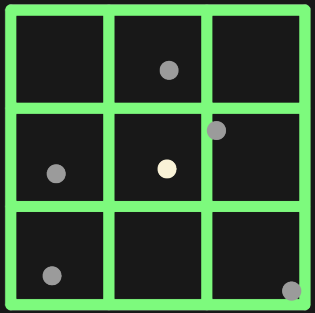
Step II: Particle Tracking

Utilizing different time intervals



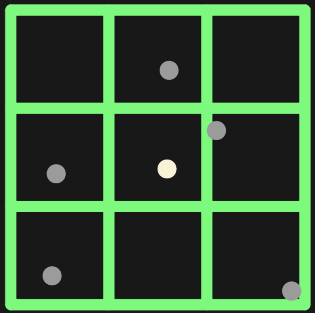
Step II: Particle Tracking

Utilizing different time intervals



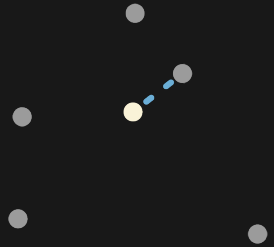
Step II: Particle Tracking

Utilizing different time intervals



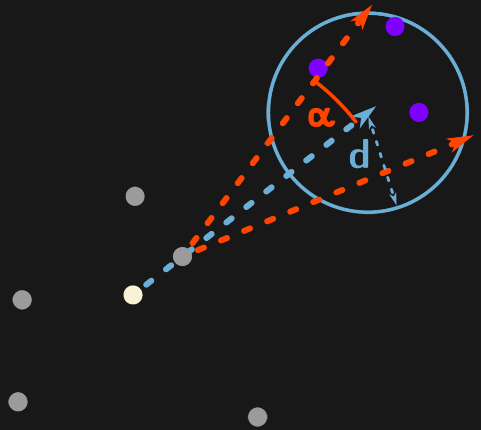
Step II: Particle Tracking

Utilizing different time intervals



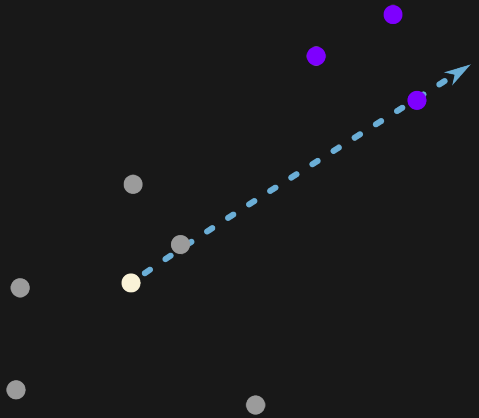
Step II: Particle Tracking

Utilizing different time intervals



Step II: Particle Tracking

Utilizing different time intervals



Step II: Particle Tracking

Preliminary results

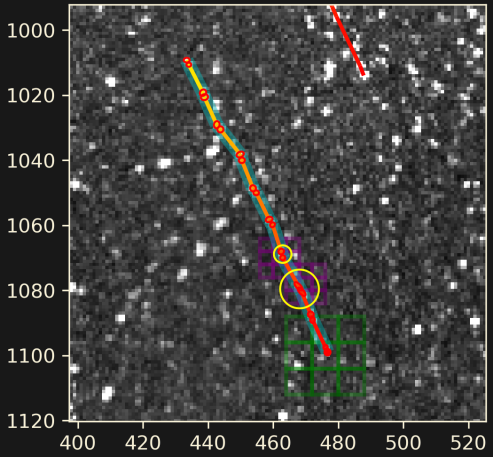


Figure 9: Single particle track

Step II: Particle Tracking

Introduction of lives

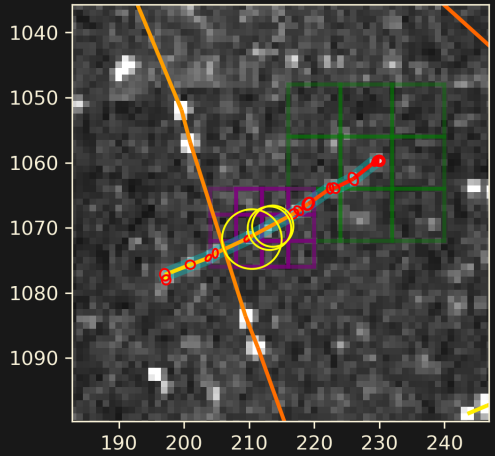
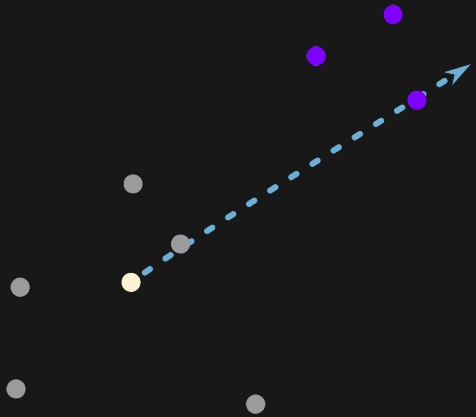


Figure 10: Particle track with missing detections

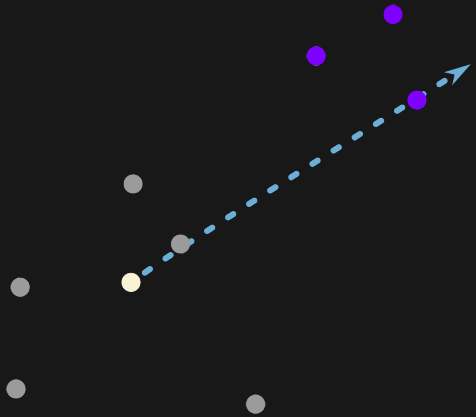
Step II: Particle Tracking

Introduction of lives



Step II: Particle Tracking

Introduction of lives



Step II: Particle Tracking

Introduction of lives

Lives: 5

Step II: Particle Tracking

Preliminary results

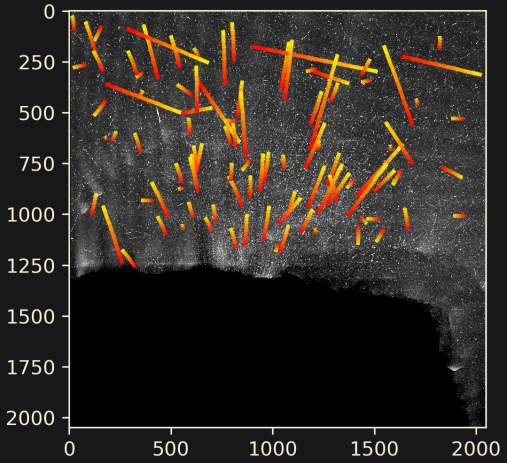


Figure 11: 'Good' particle tracks

Step II: Particle Tracking

Preliminary results

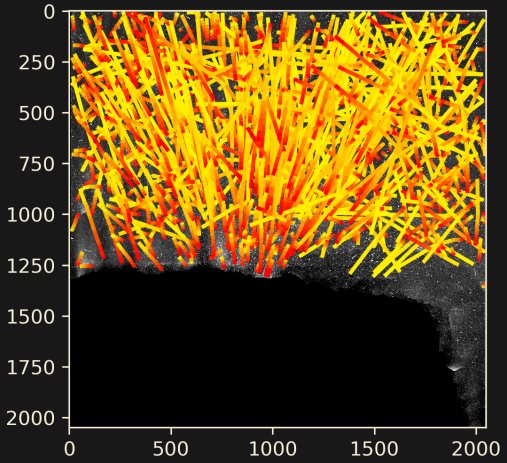


Figure 12: Particle tracks with up to 14 lives

Step II: Particle Tracking

Sources of error & validation

Step II: Particle Tracking

Sources of error & validation

Sources of error:

Step II: Particle Tracking

Sources of error & validation

Sources of error:

- **background stars**

Step II: Particle Tracking

Sources of error & validation

Sources of error:

- background stars, **cosmic rays**

Step II: Particle Tracking

Sources of error & validation

Sources of error:

- background stars, cosmic rays, **wrongly connected** / **'stolen' detections**

Step II: Particle Tracking

Sources of error & validation

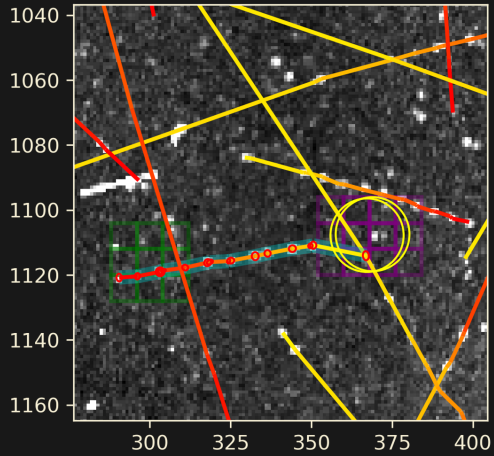


Figure 13: 'Stolen' detection from other track

Step II: Particle Tracking

Sources of error & validation

Sources of error:

- background stars, cosmic rays, wrongly connected / 'stolen' detections

Step II: Particle Tracking

Sources of error & validation

Sources of error:

- background stars, cosmic rays, wrongly connected / 'stolen' detections, **false** & **missing detections**

Step II: Particle Tracking

Sources of error & validation

Sources of error:

- background stars, cosmic rays, wrongly connected / 'stolen' detections, false & missing detections and **false positives**

Step II: Particle Tracking

Sources of error & validation

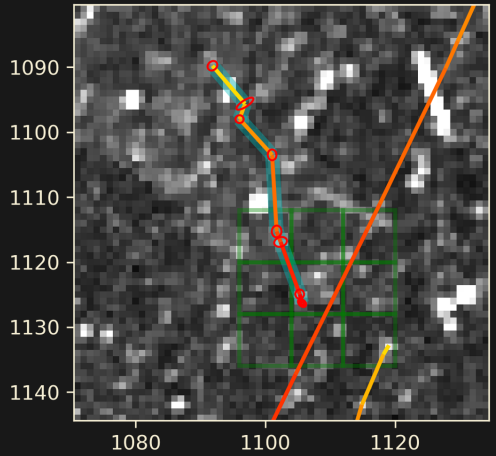


Figure 14: Track generated by noise

Step II: Particle Tracking

Sources of error & validation

Sources of error:

- background stars, cosmic rays, wrongly connected / 'stolen' detections, false & missing detections and false positives

Step II: Particle Tracking

Sources of error & validation

Sources of error:

- background stars, cosmic rays, wrongly connected / 'stolen' detections, false & missing detections and false positives

Validation:

Step II: Particle Tracking

Sources of error & validation

Sources of error:

- background stars, cosmic rays, wrongly connected / 'stolen' detections, false & missing detections and false positives

Validation:

- **Run algorithm on simulated noise**

Step II: Particle Tracking

Sources of error & validation

Sources of error:

- background stars, cosmic rays, wrongly connected / 'stolen' detections, false & missing detections and false positives

Validation:

- Run algorithm on simulated noise
- **Run algorithm on simulated data**

Step II: Particle Tracking

Sources of error & validation

Sources of error:

- background stars, cosmic rays, wrongly connected / 'stolen' detections, false & missing detections and false positives

Validation:

- Run algorithm on simulated noise
- Run algorithm on simulated data
- **Evaluate choice of free parameters**

Step II: Particle Tracking

Sources of error & validation

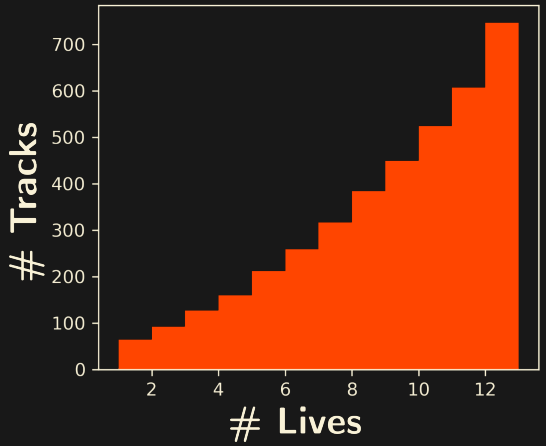


Figure 15: Evaluation of free parameters

Step II: Particle Tracking

Sources of error & validation

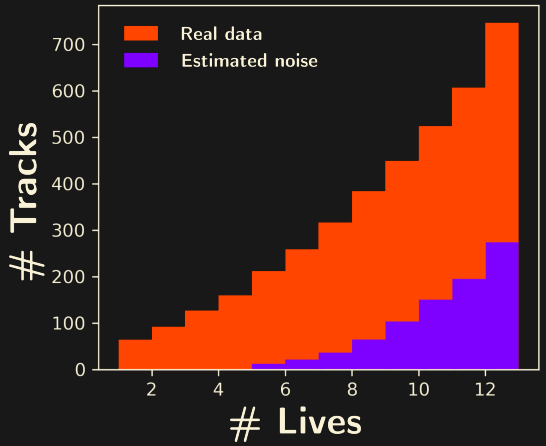


Figure 15: Evaluation of free parameters

Step III: Data analysis

Future work

Step III: Data analysis

Future work

Statistical analysis:

Step III: Data analysis

Future work

Statistical analysis:

- **Incidence angles, velocities, accelerations, etc.**

Step III: Data analysis

Statistical analysis

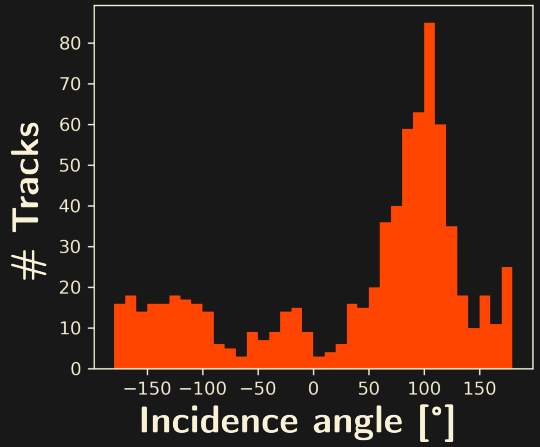


Figure 16: Statistical distribution of incidence angles

Step III: Data analysis

Statistical analysis

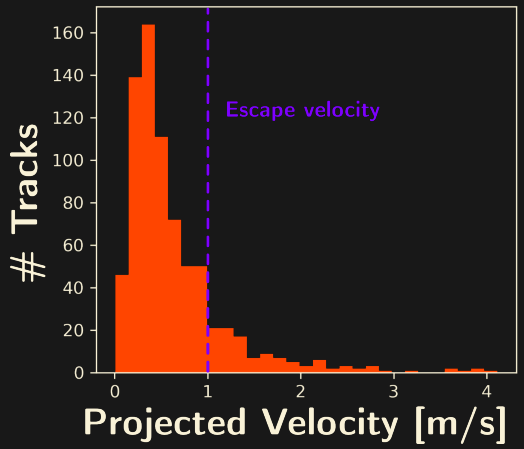


Figure 16: Statistical distribution of mean velocities

Step III: Data analysis

Future work

Statistical analysis:

- Incidence angles, velocities, accelerations, etc.

Step III: Data analysis

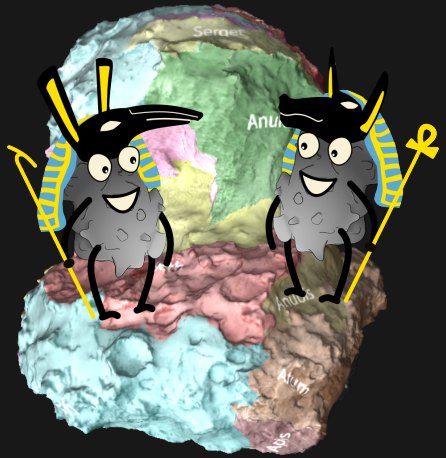
Future work

Statistical analysis:

- Incidence angles, velocities, accelerations, etc.
- **Place of origin**

Step III: Data analysis

Place of origin



Step III: Data analysis

Future work

Statistical analysis:

- Incidence angles, velocities, accelerations, etc.
- Place of origin

Step III: Data analysis

Future work

Statistical analysis:

- Incidence angles, velocities, accelerations, etc.
- Place of origin
- **Fall-back fraction**

Step III: Data analysis

Fall-back fraction

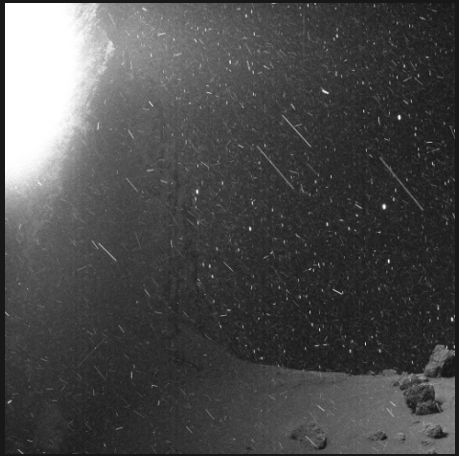


Figure 17: 'Snow fall' on 67P landru79

Step III: Data analysis

Future work

Statistical analysis:

- Incidence angles, velocities, accelerations, etc.
- Place of origin
- Fall-back fraction

Step III: Data analysis

Future work

Statistical analysis:

- Incidence angles, velocities, accelerations, etc.
- Place of origin
- Fall-back fraction

Physical interpretation:

Step III: Data analysis

Future work

Statistical analysis:

- Incidence angles, velocities, accelerations, etc.
- Place of origin
- Fall-back fraction

Physical interpretation:

- **Change in direction & acceleration due to exposure to different gas jets**

Step III: Data analysis

Future work

Statistical analysis:

- Incidence angles, velocities, accelerations, etc.
- Place of origin
- Fall-back fraction

Physical interpretation:

- Change in direction & acceleration due to exposure to different gas jets
- **Recoil from asymmetric outgassing**

Step III: Data analysis

Future work

Statistical analysis:

- Incidence angles, velocities, accelerations, etc.
- Place of origin
- Fall-back fraction

Physical interpretation:

- Change in direction & acceleration due to exposure to different gas jets
- Recoil from asymmetric outgassing
- **Conditions during/for ejection**

Step III: Data analysis

Future work

Statistical analysis:

- Incidence angles, velocities, accelerations, etc.
- Place of origin
- Fall-back fraction

Physical interpretation:

- Change in direction & acceleration due to exposure to different gas jets
- Recoil from asymmetric outgassing
- Conditions during/for ejection
- **Significance for entire comet population**

Step III: Data analysis

Future work

Statistical analysis:

- Incidence angles, velocities, accelerations, etc.
- Place of origin
- Fall-back fraction

Physical interpretation:

- Change in direction & acceleration due to exposure to different gas jets
- Recoil from asymmetric outgassing
- Conditions during/for ejection
- Significance for entire comet population
- **!NEW! Rotational period !NEW!**

Step III: Data analysis

Rotational period

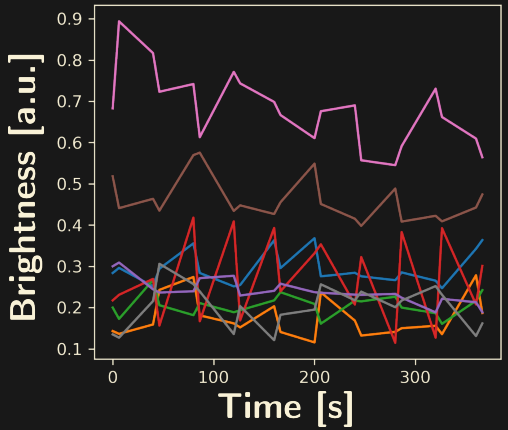
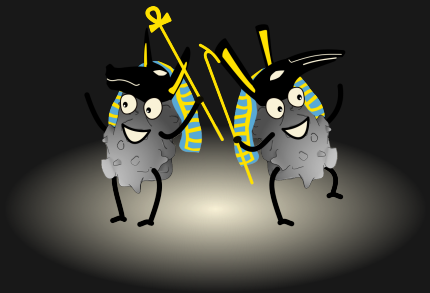


Figure 18: Brightness variations of a few tracks

Questions?



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Johny (2014) How Big Is Rosettas Comet 67p? URL https://gadgetzz.com/2014/08/10/how-big-is-rosettas-comet-67p/.