Anton Pannekoek, Marxist astronomer

Photography, epistemic virtues, and political philosophy in early twentieth-century astronomy

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Conclusion

The goal of this thesis has been to investigate Anton Pannekoek's contributions to astronomy and how these relate to both his own Marxist philosophy and the historical development of science in the early twentieth century. As indicated in the introduction, we have focused on three pertinent historiographical themes in doing so: how did astrophotography impact Pannekoek's astronomical research; what epistemic virtues did he pursue and how did these impact his research; and what connections can be found between his astronomy and Marxism.

The prevailing image of Pannekoek that comes forward in this thesis is one of an incredibly productive and versatile astronomer. Throughout his career, he successfully latched onto various upcoming fields — research on the distribution of Milky Way light, statistical research on the structure of the galactic system, and the astrophysics of stellar atmospheres — and contributed significantly to their development. Unfortunately for Pannekoek, many of the methods and theories he helped to develop and refine have since been superseded and, as a result, his contributions are now largely overlooked. As this thesis has illustrated, however, his astronomical career provides crucial insights into the development of astronomy in the first half of the twentieth century and what it meant to be an astronomer during this time.

Photography

Pannekoek's astronomical career makes the significant impact that astrophotography had on the development of twentieth-century astronomy abundantly clear. By investigating his photographic research, we arrived at valuable insight about both the practical and epistemological consequences of the implementation of astrophotography. The most important practical consequence of photography for Pannekoek was that it enabled him to conduct observational research without having an observatory. We have seen that astronomers greatly valued photography because it allowed them to record observations onto photographic plates, which could be transferred to different locations where they could be measured at length. Because the large photographic observatories often produced many more photographic plates than they could measure themselves, this led to a division of labour among astronomical institutes. Astronomers with no access to an observatory, like Pannekoek, could conduct observational research by requesting these plates from remote photographic observatories. Therefore, when he was provided with the opportunity to found the Astronomical Institute in Amsterdam, Pannekoek furnished it with measuring instruments designed for photographic plates to be able to exploit these new opportunities. The photographic plates that were measured in Amsterdam came from all over the world, ranging from the Dutch East Indies and South Africa to the United States and Canada.

At the same time, Pannekoek's reliance on remote photographic observatories for his photographic plates created an imbalanced situation, which led to various practical problems. He could not always immediately obtain the photographic plates that he wanted, for example. When he required photographic plates for J. J. M. Reesinck's research on the variation of δ Cephei from Lick Observatory, he had to wait for the astronomers there to finish their own research on the subject. On the other hand, when Pannekoek developed his own photographic projects, he had to rely on remote astronomers, like Max Wolf in Göttingen and John S. Plaskett Victoria, to implement his method correctly without having the flexibility to make immediate adjustments. Only after the first batch of the plates arrived could he alter his instructions and wait for a new, improved batch to arrive. Thus, while astrophotography provided opportunities for astronomers without observatory, it also placed them in a subordinate position.

Pannekoek's photographic research illustrates the tremendous amount of labour that went into measuring and reducing photographic plates; a characteristic he was able to use to his advantage. His dependent position meant he had access to far fewer photographic plates than the photographic observatories themselves, but he coped with this situation by focusing on work that could utilize the plates he did have to the fullest.

Each individual plate was extensively measured in minute detail to extract as much information as possible. As a result, he was the first to publish a comprehensive catalogue of spectral lines in F and G-type stars in 1951. While similar catalogues of B-type stars had been published decades earlier, the sheer amount of lines in F and G-types stars meant that none of the better equipped astronomical institutes had taken on the daunting task of measuring them all. Pannekoek thus saw the opportunity to contribute to astrophysics by doing what other astronomers were unwilling to do.

On an epistemological level, we found that Pannekoek valued photography for its ability to reduce the human aspect of observation. Unlike many of his contemporaries, however, he did not want to eliminate it entirely. This is best illustrated by the photographic method he developed for representing the visual aspect of the Milky Way. Here, the advantage of photography was that it could record the brightness of Milky Way light without being influenced by personal differences like human observers were. At the same time, he wanted photography to capture the Milky Way clouds as could be seen by the human eye. Regular photography was insufficient for this purpose because it resolved these clouds into individual stars. Instead, Pannekoek turned to the method of extrafocal photographic photometry, which he argued could mimic the anatomical and physiological structure of the human eye. Through this method, he could thus eliminate personal subjectivity while preserving collective subjectivity. Even in the photographic method, the human aspect of observation remained vitally important for Pannekoek.

Additionally, human interpretation was also needed to extract meaningful information from photographic plates, according to Pannekoek. This was an essential feature in his photographic method for statistical astronomy. Pannekoek hoped that photography could provide a more uniform distribution in the limiting magnitudes of various observations, which would make it easier to determine the distances to star clusters. In choosing how to divide the star counts measured on the photographic plate into different sections, however, he relied on the appearance of the Milky Way to guide him, rather than following a predetermined scheme. This way, he could group together parts of the sky that he believed belonged together. This method further reinforces what we have seen throughout the thesis: photography for Pannekoek was not merely a way of letting nature represent itself. Photographic plates were material objects that could be exchanged between people and institutions, and that had to be handled, measured, and interpreted to be valuable for scientific research.

Epistemic Virtues

While investigating Pannekoek's contributions to astronomy in this thesis, we have focused on the epistemic virtues he pursued in his research. This has led to a deeper understanding of his scientific methodology, how it compared to that of his contemporaries, and how it related to his philosophy of mind and ideas on scientific progress. As I have argued, two epistemic virtues, in particular, stood out in the work of Pannekoek: *judgement* and *thoroughness*.

The importance that Pannekoek placed on the virtue of judgement is evident in his research on the statistical distribution of stars. Judgement was required to determine how statistical data had to be clustered to provide meaningful results. This was not only the case for photographic plates, as discussed above, but also when it came to reducing data from published catalogues. By looking at the appearance of the Milky Way, Pannekoek used his judgement to find specific features, like clouds and clusters, to investigate in more detail. This could have a considerable impact on the results of his research, for example when Pannekoek determined the distances to the star clusters in Cygnus and Aquila and found them to be located at 40,000 to 60,000 parsec from the Sun, well outside the boundaries of the widely-accepted star system that had been derived by Jacobus C. Kapteyn. Pannekoek was thus one of the first astronomers to provide supporting evidence for Harlow Shapley's extended galactic system.

The contrast between the statistical research of Pannekoek and that of Kapteyn is especially compelling because they both used the same statistical methods. The main difference was that Kapteyn provided a uniform sorting method in which the statistical data was used to derive the parameters for an all-encompassing model of the entire galactic system. Kapteyn valued a mechanical application of his statistical method as he believed it would ensure that astronomers remain focused on the larger system and would prevent them from getting distracted by idiosyncrasies in the system. Pannekoek, conversely, argued that Kapteyn's scheme already presupposed the shape of the system and warned that his reluctance to intervene meant that there was no way to counteract this predetermined structure. The model of the galactic system that Pannekoek constructed instead was built up from individual clusters that together formed the system. What we have uncovered by focusing on epistemic virtues is that judgement was crucial for Pannekoek because it allowed him to detect and circumvent this bias in the methodology. Moreover, we can now understand how he could derive results that directly contradicted Kapteyn's model despite using the same statistical methods.

Pannekoek's emphasis on judgement can be understood in light of his ontology and philosophy of mind, which he explicated in his socialist writings. According to this ontology, the external world was a continuous and infinitely varied stream of phenomena. This external world could only be accessed through impressions received by the senses, and so the human mind could never fully access or understand it. Accordingly, that should not be the goal of science. Instead, he argued that the focus should be on how information from the senses was ordered, systematized, and interpreted by the human mind. This ability to analyse sense impressions and turn them into a coherent and comprehensible conception of the world is what set humans apart from other animals. Pannekoek's idea that science should look for structure in the sense perceptions explains why he developed various methods of representing the visual appearance of the Milky Way. These various representations provided different methods of structuring the distribution of star light; they represented independent research objects that highlighted different aspects of this distribution. The fact that these structures did not exist outside of the human mind was irrelevant if they could help us understand the phenomenon of the Milky Way. By using their judgement, astronomers would be applying one of humankind's most unique and powerful attributes.

While Pannekoek considered judgement was an essential virtue for all astronomers, this thesis has indicated that thoroughness was a virtue more catered to his personal circumstances. We have seen that thoroughness was an important virtue in his observational astrophysics, where it drove him to extract as much information as possible from each individual photographic plate. But it was a prominent feature of his theoretical astrophysics research as well. Pannekoek contended that he lacked the theoretical insight to contribute to astrophysics by developing new astrophysical theories. Rather, he worked within theoretical frameworks developed by others and investigated their consequences, possibilities, and weaknesses. In this process, thoroughness was a vital asset.

The role of thoroughness in Pannekoek's theoretical astrophysics can be most prominently seen in his theoretical models of stellar atmospheres.

There, he rejected the commonly-used simplified Schwarzschild–Shuster model and instead constructed complex versions of the Milne–Eddington model that accounted for the variation in ionization rate inside stellar atmospheres. Although such models required much more calculating work, they enabled him to conduct a thorough investigation of the physical processes occurring inside stellar atmospheres. These models, however, consistently failed to reproduce observed stellar spectra accurately, with Pannekoek unable to pinpoint exactly where the problem lied. The solution was eventually found by Rupert Wildt, who adjusted Pannekoek's models with new data from physics and managed to show that they had underrepresented the influence of the negative hydrogen ion. Thus, while Pannekoek failed to find the solution himself, he did manage to contribute significantly to the development of theoretical astrophysics through his thorough computations of complex models.

Thoroughness was not just a practical virtue for Pannekoek, however. He also considered it a truly epistemic virtue vital for scientific progress. According to his ideas on scientific development, scientific knowledge grew through the dialectic of theory and observation; observation tested theories and suggested improvements, while theories modelled observational results and indicated the direction of new observational research. In this process, thoroughness was crucial because meticulous measurements and complex calculations allowed for a more exact comparison between theory and observations. Therefore, Pannekoek's adherence to the virtue of thoroughness can be interpreted as a consequence of both circumstance and conviction.

Science and Marxism

As has been noted in the introduction of this thesis, historical literature on Pannekoek has so far largely neglected the connections between his astronomy and Marxism. But as evidenced in the preceding chapters, this separation into two distinct careers is misleading as there were numerous ways in which the two intersected. Moreover, by considering his Marxist philosophy and theories, we get a much better insight into some of the methodological and practical choices Pannekoek made in his astronomical career.

One of the most profound connections between Pannekoek's astronomy and his socialism was through his Marxist philosophy of mind. As we have seen, this philosophy led him to emphasize the importance of judgement in his astronomical research. It also impacted his conceptualization of dialectic materialism as the scientific method for socialist research. According to this method, the Marxist theorists had to analyse how material factors — whether social, economic, or even ideological — determined the behaviour of social classes. For astronomers and Marxists alike, open-mindedness was imperative; they should not let themselves be guided by preconceived ideas about how the stellar systems should look or how the revolution should play out. Such preconceptions would alter their perceptions and would lead them to see what they expected to see. This suggests that, rather than there being some fundamental disconnect, Pannekoek's conception of the ideal scientist and the ideal Marxist were both rooted on the same epistemic concerns, each adapted to suit its own field of research.

Although this study revealed strong relations between Pannekoek's epistemic virtues in his approach to socialism and science, they are certainly not limited to these virtues alone. There is also a clear analogy between his model of the galactic system and his model for council communism. In both cases, he rejected the top-down model that emphasized the overarching system as a meaningful entity. Instead, he advocated a bottom-up method that emphasized the way in which individual persons or stars congregate into larger systems. The collection of these individual clusters provides sufficient structure for the system as a whole without requiring an additional overarching layer.

Finally, by considering Pannekoek's Marxist writings, we can understand why he remained in astrophysics even when he believed he lacked the theoretical aptitude to contribute on a fundamental level. There, Pannekoek explained that scientific progress was an important prerequisite for social progress, for example, through technological advancements that derived from scientific development. Astrophysics was an especially promising field for this purpose because it searched for the stellar energy source, which could perhaps lead to useful energy sources on Earth. Even more important, however, was the educational value of scientific research. For the education of the next generation of scientists, it was necessary to illustrate the proper scientific method through example and show the importance of virtues such as judgement and thoroughness. For the wider public, too, these were virtues that they required to challenge received wisdom and assess for themselves their social, economic, and cultural circumstances.

By looking beyond the separation that Pannekoek himself had created between his astronomical and socialist career, we have found numerous ways in which his astronomy and Marxism were interconnected. The fact that we have found these connections re-emphasizes that science should not be detached from its cultural and political context. We have seen that, by studying Pannekoek's astronomy in the context of his political philosophy, we gain a deeper understanding of the practical, methodological, and epistemological choices he made during his research. Moreover, in doing so, we have arrived at a more unified and complete description of his entire professional life — a description that recognizes that behind Pannekoek-the-astronomer and Pannekoek-the-Marxist there was a single person with the same convictions, the same virtues, and a consistent worldview.