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Anton Pannekoek, Marxist astronomer

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

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Archives

- AIP** Niels Bohr Library & Archives, American Institute of Physics, College Park, MD.
- AIP/DM Donald Menzel autobiography, 1974 [MB2013-1167].
- AIP/OH Oral History Interviews, www.aip.org/history-programs/niels-bohr-library/oral-histories.
- AIP/OS Otto Struve selected correspondence, microform [MI78].
- API** Archive of the Anton Pannekoek Institute, University of Amsterdam.
- HUA** Harvard University Archives, Cambridge, MA.
- HUA/DM Papers of Donald Howard Menzel [HUG 4567].
- HUA/HCO Harvard College Observatory, Records of the Director, Harlow Shapley, 1921–1956 [UAV 630.22].
- HUA/HS Papers of Harlow Shapley [HUG 4773].
- IISH** International Institute of Social History, Amsterdam.
- IISH/AP Archief Anton Pannekoek [ARCH01030].
- LAC** Library and Archives Canada, Ottawa.
- LAC/DAO Dominion Astrophysical Observatory, Office of the Director [R214-254-4-E].
- LM** Archive of Laurence A. Marschall [in possession of author].
- MB** Museum Boerhaave, Leiden.
- MB/AP Persoonlijk archief van Antonie Pannekoek [a 631].
- MB/CE Correspondentie, aantekeningen Cornelis Easton [a 427].

- NBA** **Niels Bohr Archive, University of Copenhagen.**
 NBA/LR Léon Rosenfeld Papers, 1911–1974.
- NHA** **Noord-Hollands Archief, Haarlem.**
 NHA/HL Lorentz, prof. dr. H. A., te Haarlem [364].
- SA** **Stadsarchief Amsterdam.**
 SA/5H Archief van de Vijfde HBS met Drie-Jarige Cursus [1087].
- SUG** **Niedersächsische Staats- und Universitätsbibliothek
 Göttingen.**
 SUG/KS Nachlass Karl Schwarzschild.
- UBH** **Universitätsbibliothek Heidelberg.**
 UBH/MW Nachlasses Max Wolf [Heid. Hs. 3695].
- UBL** **Leiden University Library, Special Collections.**
 UBL/ESB Leiden Observatory Archives, directorate E. F. van de Sande
 Bakhuyzen [ubl146].
 UBL/WdS Leiden Observatory Archives, directorate Willem de Sitter
 [ubl135].
- UCSC** **University of California, Santa Cruz, Special Collections &
 Archives.**
 USCS/LO Lick Observatory Records: Series 1 Correspondence
 [UA.036.Ser.01].
- VO** **Archive of the Vatican Observatory, Rome.**

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Summary

Anton Pannekoek, Marxist Astronomer: Photography, Epistemic Virtues, and Political Philosophy in Early Twentieth-Century Astronomy.

Anton Pannekoek (1873–1960) was both an innovative astronomer and influential Marxist thinker. While historians have extensively discussed his socialist career, his astronomical career has received much less attention. This thesis provides a comprehensive overview of Pannekoek’s astronomical research both in the context of the historical development of astronomy in the twentieth century and the in context of his own Marxist philosophy. Throughout the thesis, the focus is on three pertinent historiographical themes: the impact of photography on astronomy, Pannekoek’s epistemic virtues, and the connections between his astronomy and Marxism.

Chapter 1 discusses Pannekoek’s efforts to create a complete representation of the distribution of Milky Way light. The visual appearance of the Milky Way was an optical illusion, according to Pannekoek, created by how the eye recorded the light of innumerable stars in the Milky Way and how the mind interpreted this information. Nevertheless, he argued that it was important to study the appearance of Milky Way because it provided valuable information on the distribution of stars. Such an assessment was consistent with his Marxist philosophy, which emphasized the role of the human mind in understanding the external world. According to Pannekoek, 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 the role of the human mind was to order, systematize, and interpret these sense impressions. This ability

is what set humans apart from other animals. Whether or not the Milky Way existed outside of the human mind was thus irrelevant if it could help us understand the world.

Pannekoek used both visual and photographic observations to observe the Milky Way. In the former case, he combined the observations of multiple independent observers to create what he called the 'mean subjective image'. In doing so, he wanted to eliminate individual subjectivity while preserving collective subjectivity, thus creating the Milky Way as the average human would see it. In the case of photographic observations, Pannekoek used the technique of extrafocal photography to mimic the physiological characteristics of the human eye while avoiding the psychological characteristics of human observers. The photographic plates required for this research were brought in from Germany, the Dutch East Indies, and South Africa, and measured in Amsterdam. The resulting image of the Milky Way was represented using various techniques: verbal descriptions (only in the case of visual observations), numerical tables, isophotic diagrams, and naturalistic drawings.

Chapter 2 studies Pannekoek's statistical research on the distribution of stars in the galactic system. Rather than searching for the general shape and size of the entire galactic system, like Jacobus C. Kapteyn, Pannekoek focused on individual clusters and investigated them in detail. In this research, the epistemic virtue of *judgement* played a crucial role. Judgement was needed to select specific features in the stellar distribution to investigate, and it was needed to interpret the results of this research by comparing them to the visual appearance of the Milky Way. Although Pannekoek used the same statistical methods as Kapteyn, their difference in approach led to contradictory results. The distances Pannekoek found to the Milky Way clouds were much larger than Kapteyn's entire system and instead concurred with Harlow Shapley's extended galactic system.

Pannekoek's main objection against Kapteyn's method was that the shape of his system was predetermined by the way he organized the statistical data. Moreover, Pannekoek argued, the mechanical way in which Kapteyn applied his scheme prevented him from detecting and correcting this bias in his model. Pannekoek's alternative method for constructing a model for the galactic system was not to start from a predetermined scheme for the entire system but instead to build the system up from individual clusters.

There are clear parallels between Pannekoek's statistical astronomy and his Marxist philosophy. His model of the local system is analogous

to his model for council communism. In both cases, he rejected a pre-determined top-down strategy that treated the overarching system as a meaningful entity. Instead, he promoted a bottom-up strategy that explored how individual persons or stars congregated into larger systems. The collection of these individual clusters provided sufficient structure for the system without requiring an additional overarching layer. Similarly, his rejection of mechanical materialism shows striking parallels with his rejection of mechanical sorting schemes in astronomy. In both cases, by neglecting the ability of the human mind, crucial information was overlooked or misinterpreted.

Chapter 3 focuses on Pannekoek's research on the astrophysics of stellar atmospheres and how they related to his ideas on scientific and social progress. Pannekoek faced with several practical constraints in his astrophysics research. In the case of observational research, Pannekoek faced with the circumstance of not having an observatory. To still conduct observational research, he had to rely on photographic plates that were borrowed from other institutions or recorded by himself during research expeditions. As a result, he had access to far fewer photographic plates than observational researchers working at large photographic observatories. To make the fullest of the plates he did have, Pannekoek focused on the virtue of *thoroughness*. He decided to measure every plate in as much detail as possible, for which other astronomers often lacked the time, thereby establishing his niche in observational research.

In the case of theoretical astrophysics, Pannekoek believed he lacked the theoretical insight to develop new theories or make significant breakthroughs. Here, too, thoroughness became an essential virtue. He decided to focus on investing and further developing already existing theories, like Meghnad Saha's ionization formula, and constructing detailed theoretical models of stellar atmospheres. Pannekoek believed he could best contribute by thoroughly computing the exact consequences of theoretical assumptions and physical conditions in his models so that these could be assessed through a comparison with observational results. To do so, he used the method of numerical integration to solve complicated differential equations, instead of simplifying the models so that they could be calculated analytically as many of his contemporaries did.

Thoroughness was not just a practical virtue for Pannekoek, however. He also considered it an 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 theor-

ies 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.

The thesis as a whole illustrates the significant impact photography had on Pannekoek's astronomical research. On a practical level, photography allowed him to conduct observational research even though he lacked an observatory. On an epistemological level, it enabled him to reduce the human aspect of observation, although he was careful not to eliminate it entirely. What becomes clear from Pannekoek's photographic research is that it was not merely a way of letting nature represent itself. Photographic plates were material objects that could be exchanged between people and institutions, and they required significant labour to measure and interpret them before they became valuable for scientific research.

The focus on Pannekoek's epistemic virtues in astronomy leads to a deeper understanding of his scientific methodology and how it compared to that of his contemporaries. Two epistemic virtues, in particular, stood out in the work of Pannekoek: judgement and thoroughness. Investigating the role of judgement in his statistical astronomy highlights the main difference between his approach and that of Kapteyn. The focus on the role of thoroughness in Pannekoek's astrophysics explained how he adapted his methodology according to the constraints of his personal situation and his ideas on scientific and social progress.

Finally, by investigating Pannekoek's astronomy in relation to his political philosophy, we have found numerous ways in which these were interconnected. These existed through his philosophy of mind, in analogies between the systems created in astronomy and socialism, and in the goal of scientific research. Through these connections, we better understand 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.

Samenvatting

Anton Pannekoek, marxistisch astronoom. Fotografie, epistemische deugden en politieke filosofie in vroegtwintigste-eeuwse sterrenkunde.

Anton Pannekoek (1873-1960) was een innovatief astronoom en een invloedrijk marxistisch denker. Zijn carrière in de arbeidersbeweging is uitgebreid onderzocht door historici; zijn sterrenkundige carrière daarentegen heeft een stuk minder aandacht gekregen. Dit proefschrift bespreekt Pannekoeks astronomisch onderzoek zowel in de context van de historische ontwikkelingen in de sterrenkunde tijdens de eerste helft van de twintigste eeuw, als in verhouding met zijn eigen marxistische filosofie. Hierbij legt het proefschrift nadruk op drie relevante geschiedkundige thema's: de invloed van fotografie op de sterrenkunde, Pannekoeks epistemische deugden, en de dwarsverbanden tussen zijn sterrenkunde en marxisme.

Hoofdstuk 1 beschrijft Pannekoeks inspanningen om de verdeling van het licht in de Melkweg volledig weer te geven. Hij stelde hierbij dat het visuele voorkomen van de Melkweg een optische illusie was, die werd gevormd door de werking van het oog, dat het licht van ontelbare sterren verzamelde en registreerde, en de geest, die deze informatie vervolgens verwerkte. Desondanks vond Pannekoek het belangrijk om dit voorkomen te bestuderen omdat waardevolle informatie gaf over de verdeling van sterren aan de hemel. Deze manier van redeneren kwam overeen met zijn marxistische filosofie, waarin hij de rol benadrukte die de menselijk geest speelt in het begrijpen van de externe wereld. Pannekoek conceptualiseerde de externe wereld als een constant veranderende en eindeloos gevarieerde stroom verschijnselen. Informatie over deze externe wereld

kon enkel verkregen worden via de zintuigen en het was de taak van de menselijke geest om deze zintuiglijke indrukken te ordenen, systematiseren, en interpreteren. Hiermee onderscheidden mensen zich van andere dieren. Of de Melkweg ook buiten de menselijke geest bestond was niet relevant voor Pannekoek, zo lang het concept maar kon helpen om de wereld beter te begrijpen.

Pannekoek gebruikte zowel visuele als fotografische technieken om de Melkweg te onderzoeken. In het eerste geval combineerde hij de observaties van verschillende onafhankelijke waarnemers om een collectief beeld te creëren, wat hij het ‘gemiddeld subjectief beeld’ noemde. Hiermee hoopte hij individuele subjectiviteit uit te kunnen sluiten terwijl collectieve subjectiviteit bewaard zou blijven. Daarmee kon een Melkwegbeeld gecreëerd kunnen worden zoals een gemiddeld persoon het zou zien. In het geval van fotografische waarnemingen gebruikte Pannekoek de methode van extrafocale fotografie, waarbij het beeld bewust onscherp werd genomen waardoor het licht van verschillende sterren kon overlappen. Hiermee wilde hij de fysiologische eigenschappen van het menselijk oog nabootsen zonder dat deze beïnvloed konden worden door de psychologische eigenschappen van menselijke waarnemers. De fotografische platen voor dit onderzoek werden opgenomen in Duitsland, Nederlands-Indië, en Zuid-Afrika, en volgens naar Amsterdam gebracht alwaar ze werden uitgemeten. Het resulterende Melkwegbeeld werd op verschillende manieren weergegeven: door middel van verbale beschrijvingen (enkel voor de visuele observaties), numerieke tabellen, isofotische diagrammen, en natuurgetrouwe tekeningen.

Hoofdstuk 2 bestudeert Pannekoeks statistisch onderzoek naar de ruimtelijke verdeling van sterren in het Melkwegstelsel. In tegenstelling tot voorgangers als Jacobus C. Kapteyn, die vooral op zoek waren naar de algemene vorm en grootte van het gehele stelsel, had Pannekoek meer oog voor individuele clusters en bestudeerde hij deze in detail. Hierbij was een belangrijke taak weggelegd voor de epistemische deugd *beoordelingsvermogen*. Dit was bijvoorbeeld nodig om specifieke bijzonderheden in de sterverdeling te selecteren voor onderzoek, maar ook om de resultaten van dit onderzoek vervolgens te interpreteren door middel van een vergelijking met het visuele voorkomen van de Melkweg. Hoewel Pannekoek dezelfde statistische methodes gebruikte als Kapteyn, leidde hun verschillende benaderingen tot tegengestelde resultaten. De afstanden die Pannekoek vond naar Melkwegwolken waren significant groter dan Kapteyn had berekend voor zijn totale stelsel. Pannekoeks afstanden kwamen beter

overeen met het uitgebreidere Melkwegstelsel van de Amerikaanse sterrenkundige Harlow Shapley.

Pannekoeks belangrijkste bezwaar tegen Kapteyns aanpak was dat de vorm die het systeem kon hebben al van tevoren was vastgelegd door de manier waarop Kapteyn zijn statistische data verwerkte. Bovendien zorgde de mechanische manier waarop Kapteyn zijn programma uitvoerde ervoor dat hij dit vooroordeel in zijn model niet kon ontdekken en corrigeren, aldus Pannekoek. In plaats van het gehele Melkwegsysteem volgens een van te voren bepaald systeem te onderzoeken, stelde hij voor om het lokale sterrenstelsel van onderaf op te bouwen vanuit individuele clusters.

Er zijn duidelijke parallellen zichtbaar tussen Pannekoeks statistische sterrenkunde en zijn politieke ideeën. Zijn model voor het lokale sterrenstelsel is overeenkomstig met zijn model voor het radencommunisme. In beide gevallen wees hij een van bovenaf bepaalde strategie die betekenis gaf aan een overkoepeld systeem af. In plaats daarvan benadrukte hij dat gekeken moest worden naar hoe systemen van onderaf werden opgebouwd vanuit individuele personen of sterren. Deze opbouw, stelde hij, gaf voldoende structuur waardoor een extra overkoepelende laag overbodig was. Op een soortgelijke manier vertoont Pannekoeks afwijzing van het mechanisch materialisme een opvallende parallel met zijn afwijzing van mechanische methodes om statistische data te analyseren. In beide gevallen beargumenteerde hij dat het negeren van het menselijk denken ervoor zorgde dat cruciale informatie verloren ging.

Hoofdstuk 3 richt zich op Pannekoeks onderzoek naar de astrofysica van steratmosferen in relatie tot zijn ideeën over wetenschappelijke en maatschappelijke vooruitgang. Pannekoek werd in zijn astrofysica geconfronteerd met enkele praktische beperkingen. Zo beschikte hij niet over een eigen sterrenwacht. Om toch observationeel onderzoek uit te kunnen voeren leende hij fotografische platen van andere instituten en ging hij op onderzoeksreizen om zelf ook platen op te nemen. Het gevolg hiervan was wel dat hij veel minder platen tot zijn beschikking had dan observationele sterrenkundigen die werkzaam waren bij grote fotografische sterrenwachten. Om optimaal gebruik te maken van de platen die hij wel had, benadrukte Pannekoek de epistemische deugd *grondigheid*. Hij besloot om elke plaat tot in het fijnste detail uit te meten, iets waarvoor andere sterrenkundigen vaak simpelweg de tijd niet voor hadden. Hiermee wist hij alsnog zijn eigen niche te creëren binnen dit onderzoeksveld.

Met betrekking tot de theoretische astrofysica meende Pannekoek dat hij het theoretisch inzicht miste dat nodig was om nieuwe theorieën te ontwikkelen of lastige problemen op te lossen. Ook in dit geval werd grondigheid een essentiële epistemische deugd in zijn onderzoek. Hij besloot zich te richten verder uitwerken van al bestaande theorieën, zoals Meghnad Saha's ionisatievergelijking, en het maken van gedetailleerde modellen van steratmosferen. Pannekoek beschouwde het als zijn taak om de exacte gevolgen van theoretische aannames en fysische omstandigheden in zijn modellen zo grondig mogelijk uit te rekenen, zodat ze beoordeeld kunnen worden aan de hand van een vergelijking met waarnemingsresultaten. Hiervoor maakte hij gebruik van numerieke integratie om gecompliceerde differentiaalvergelijkingen uit te rekenen, in plaats van zijn modellen te simplificeren zodat ze analytisch op te lossen waren, zoals veel van zijn tijdgenoten deden.

Grondigheid was echter niet alleen praktische deugd voor Pannekoek. Hij meende dat het ook een epistemische deugd was dat cruciaal was voor wetenschappelijke vooruitgang. Volgens zijn ideeën over wetenschappelijke ontwikkelingen groeide wetenschappelijke kennis door de dialectiek tussen theorie en waarneming; waarnemingen testen theorieën en suggereren theoretische ontwikkelingen, terwijl theorieën waarnemingsresultaten modelleren en de richting van nieuw observationeel onderzoek bepalen. In dit proces speelde grondigheid een cruciale rol omdat zorgvuldige metingen en complexe berekeningen exactere vergelijkingen tussen theorie en waarneming mogelijk maken. Het nastreven van grondigheid door Pannekoek kan dan ook gezien worden als het gevolg van zowel omstandigheid als overtuiging.

Het proefschrift als geheel illustreert de aanzienlijke impact die fotografie had op Pannekoeks sterrenkundig onderzoek. Op praktisch vlak zorgde fotografie ervoor dat hij observationeel onderzoek kon uitvoeren ondanks dat hij geen sterrenwacht had. Op kennistheoretisch vlak zorgde het ervoor dat hij het menselijk aspect van het waarnemen kon reduceren, hoewel hij er wel voor waakte het niet volledig uit te bannen. In Pannekoeks fotografisch onderzoek komt duidelijk naar voren dat fotografie niet enkel gebruikt werd om de natuur zichzelf te laten weergeven. Fotografische platen waren materiële objecten die uitgewisseld werden tussen mensen en instanties en waarvoor veel arbeid nodig was om ze nuttig te maken voor wetenschappelijk onderzoek.

De nadruk op Pannekoeks epistemische deugden leidt tot een beter begrip van zijn wetenschappelijke methodologie en hoe dit zich verhoudt

tot dat van zijn tijdgenoten. Twee epistemische deugden in het bijzonder springen hierbij in het oog: beoordelingsvermogen en grondigheid. Door de rol van beoordelingsvermogen in Pannekoeks statistische sterrenkunde te belichten wordt het contrast tussen zijn aanpak en dat van Kapteyn duidelijker zichtbaar. De focus op de rol van grondigheid in Pannekoeks astrofysisch onderzoek maakt duidelijk hoe hij zijn methodologie had aangepast aan zijn persoonlijke omstandigheden en zijn ideeën over wetenschappelijke en maatschappelijke vooruitgang.

Het onderzoek naar de raakvlakken tussen Pannekoeks sterrenkunde en zijn politieke filosofie tenslotte, laat meerdere manieren zien waarop ze met elkaar verbonden waren. Dit was bijvoorbeeld terug te vinden in zijn filosofie van de geest, in parallellen tussen de systemen die hij ontwikkelde in de sterrenkunde en het radencommunisme, en in wat hij zag als het doel van wetenschappelijk onderzoek. Door deze dwarsverbanden te onderzoeken ontstaat een beter beeld van de praktische, methodologische, en kennistheoretische keuzes die hij maakte in zijn onderzoek. Bovendien geeft het een beter geïntegreerd en completere beschrijving van zijn gehele professionele carrière — een beschrijving die erkent dat achter Pannekoek-de-astronoom en Pannekoek-de-marxist één enkel persoon schuilt met dezelfde overtuiging, dezelfde deugden, en een consistent wereldbeeld.

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My conversations with Edward van den Heuvel early in the project provided an excellent introduction to Pannekoek's astronomical research

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Throughout my research, I often relied the increasing number of online databases that provide digital access to public domain sources that would be very difficult to obtain otherwise. Often, these databases provide direct access (in the form of digital facsimilia) to the original sources and therefore do not appear in explicitly my bibliography. Their services, however, are greatly appreciated. The databases I relied on most were the SAO/NASA Astrophysics Data System (adsabs.harvard.edu); KNAW Digital Library (dwc.knaw.nl/toegangen/digital-library-knaw/); and Association Archives Anton Pannekoek (aaap.be).

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