

Looking Stereoscopically at Goethe vs. Newton: Heisenberg and Pauli on the Future of Physics

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Abstract: Goethe's polemics against Newtonian optics is not rarely mentioned as a singular instance of incompetent stubbornness, or quickly disposed of as an embarrassing incident, not worthy of Goethe's stature. Nonetheless, Goethe's presence in the mind of 20th-century physicists is not a negligible chapter, not only due to the pre-eminence of his literary work but to a suffused *Naturphilosophie* as well. Even more significantly, physicists of the calibre of Heisenberg and Pauli, while openly recognizing the 'mistakes' of the Goethean polemics in optics, tried to extract from that episode important lessons and expectations about the future of science.

Keywords: Weltformel, W. Heisenberg, J.W. Goethe, Naturphilosophie, W. Pauli, future of physics.

1. A question of methodology (or: did Heisenberg retire at age 26?)

One of the key figures of 20th-century physics, Werner Heisenberg, speaking about a peak of world literature and one of the highest symbols of his culture, Johann Wolfgang von Goethe: is it not a very intriguing topic? If, as we shall discuss, Heisenberg's reflections on Goethe did receive some attention, the way they were (not!) contextualized leaves many perplexities and, with that, much work to do. In this paper, we aim at sketching a hopefully fruitful framework to address such perplexities. Today, Goethe's polemics against Newtonian optics is often dismissed, not rarely with scientific overtones, as the stubbornness of an exceptional *dilettante* with no exceptional inclination for mathematized science. And yet, if we look at what very distinguished 20th-century physicists thought about it, we easily realize how simplistic and untenable this *idée reçue* is. To see that, it would be sufficient to collect various Goethean references (of course not limited to the *Farbenlehre*) among those physicists, from Schrödinger to London, from Sommerfeld to Born, from Heitler to Weisskopf, from Bethe to Teller, from Pauli to Fierz, from Heisenberg to Weizsäcker, from von Neumann to Nambu – just to go outside of the German-speaking area. While such an operation would perhaps not shed particular light on the history of physics itself, it would at least counterbalance the systematic omission of this important cultural aspect: an omission that has regularly taken place, and still does, among historians of physics, and not only.

In a sense, one might say that this hypothetical survey would not reveal anything shocking: after all, it is hardly surprising to find Goethe's spectre among those educated people of the German-speaking area who grew up in the late 19th or early 20th century and were thereby influenced, one way or another, by the Goethean ideal of *Bildung*. Is it not, one might ask, the same sort of influence that, say, made the *ragazzi di via Panisperna* regularly quote Dante, despite the quite narrow cultural interests of some of them? Although tempting, the analogy does not hold to a less superficial inspection and, in fact, instructs on the disanalogies. If Fermi or Segré would not have even dreamt of discussing Dante's *Quaestio de aqua et de terra* in relation to their physics, the same did not happen with Goethe. Part of the reason is – it goes without saying – the temporal distance, but the main one is that Goethe himself engaged with a tradition, that of modern science, which physicists of the 20th century still felt themselves belonging to, notwithstanding the conceptual shifts that had meanwhile occurred. Plus, many of the mentioned physicists were in different measure imbued with the relationship with nature as expressed by Goethe's lyrics. This is particularly clear in the case of Heisenberg. His collections of speeches and essays, aimed at larger audiences, have been translated and commented upon. Most of the times, however, these attempts at commenting Heisenberg's thought for how it shows through his speeches and essays – whether they were dedicated to ancient philosophy or to Goethe – are very poor and almost completely a-historical, as if the years in which Heisenberg had written them represented mere numerical labels with no intertwinement with his intellectual journey, nor, in particular, with the new physics that he was busy developing and that would culminate, during the '50s, in the so-called *Weltformel* (no less ambitious than a “world formula”: see Blum (2019)). In international literature (but what follows applies to the Italian situation as well, just to make an example) such commentaries reduce to more or less faithful paraphrases accompanied by some vague invocation of well-known and over-abused keywords such as “uncertainty”, “observer”, and so on. Otherwise, as we shall discuss, we can find some purely externalist contextualizations that seem to ignore both Heisenberg's life of the mind and what Goethe could represent there. That Heisenberg's philosophical reflections proceeded in parallel with his work as a physicist seems, *de facto*, totally ignored: if he had retired from physics in 1927, at age 26, and started to tour around the world just holding conferences at “cultural clubs”, the resulting picture would not look very different from the one emerging from those commentaries. In the following, by focusing on a specific example of his Goethean speeches, we address more precisely the aforementioned shortcomings, and point out what in our opinion represents a much richer and interesting direction of research. Since we believe that the distortions that affect Heisenberg's case are not restricted to it, by way of Heisenberg's example we wish to give a wider methodological message as well.

2. Yearning for Goethe's nature, towards the future: from the war to the *Weltformel*

The year is 1941: in the current popular imagination, that is the hour of M. Frayn's *Copenhagen*. Earlier there seems to be just the young Heisenberg of the uncertainty principle, later only silence; as for that historically dramatic moment suspended between the

two, “uncertainty” gets applied to Heisenberg’s own persona with some by now quite trite and abused conflation. Period. Of course, nobody here intends to deny that there is some degree of ambiguity – which might also be considered as complexity – in Heisenberg. However, it is not in our interest to add yet another ethical or political consideration to a debate which not rarely turns out to be quite gross and oversimplistic and, in any case, we believe that before judging one should understand. The reason we are bringing up all this is that we *can* actually try and say something more substantial than an uncertainty joke about what was going on in Heisenberg’s mind during that period, as well as later. While, obviously, any text, naïvely taken at face value, can mislead about the author’s intentions, nonetheless there are enough elements, over the *longue durée*, to plausibly assess the importance and recurrence of some thought, instead of claiming its opportunistic contingency with some more or less automated “method of suspicion”. Heisenberg’s confrontation with Goethe was certainly a trait that accompanied him throughout his life, from his youth until the last days of his life in 1976 (Heisenberg 1989, pp. 130-ss.): still, when we read some of the aforementioned contextualizations (occasionally well-documented, nevertheless) in the political and public sphere, we get the impression that Heisenberg must have felt forced more to speak about Goethe due to some “agenda” than to take part in the nuclear project during the war (see Carson (2010); actually, on p. 54, there is some insightful remark in the direction we point out in the following). This being said, we can take as a paradigmatic example a conference that during the same year we were mentioning, 1941, Heisenberg held in Budapest: it is actually one of the main texts of his reflection on Goethe and its title is *The Teachings of Goethe and Newton on Colour in the Light of Modern Physics* (Heisenberg 1952, pp. 60-76). Perhaps also because of the fact that it got later included into a collection of essays spanning many years, the chronological indication has been almost totally neglected by people who dealt with the content of the speech (even in respectable ways, such as Cappelletti (2001)). If the year gets underlined, however, it is even taken by some with acrimony (as we ourselves can testify from recent scholarly events), as if to say: “They were in the middle of World War II, and Heisenberg was entertaining himself with such amenities?” Leaving aside similar remarks, that clearly show a degree of confused hostility and ignorance, it is precisely that historical context that has to be kept in mind while reading the speech. Heisenberg was not merely giving his illustrious opinion on an episode of the past, which, by his own admission at the very beginning, had already been settled very clearly (“That battle is over. The decision on ‘right’ and ‘wrong’ in all questions of detail has long since been taken” (Heisenberg 1952, p. 60)): all his speech is pervaded by a sense of urge, by a yearning for the future (which cannot but appear even more intense, keeping in mind the historical context), by the need of bringing to an end what was started, so that, finally, there would be room to develop a new worldview and a Goethean-like relation with nature. Heisenberg was using these expressions with reference to classical physics, of which the new quantum lessons represented both the completion (still to be brought to the extreme) and the overcoming, but it is difficult not to perceive other connotations as well, given the historical moment and the thorny situation Heisenberg himself was in; after all, in 1941 the impression that the war could soon be over was conceivable – and, once it was over, developing a new worldview would indeed have been an urgent task. In the

midst of all this, science (no doubt a driving force) had to be strongly defended – Heisenberg was saying in the speech – against some “voices” that had been making accusations about the alienation of mankind, the sterility of abstractness, and so on. Whose voices were those? That is another element of contextualization which is missing in the available literature and, to our perplexity, has been simply ignored. Heisenberg does not make any explicit name there, but he was clearly taking stance in a debate that was certainly well alive in the German world of the previous twenty years. Even in absence of a direct contact or reference, it would be stimulating to put Heisenberg’s position in discussion with the criticisms advanced, just a few years earlier, by Husserl in a series of conferences that constitute his famous *Crisis of European Sciences*; a confrontation which is meaningful not only as a tension, but also for the contact points, such as Heisenberg’s awareness (as displayed in the much more articulated and extended “1942 Manuscript”, itself permeated with a Goethean inspiration – see Heisenberg (2019)) that the methods of physics do not grasp the *plenum* (or *holon*) of things and cannot exhaust nature. Other voices, against which Heisenberg’s position is more of an assertive opposition, are definitely those of Spengler and his epigones, with very arbitrary (to say the least) “interpretations” of the rise of quantum physics as the self-annihilation of science and various orgies of irrationalism: the West was at the sunset... In a sense, there seems to be a sort of battle for the soul of Goethe between Heisenberg and Spengler, since they both claim its importance for the future. Other interesting confrontations could be made with Thomas Mann’s speeches, between the ’20s and the early ’30s, where he reconsidered the old Goethe’s premonitions of technology and mass society, and so on. Heisenberg, in any case, was making no concession to points of view that could be characterized as “there is too much science” or “science has to be abandoned”; this, of course, was to be expected, but the outline that he sketched (and that we could oppose to a Spenglerian narrative) is more original and interesting. The only way out is through. The basic conceptual features of the tradition from which the worldview of classical physics sprang have to be identified and brought to the extreme; once this is done and put well in order, there will be no confusion or improper overlapping between the experience of our senses and what the practices of physics deal with (where our ordinary life-based notions are meaningful only up to a point and in some degree, as clearly shown by quantum mechanics), leaving instead room to a Goethean relation with nature. Far from disrupting natural unity, modern science – Heisenberg says with an argument in a sense more Goethean than Goethe – has since the early 19th century revealed us a deeper level of understanding of this unity, that would have been unachievable through other means. As for the repel that some felt towards abstraction or even mathematization, Heisenberg concedes that not anyone may like walking down that path, but once its fruits are mature, all of mankind will benefit from them. Not only: claiming again, in a sense, Goethe on his side, Heisenberg contests that the latter’s science is actually without mathematics and underlines the crucial role of symmetries – notion that, by the way, was going to grow dramatically in importance in the following decades, both in Heisenberg’s own theories and in mainstream research about particles. We have thus touched upon three strata of contextualization, which go well beyond some bland paraphrase which just remarks that Heisenberg was saying, somehow *super partes*, that Newton’s and Goethe’s optics belong to different

levels. There is a level of historical contextualization, which is certainly not irrelevant; in this very limited space we have just, of course, given some suggestion or offered some conjecture, but the main goal is to open such a discussion, instead of merely commenting, from an external when not alienated point of view, that Heisenberg's speeches about Goethe were part of some political agenda and so on. Surely many scientists, from the 19th century on, confronted themselves publicly with the delicate question of Goethe's crusade against Newton; politics and regimes changed, but they continued to do so. While of course it is to be expected that political and cultural powers try to give their own version of the national poet, the aforementioned search for agenda behind Heisenberg's Goethean references seem mainly to reveal a deep ignorance or misunderstanding of what Goethe could represent for Heisenberg (and not just for him). After all, one of Heisenberg's main biographies at the moment defines Goethe "a romantic poet" who – it is suggested – had an antiscientific influence on Heisenberg (Cassidy 2009): besides being cringeworthy, this is *not even wrong*, as Pauli would say. A second level of contextualization deals with the "voices" of his age; however, if we were to stop at this point, we would simply remark (still a respectable task, for sure) the cultural value of science. What we find most interesting and, at the same time, perhaps most lacking in the current literature is the third level of contextualization, where the intertwinement between Heisenberg's reflections on Goethe or philosophy and his attempts at building a new physics gets manifested. The identification of the fundamental traits of scientific thought, which according to Heisenberg have to be brought to completion, led him to confront himself with the philosophical tradition, in particular the ancient Greek one. The reflections on Goethe are of course intertwined with such a task, but what is important to understand and highlight is that they are also referred to a *future* Goethean phase. In-between, building on the quantum lessons that he himself had largely contributed to unveil, Heisenberg would try to develop a new kind of physics, that he announced in the late '50s and came to be known as his *Weltformel* (Blum 2019). Those same years, not by chance, saw the appearance of his famous lectures on *Physics and Philosophy*. The often-surprising parallelism between the two is one of the tasks we will face in forthcoming work; for now, suffice it to say that the "philosophical" commentators of those lectures seem to even ignore the existence of Heisenberg's *Weltformel* – as if he, indeed, retired from physics at age 26. Just to make an already foreshadowed example: if Heisenberg invited to choose Plato over Democritus and claimed that a new conception of particles was required, he was making a reference to a conceptual shift somehow implemented in his new theory. Particles were no longer considered "atomistically" (in the etymological sense), as minimal parts or blocks of matter, but as forms of a single substance (*viz.*, a single fermionic field in the *Weltformel* Lagrangian). Forms and symmetries against an atomistic way of thinking: hence Plato over Democritus.

3. Pauli's aspiration to the *Unus Mundus*

After remarking on the kind of intimate dialogue that Heisenberg's Goethean reflections entertained with the projects of his own physics, we may highlight, as a conclusion, some

hitherto-unnoticed parallelism with another great physicist. If, as we have seen, it is easy, at least for those who know which authors they are talking about, to associate Heisenberg with Goethe's lyrical feeling for nature and aspiration towards an integration of human faculties, but also, after the shadows of the war were cast on his figure, with Faust (according to a stereotypical juxtaposition that, by the way, would deserve a less superficial use and consideration), Pauli's character immediately suggests another side of Goethe and his work: Mephistopheles – again, not in a banal or generic sense as the popular devil, but as that distillate of worldly wisdom and irreverence which was nicely underlined, among others, by V. Mathieu in *Goethe e il suo diavolo custode*. Indeed, to reinforce this impression, we may also recall the *Faust*-inspired parody staged in Copenhagen, at Bohr's court in 1932, with Pauli's participation (as Mephisto, needless to say). In any case, Pauli too had his own version of Goethe, as can also be seen by mentions here and there in his beautifully written epistolary, where at some point Pauli and his assistant Fierz even started roleplaying, cheek-in-tongue, as Goethe and Eckermann (Pauli 2005, p. 108; 226). Beyond all these connotations, which in any case would require more extensive and systematic analysis, we can find a remarkable convergence of views with Heisenberg about the future of physics. Despite the heated and, on Pauli's side, quite harsh conflict between the two of them regarding the *Weltformel* or, we could say, about the way to reach that future, they definitely shared, under the aegis of Goethe, the aspiration towards a kind of unity and integration that went far beyond the mere unification of fundamental interactions, as we would say today. The fact that Heisenberg himself was well aware of this lesser known aspect of Pauli cannot be deduced solely from their personal relations, but can be also inferred from the essay he dedicated to Pauli's "philosophical outlook" right after his death, shortly after the *Weltformel* events (Heisenberg 1974, pp. 30-38). Of course, their influences and viewpoints were different, or at the very least well distinct, given – *inter alia* – Jung's influence on Pauli. The passage that we wish to bring attention to, in fact, comes from a 1955 text which is deeply imbued with Jung's thought and his archetypes. In the wake of the latter, Pauli had spent some time to examine the Kepler-Fludd dispute, where he believed he could find manifestations of archetypal images as well as of "complementary" attitudes (i.e., Kepler's and Fludd's) towards the world, at that point when the waters of alchemy and the emerging new science (the moment of *Dämmerung*, when the contours become dim) were still mixed. Pauli resorted to a sort of generalized version of the principle of complementarity, as Bohr himself had done in other areas of knowledge by the way, in order to take into account both conflicting viewpoints. In this way, he was invoking for the future a new unitary view of nature, of psyche and matter, as once upon a time realized – at least in the Jungian reading – by the alchemists' *Unus Mundus*, where "unus" really stands for "single one", beyond dualisms. In the middle of these considerations, Pauli made a parallelism between the Kepler-Fludd dispute and Goethe's polemics against Newtonian optics, and suggested reading the latter analogously, in terms of complementarity. After remarking on Goethe's "intuitive" power (notion that, of course, can be read with Jungian connotations, but we also underline that, according to Pauli and not only, it was a defining feature of Heisenberg as well) in relation to Nature, he adds (Pauli 1994, p. 146):

But the general attitude of man towards nature which alchemy expresses, directed as it is towards the experience of unity, should not simply be equated to its outgrowths, among which was the familiar ever fruitless and often fraudulent fabrication of gold. Goethe's scientific conceptions, which were so often in opposition to official science, become more comprehensible in the light of their alchemical sources, the terminology of which comes to light quite plainly, especially in "Faust". Goethe was an emotional type and hence more susceptible to the experience of unity – "nichts ist drinnen, nichts ist draußen, denn was innen, das ist außen" (nothing is inside, nothing is outside, for what's inside that is outside) – than to critical science. In this regard it was alchemy alone that suited his emotional attitude. This is the background of Goethe's antagonism to Newton, a topic upon which much has been written. Less well-known are the earlier polemics between Kepler, representing the science which was just developing, and the English physician Robert Fludd, who belonged to the order of Rosicrucians and represented the Hermetic tradition. I believe that one is justified in applying to Kepler-Fludd and Newton-Goethe the old saying "Was die Alten sungen, das zwitschern die Jungen" (the young twitter as the old folk sang).

This is a nice and quite significant resonance with Heisenberg and, we think, it would not be an easy task to reduce all this to some contingent political agenda. For sure, we may at least say that both Pauli and Heisenberg could agree with Nietzsche (*Human, All Too Human* §221) that the age of Goethe was still to come.

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