9 Popularizing the Cosmos

Pedagogies of Science and Society in Anton Pannekoek's Life and Work

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Abstract

New expectations about the role of the astronomer in modern life emerged in the early twentieth century. This chapter sketches Anton Pannekoek's role in fostering new forms of public and political engagements with astronomy. Through his scientific writings and photography, Pannekoek did more than foster the wonders of nature and science. He also presented astronomy as a field that instilled large-scale visions of society and human progress. After considering Pannekoek's efforts to build stronger connections between science and polity in both galactic astronomy and council communism, it concludes with thoughts about Pannekoek as a key early twentieth-century figure in a new tradition of historical writing about scientific instruments and practice.

Keywords: Anton Pannekoek, photography, science popularization, historiography of science, Marxism, British Astronomical Association

> What really is the Milky Way? Exactly speaking, it is a phantom; but a phantom of so wonderful a wealth of structures and forms, of bright and dark shapes, that, seen on dark summer nights, it belongs to the most beautiful scenes which nature offers to man's eyes.
>
> Anton Pannekoek, *History of Astronomy*, 474.

In his 1961 historical account of the origin and development of astronomy, Pannekoek touched only lightly on the two subjects that had brought him greatest scientific fame: his investigations of the Milky Way and stellar spectra. Instead, he mapped the unfolding of what he referred to as 'the

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concept of the universe', which he defined as a 'new concept of the world' that had opened 'new ways of thinking'. Driven by 'a strong social development', he stated, astronomy since the sixteenth century had unsettled beliefs and certainties, disclosing 'that what seemed the most certain knowledge of the foundation of our life' (that is, the immobility of the sun) 'was merely an appearance'. The replacement of a fixed earth to an idea of 'endless space' had been a 'revolution', forcing the reorientation of humankind to the world. In those centuries of revolution, the contest over astronomical truth was 'an important element in the spiritual struggle accompanying the great social upheavals', he wrote, stirring the minds of 'mankind'. While other sciences (physics, chemistry, and biology were the ones he named) had gradually surpassed astronomy in their practical applications, he wrote, astronomy stood apart as a leading index of the "transformation of the human race" from the ancient world to the present, an 'essential part in the history of human culture."[1]

Studies on relations between Pannekoek's career as a scientist and his political ideals necessarily must weigh the tremendous growth of public prestige for astronomy in the first half of the twentieth century. Across his long career, involvement with astronomy and especially the scientific study of the Milky Way, Anton Pannekoek combined scientific discovery with a passion for fostering public understanding and an awareness of the leading astronomical debates of his day. Although he is recognized as a leading twentieth-century astronomer, Pannekoek's creativity and capacity to think beyond the boundaries of existing paradigms were not confined to astronomy. As a theoretical leader of the radical left wing of the communist movement, he also tried to imagine a radically new social order on earth. Given his prominence, it is tempting to see him mainly in terms of his unique characteristics. By taking a closer look at his navigations through the diverse contexts of early-twentieth-century scientific and political circles, however, we come to understand him not as an idiosyncratic lone individual, but as a figure who was greatly concerned with new forms of public engagement in both radical politics and the new astronomy and was fully immersed in their public networks.

This paper considers three spheres in which Anton Pannekoek worked to build stronger connections between science and polity in both galactic astronomy and council communism: his early associations with the British astronomical community, his involvements in photography, and his work as an author and leading popularizer of astronomical science. Across his life

1 Pannekoek 1961, 14-15.

and career, Pannekoek's ideas about the role of institutions in the changing conditions of knowledge, the preeminence of machines and instruments in his concepts of science, and *techne* as a kind of labour were shaped within a wider international astronomical community that was itself focused on fostering stronger relationships between astronomy and society. These wider ideas and associated practices informed both his astronomical practice and his approach to writing the history of science.[2]

The paper concludes with thoughts about Pannekoek as a figure who put the telling of historical narratives about astronomy in the foreground of his efforts to bridge practice and theory. From his earliest contact with British amateur astronomical associations in the 1890s to his later writings about the history of science Pannekoek always placed science *in* society: the changing conditions of knowledge, and the place of the scientist in those changes, were at the centre of his thinking and writings. He wrote about the conditions of science in a world that he genuinely believed was evolving into a socialist system. In both astronomy and radical politics, Pannekoek publicly articulated a strong connection between astronomy and its publics, from the scientific gathering of data on one hand, to the dissemination of research findings, on the other. In this reading of his work, astronomy is not seen as something separate from the wider public sphere (the sphere in which politics is supposed to operate). Instead, it is evident that although it is challenging to trace the connections between his 'scientific' and 'political' views, what connected them was his approach to a conception of the proper relation of science and the publics with which they were concerned. More than most astronomers of his day, Pannekoek was interested in bringing science to the public (through public lectures, scientific education, popularization, and dissemination of research findings in ways that were generally accessible, e.g. through his historical writings). At the same time, as even his earliest work in amateur astronomy shows, he recognized the value of members of the public to the construction of a culture of astronomy (e.g. through creation of norms and even, in some cases, as with the BAA, data).

The Hand of Social Institutions in Regulating Astronomy

Pannekoek's ideas about science as a productive tool strongly informed his practical approach to astronomy networks. This may be seen, for example,

2 See especially: Tai 2017.

right from the beginning of his astronomical career, when he was in his early twenties and engaged with British astronomers about the need for techniques for synchronizing the work of many individual observers. Pannekoek's early interest in the British astronomical community's programme of astronomical research demonstrates an early commitment to widen public participation in astronomy.

The British amateur and professional astronomical community had high ambitions for a vast international network of scattered observers around the world. The British Astronomical Association (BAA), for example, was founded in 1890 to encourage amateur astronomers, but its members also included many professional astronomers, and the society was unusual in including women – making it more progressive than many other scientific organizations at the time.[3] The BAA became a central site for the collection of empirical data from disparate members scattered across the globe, who sent their astronomical observations and drawings to Burlington House in London, where they were discussed and often incorporated in maps and charts of astronomical objects.[4] Recognizing the challenge of coordinating the work of multiple observers, the BAA devised strategies and provided what might be termed 'epistemic advice' to prospective observers around the world.

These ideas resonated with the young Pannekoek. He especially was drawn to the work of Nathaniel Green, the president of the BAA. Green was also a painter and taught astronomers how to sketch physical landscapes showing surface details and cloud patterns. He was a long-time advocate of artistic and subjective skills in planetary drawing and engaged in discussions with other amateur astronomers about how to create maps and charts using data from far-flung individuals with different seeing and drawing styles.[5]

Like the British amateur astronomers, Pannekoek regarded the study of the Milky Way as a useful field open to young enthusiasts like himself, whose data-gathering contributions he both encouraged and actively sought to channel. In 1897, he published a paper titled 'On the existing Drawings of the Milky Way and the Necessity of Further Researches' in the *Journal of the British Astronomical Association*, in which he noted that for observations of the Milky Way '*no instrument whatever is required*; nothing, indeed,

3 Elizabeth Brown, possibly the only woman in England at the time to own her own observatory, became head of the Solar Section.

4 The work of British amateur astronomical observers is discussed in Tucker 2005, chapter 5.

5 On the role of drawings and photography in astronomy, c. 1870-1930, see Nasim 2013; Pang 1997; Tai 2017; Tucker 2005, 209-211; and Chaokang Tai, 'The Milky Way as Optical Phenomenon', in this volume, 219-247.

except a pair of rather sharp eyes and a sky of tolerable clearness'.[6] He praised standardization, social networks, utility, training and discipline, mechanical reproduction in the new amateur astronomy, seeing them as markers of progress. The following year, Pannekoek related to Green in a letter that he welcomed the formation of a section dedicated to the study of the Milky Way.[7]

Pannekoek's ideals of observation were not unique to Pannekoek, but were instead shared by many contemporary planetary astronomers in British amateur astronomical networks. Yet how were these ideals to be achieved in practice? In astronomy, there were widespread differences in various representations of the same object; as Pannekoek explained the familiar problem: 'In certain parts the two drawings seem to represent wholly different objects'.[8] These differences between the representations of different observers, Pannekoek explained, were caused by errors and problems of 'subjectivity'. Visual subjectivity thrived beside invocations of 'mechanical objectivity' in nineteenth-century science. The British astronomer Walter Maunders had even coined the term 'artistic personal equation' to describe the discrepancy between observers' planetary drawings – referring to the technical term, 'personal equation', that astronomers used to denote differences in the reaction times of observers who recorded the transit of stars across a telescopic meridian.[9] Although Pannekoek agreed that the multiplication of observers introduced subjective errors, he thought that they could be overcome. As he put it, 'the influence of all of these causes of error may be greatly diminished by the co-operation of many persons with a certain ability of observing, and much good will accrue to the cause of science'.[10]

Pannekoek saw the mechanical reproduction and distribution of charts as a possible solution for subjective errors. Most star charts, however, were not adapted for use for the Milky Way: Pannekoek thought their scale was too small, and left little space for drawing minute differences of brightness. He also noted that his fellow Dutch astronomer and leading describer and interpreter of the Milky Way, Cornelis Easton (1864-1929) had published a catalogue that made it possible to draw a star chart in cylindrical projection

6 Pannekoek 1897b, 39; emphasis added.

7 Anton Pannekoek to Nathaniel Green, 1 December 1898, RAS.

8 Pannekoek 1897b, 40.

9 For more on the 'artistic personal equation', see Tucker 2005. On the problem of the personal equation in Victorian astronomy, see esp. Schaffer 1988.

10 Pannekoek 1897b. For more on this, see Chaokang Tai, 'The Milky Way as Optical Phenomenon', in this volume, 219-247.

for use in Milky Way studies. Pannekoek took it upon himself to make these charts and had them lithographed by Easton, 'and now they may be had by anyone studying this subject at very slight expense'.[11]

Pannekoek's engagement with the BAA offers an early glimpse of what would become a long career of public engagement with astronomy. It also prefigured what would become a lively and enduring correspondence with leading British thinkers in both science and politics for the duration of his lifetime. Astronomy was well suited to public engagement, since it needed a large pool of observers, equipped with basic instruments. From his earliest days as an astronomer to the end of his career, Pannekoek showed a dedication to the value of contributions from extended networks of disparate observers – as well as to the practical challenges involved in building them.[12] This was no fleeting interest, for even at the end of his career, he expounded on how amateur astronomers could contribute to the observations of the Milky Way without any astronomical instrument, especially in the Southern subtropical zones known for their especially clear skies.[13]

Theories of Science and Marxism, and the Pre-eminence of Machines

Pannekoek's vision of the role of the astronomical observer in visualizing the natural order of the galaxies coincided with his strenuous and devoted efforts, in other contexts, to visualize a new social order. As is discussed in other parts of this volume and in an important recent paper by historian of science Chaokang Tai, this can be seen in his attempts to clarify the relationship between science and Marxism in his writings beginning as early as the early 1900s.[14] Yet, it is in how he saw the relationship between technology, knowledge and labour, and his larger conception of the world that he shared much in common with his astronomical and political contemporaries, especially those who reached out to new public audiences

11 Pannekoek 1897a, 80.

12 Pannekoek 1961, 422. He credited amateurs with opening up new fields of astronomy, such as observations of shooting stars.

13 Pannekoek 1957.

14 Tai 2017. Pannekoek's influence in the field of Marxism continues to receive attention, following an upsurge of interest among a new generation of socialists and historians in the late 1960s. For more background on his politics see esp. Gerber 1989; Roth 2015; Boggs 1995; and Hoffrogge 2015. Reviews of Pannekoek's political writings are also useful, see, e.g. Lane 2005; Schurer 1963; Malandrino 1984; Souyri 1979.

beyond professionals (in the case of astronomy) and party leaders (in the case of politics).[15] For Pannekoek, as for other contemporary scientists, the essence of historical change was in technology:

> The basis of society – productive power – is formed chiefly through technology [...] Technology does not merely involve material factors such as machines, factories, coal mines and railroads but also the ability to make them and the science which creates this ability. Natural science, our knowledge of the forces of nature, our ability to reason and cooperate are all important as factors of production. Technology rests not only on material elements alone, but also on strong spiritual elements.[16]

Some glimpses of his thinking on this point can already be identified in the 1904 article 'Klassenwissenschaft und Philosophie', in which he called into question some tenets of orthodox Marxism. This article addressed two levels: 'an examination of the methods, meanings and objects of inquiry behind scientific knowledge; and an analysis of the position of science in human social and mental activity'.[17] Among the various forms of what the socialist philosopher Joseph Dietzgen (1828-1888) described as the 'thought activity' of a historical epoch, none had more importance for him than science – which, Pannekoek suggested, 'stands as a mental tool next to the material tools and, itself a productive power, constitutes the basis of technology and so is an essential part of the productive apparatus'.[18]

One outlet where Pannekoek's expressed his ideas about technology and knowledge was his writing on photography. Furthermore from 1908 to 1914, he wrote several articles for socialist papers with the intention of developing a body of popularized theory addressed to the average worker. As a Marxist, he faced the challenge of reconciling the need for a revolution with the idea of scientific progress: scientists believed that science was cumulative, at odds with the notion of revolution. In his writings from the first two decades of the century he held that the scientific disciplines of the nineteenth century were the 'spiritual basis of capitalism' yet at the same time that 'a certain form of science

15 On the professionalization of nineteenth- and twentieth-century astronomy in particular see, among others, Andrews and Siddiqi 2011; DeVorkin and Smith 2004; Heyck 1983; Pang 2002.

16 Pannekoek as in Gerber 1978, 9-10, n. 24.

17 Gerber 1978, 9.

18 Pannekoek 1948a, 19. Pannekoek played a major role in assuming Dietzgen's currency among rank-and-file working-class militants, see Gerber 1978, 4.

can be both an object and a weapon of class struggle'.[19] Historically, he thought, science had been subordinated to the requirements of class relations within a given social system. The science and technology of the socialist future would necessarily develop out of the foundations laid by previous scientific and social developments, but he lamented the fact that scientists in the twentieth century seemed isolated in their specialties or bearers of reactionary ideas.[20] By 1937, Pannekoek rejected determinism, and he believed that the key to socialist victory lay in a mental revolution amongst the working class, freeing them from their 'spiritual dependence' on the ruling class through the latter's control over the press, science, schools, and the church and the persistence of traditional ways of thinking, handed down 'in the form of prevailing beliefs and ideologies, and transferred to future generations in books, in literature, in art and in education'.[21]

'The Application of Photography was a Revelation'

Pannekoek regarded photography as a social and material technology – *techne* – and work with machines as a kind of labour.[22] Astronomy, in particular, he thought, rested on broad social and artisanal foundations, which became a major theme of his later writings in the history of astronomy. In *History of Astronomy*, for example, he explained:

> Astronomy profited from the increasing perfection of optical techniques developed on behalf of practical photography since its discovery in 1839. Laborious theoretical computations [by scientists] combined with the practical inventiveness of constructors [...] gradually creating a number of increasingly more perfect types of optical systems. [...] The demands for great brightness, an extended field, and faultless depicting could

19 Gerber 1978, 10.

20 Gerber 1978, 11.

21 Pannekoek as in Gerber 1978, 19.

22 For more on Pannekoek's photography, see Tai 2017, 226-230. Tai shows that, despite his contributions to astronomical photography, Pannekoek believed that photography could never replace human-eye observations (p. 226). By 1919, he had developed a method that would make photographic representation of the Milky Way possible through a technique of extrafocal photography. However, as Tai demonstrates (p. 228), unlike other photographs, his attempt was not to depict the Milky Way exactly: 'Instead, its purpose was for photometry, to provide numerical values for the brightness measurement of the Milky Way, which in turn could be used to construct isophotic maps.'

> not be met at the same time; [...] thus a wealth of different types has been invented and constructed. [...] Portrait objectives of larger angular aperture for the use of amateur photographers are found all over the world in thousands of cameras. [...] [I]n larger dimensions, they have been made especially for [astronomical] observatories, providing a new type of instrument that offered new aspects of celestial objects.[23]

While Pannekoek was not unusual in advocating the use of photography and other instruments in astronomy, he stood out from other scientists in his vocal and public advocacy of photography and in his effort to construct historical narratives about the role of machines and instruments in astronomical practice that included artisanal labour and collective achievement. According to Pannekoek, 'the application of photography was a revelation',[24] even if he also acknowledged the role of experience and subjectivity in photography, and its limitations compared to human-eye observation.

Pannekoek's extensive writings about photography of the Milky Way span from his earliest papers in the late 1890s, to his latest at the end of his career.[25] Although he praised visual observations of the Milky Way, he declared that the photographic method offered 'far greater wealth of detail', describing the difference between visual and photographic methods this way:

> We might describe the aspect the Milky Way would present to eyes that were far more sensitive to faint glares of light than ours and at the same time able to distinguish smaller details. A comparison with the focal photographs of Barnard and Ross shows a smoothing out of all sharp detail, thus gaining a true representation of the surface intensity which is lacking there.[26]

Photographs, Pannekoek stated, revealed 'the most picturesque aspect' of the Milky Way, 'the dark features, empty spaces almost without stars, often sharply defined.[27]

Ultimately, Pannekoek would devote around forty pages to the role of photography and photometry in astronomy in his *History of Astronomy*. He

23 Pannekoek 1961, 337.
24 Pannekoek 1961, 475.
25 See, e.g. Pannekoek 1897b; 1923; 1925; 1940; Pannekoek and Koelbloed 1949.
26 Pannekoek and Koelbloed 1949, 28.
27 Pannekoek 1897b, 39.

wrote that 'For a body so rich in detail as the moon, photography meant invaluable progress. A single photograph picturing the entire disc at once replaced hundreds of drawings that would have taken months and years at the telescope; moreover it was trustworthy as a document'.[28] Nevertheless, Pannekoek also recognized the failures and frustrations of photographic work:[29] 'A photographic atlas of the moon differs from a visual atlas, in that it gives the direct aspect of the moment with all its shadows; it is not a topographic map constructed by the astronomer out of a number of drawings at different phases.' For this reason, he thought, 'visual work should not be abandoned: many amateurs with good telescopes [...] continued their study of the details of special objects, chiefly to check the occurrence of small changes.'[30]

Pannekoek's drawings of the Milky Way – widely regarded as among the most accurate in the world at the time – were more than discovery tools, for exchanges among astronomers, however. Their reproducibility made them a critical part of the public's very image of astronomy and of science. In his lifetime, and partly under his influence, photography began taking on broader pedagogical, social, and conceptual aims: goals that in turn envisaged a much greater social role for science and scientists. On this reading, the 'revelations' of astronomy through the reproduction of photographs could be made available for wider projects (both socialist and humanist).[31]

For more than simply instructing people on the wonders of science and nature, Pannekoek and others also recognized that photographs of the Milky Way and other astronomical phenomena presented new opportunities for instilling visions of society and opening new possibilities for social progress. Over the course of his career his writings and lectures were filled with discussions about the productive value of labour in relation to the progress of knowledge.

28 Pannekoek 1961, 373.

29 He said that 'the work was never finished, because every succeeding year brought a new opposition, with new observations'; if this work were neglected, however, 'the predicted result would be more and more in error'. Pannekoek 1961, 354.

30 Pannekoek 1961, 374.

31 Beyond instructing people on the wonders of science and nature, Pannekoek recognized that depictions of the Milky Way and other astronomical phenomena presented new opportunities for instilling visions of society and opening new possibilities for social progress. Across Europe and the Soviet Union, exhibitions and public displays of astronomical phenomena, including planetaria, were being made to serve broader socialist and humanist goals. For more on the wider context, see esp. Benjamin 2006; Smolkin-Rothrock 2011; Strickland 2015.

Pedagogies of Science as Historical Narratives

Pannekoek quit the Communist International in 1921 and went into a self-imposed six-year long break from revolutionary politics. In 1921, he built an astronomical laboratory dedicated to teaching and research. Including the measurement and reduction of photographic plates of the Milky Way taken by other observatories throughout the world.[32] This research remained an important topic at the astronomical institute for the next couple of decades, even as Pannekoek redirected his attention to the newly emerging field of astrophysics of stellar atmospheres. Meanwhile, the political movement that he had led remained relatively small, and according to some historians, struggled to gain any support or relevancy.[33]

In his astronomical work and popular-science writings, as in his ongoing political work with workers' councils and left-wing politics, Pannekoek tackled questions of truth but also of visibility and epistemology: what could be known, and through what means. To Pannekoek, what mattered *was the integrity of the process itself – the scientific method.* From the middle years through to the end of his career, Pannekoek's continued correspondence with Communists and other labour activists provided an outlet for his critical reflections, as did his later widely read popular history of science writings.

Across the spheres in which he worked, his epistemic values were engaging with both Marxist theories of science and standard disciplinary norms within astronomy; albeit often in unpredictable and uneven ways. During the course of his life, a clear connection is exhibited between his ideas and values about science and the civic ideals that he upheld. It is manifest in his philosophical understanding of the public role of science and, even more important perhaps, in the way that he practised astronomy and wrote its history with a keen eye to its social conditions. Yet Pannekoek's ideas about science and Marxism, far from being idiosyncratic, must be seen as representative of a wider response to a wider set of rising ideas in Europe in the early twentieth century about practical astronomy, mass culture, and Marxism that others also shared.

32 By founding an astronomical laboratory, Pannekoek explicitly followed in the footsteps of Groningen professor J.C. Kapteyn. See Edward P.J. van den Heuvel, 'Anton Pannekoek's Astronomy in Relation to his Political Activities and the Founding of the Astronomical Institute of the University of Amsterdam', in this volume, 25-50.

33 Discussed in Gerber 1978; Hoffrogge 2015, among others.

History of Astronomy as a Vision of Politics and Society

Pannekoek's writings on the history of science clearly attest to his idea about the role of technology and astronomy in human history. History of science writing was a site of significant political debate in the 1930s and 1940s. Pannekoek's commitment to popularizing the scientific method in the wider public sphere and seeking to change the terms in which its role in society was understood, was a goal shared by many fellow Marxist scientists who also turned to history at around the same time.

In 1931, at a landmark event in many origin stories of the history of science, the Second International Congress of the History of Science and Technology took place in London, where the Soviets were represented by a delegation led by Nikolai Bukharin. It was here that Boris Hessen, the Soviet physicist and philosopher, presented his now famous paper, 'The Socio-Economic Roots of Newton's Principia', which became foundational in the history of science, opening the door to modern studies of scientific revolutions and sociology of science. In the paper, Hessen argued that Newton's work was not the disinterested study of the natural world, but was motivated by an attempt to solve the problems of the day.[34]

Hessen's focus on the relationship between society and science attracted significant attention, yet similar views had been expressed a year earlier by Pannekoek, in a paper that he published titled 'Astrology and its Influence on the Development of Astronomy' in *the Journal of the Royal Astronomical Society of Canada*.[35] There, he argued that scientific knowledge was embedded in the social and economic conditions of its time, especially in the case of astronomy. Indeed, he explained, 'For the other sciences, history is confined almost entirely to the last three or four centuries; their development took place within the walls of universities and laboratories, far from the convulsions of social and political life.' Their practitioners were always modern men whose traditions were similar to own. 'With astronomy matters are different', he said 'its history accompanies the development of mankind from its first beginnings.'

> Our predecessors were Babylonian priests and magicians, Greek philosophers, Arabian princes, medieval monks, Renaissance noblemen

34 On Hessen, see Freudenthal and McLaughlin 2009; Graham 1985.

35 Pannekoek 1930; this lecture was originally delivered in Dutch in 1916 as inaugural lecture in Leiden when Pannekoek started as unpaid lecturer in the history of astronomy, see 1916. I am grateful to Chaokang Tai for the reference.

> before they turned into modern university professors. For them the science of the stars stood not apart from their other opinions but was intimately interwoven with their philosophical and religious conception of life. In the sixteenth century the contest about astronomical truth was part of a struggle between world conceptions, and was deeply connected with the social struggles of that time. In this strife astronomy cleared the way for the freedom of scientific research more generally.[36]

He continued, saying that as astronomy was more closely shaped by practical necessities of life such as commerce and time reckoning:

> What was the reason that these primitive people turned their eyes to the stars and began to observe them regularly? Was it admiration of the beauty of the heavens, was it the dawning impulse of study to find out the cause of the phenomena? No, it was the hard necessity of life that induced them to look at the sky, the practical needs connected with their labour and intercourse with other people.[37]

He concluded by gently rebuking historians who dismissed the idea that astrology was founded on 'reasons from experience'. In fact, he retorted, 'modern writers are in the habit of speaking of old astrology as a regrettable aberration of the human mind, and of trying to wash the famous astronomers of history clean from the stain of having believed this superstition'. Yet 'nothing could be more false than this standpoint'. 'In our textbooks only that part of ancient astronomy is reproduced which coincides with the beginnings of our modern science. But in reality, the ancient science of the stars was in the first place astrology'.[38]

As a young astronomer, Pannekoek had struggled with what he saw as lack of the social relevance of his work. As he once wrote:

> Why can't I participate and find my place in the struggle? While everyone (?) contributes to improving the [social] conditions, I'm here, reducing meridian positions. Science is surely the only lasting and progressive factor in the changing of people and conditions. It must prepare for a

36 Pannekoek 1930, 159.
37 Pannekoek 1930, 160.
38 Pannekoek 1930, 169.

> better future: it is the reason why humanity has come to the point where it can enable her to become free and happy. But what mental gymnastics is required to follow the connection, in all its twists, between social happiness and reducing stellar positions.[39]

Pannekoek wrote this in a period before he moved to Germany, when he was a young aspiring astronomer and struggling with his political ideas. Now, he found history as a resource for answering this question. Pannekoek dedicated himself to writing popular histories of astronomy from 1930 onwards, becoming one of the discipline's leading chroniclers at a time when history of science itself was on the rise. In writing popular histories of astronomy, he sought to promote the status and progressive values of science in modern society. He also wanted to correct the popular image of astronomy as a labour-neutral endeavour; far from being otherworldly, astronomy was a science that was embedded in the rough-and-tumble of life, in contrast, he thought, to other sciences.

Pannekoek expressed the view that science was not an individual pursuit of knowledge, but a social activity; one in which the main idea was producing results through practice. He also emphasized the social-economic roots of science with early astronomy as a primary example. Pannekoek's popular writings about astronomy should be placed in the context of other contemporary Marxist writers on the history of science, including British counterparts like J.D. Bernal (1901-1971) as well as the Austrian philosopher of science Edgar Zilsel (1891-1944).[40] As a historical materialist, he affirmed the social origins of ideas, rather than stressing only the genius of individual men. The works of Ptolemy, Copernicus, Kepler, Newton, and Laplace were not epiphanies but 'consecutive steps in our knowledge of world-structure'.[41]

Advancing what historians might now recognize as a rejection of the 'Whig interpretation of history', Pannekoek contended that it was necessary for the historian to inhabit the worldview of the times, rather than assessing its strength or weakness from the standpoint of present understanding. This may be seen in his historical treatment of the importance of medieval astrology in the historical development of modern science. Pannekoek

39 See Anton Pannekoek, 'Wijsbegeerte en Politiek, Notebook 1898-11', June 1899, API, on 12. Translation by Chaokang Tai.

40 See Zilsel 1942. Although Hessen is generally brought up to do with Marxist accounts of the history of science, Zilsel gets discussed far less. Long 2011 has a section on Zilsel. I am grateful to Robert W. Smith for pointing out the relevance of Zilsel's work in this context.

41 Pannekoek 1961, 422.

argued that astrology and astronomy shared their basis in socioeconomic conditions: He asked:

> If we place ourselves a moment into the ideas of those times then what more sublime aim could there be imagined than to investigate and to discover the most intimate connection between men and the world, between the course of the stars and happenings on earth? [...] From this standpoint we will not be astonished to find most of the great astronomers of antiquity also believing in astrology.[42]

On Pannekoek's account, astrology, far from being a false vision, helped lay the foundations for the later development of modern astronomy with its careful and assiduous observation of irregularities with celestial bodies, including those of no use for calendar and travel. Instead of saying that Renaissance Europe was in the grip of false superstitions like astrology, limited to a few outlier magicians, he declared that the entire 'world concept' of medieval Europe was 'pervaded and dominated by astrology', a development that he linked with the facilitation of a spirit of 'wonder' that he connected with the rise of inductive science.[43]

In Pannekoek's later life, then, science and socialism finally came together in a direct manner. In his history of science publications he actively attempted to relate the study of astronomy with the practical needs and technological advances of the societies in which it was developed. He argued, for example, that the discovery of Neptune was much better received in France than in England because in France the bourgeoisie was still struggling for power and could make use of such a remarkable scientific achievement, while in England, the battle had already been won.[44]

For Pannekoek, the materialist conception of history was neither a fixed system nor a certain theory; it was a method of research that searched for the plausible causes of social developments.[45] Yet often, the focus of Marxist historians of the 1930s and 1940s was on economic factors such as ownership of the means of production, labour relations, and the distribution of capital. Pannekoek's research method, on the other hand, was to explain how ideas emerge as the result of economic, social, and ideological conditions. In

42 Pannekoek 1930, 170.

43 Pannekoek 1961, 176-177.

44 On the Neptune discovery and its interpretation, see Smith 1989; Hubbell and Smith 1992; and Bart Karstens, 'Anton Pannekoek as a Pioneer in the Sociology of Knowledge', in this volume, 197-217.

45 Tai 2017, 247.

particular, he put a strong emphasis *on the role of the mind in interpreting these material factors.* The role of the mind, he argued, differentiated historical materialism from mechanical materialism, which, according to him, reduced the entire world to the deterministic movement of particles.[46] Historical materialism was not limited to physical matter alone; instead, it was expanded to include anything that could have an objectively observable effect. As he wrote:

> The human mind is entirely determined by the surrounding real world. […] [T]his world is not restricted to physical matter only, but comprises everything that is objectively observable. The thoughts and ideas of our fellow men, which we observe by means of their conversation or by our reading are included in this real world. Although fanciful objects of these thoughts such as angels, spirits, or an Absolute Idea do not belong to it, the belief in such ideas is a real phenomenon, and may have a notable influence on historical events.[47]

Pannekoek emphasized what his contemporaries referred to as the 'mental' factors of materialism (e.g. tradition and religion). Only by removing the strict demarcation of mind and matter, did he think that society could be researched with scientific methods.

Pannekoek's *History of Astronomy* was published in Dutch in 1951, and later translated and published in English in 1961. It stands out from other contemporary works about the history of science in several respects. While it praised scientific achievements and instrumental advances, it did not focus on single individuals or great discoveries; instead, its central themes were the refinement of practice and theory, the struggles between 'world systems' of knowledge, and the relevance of geography, climate, and trade, and sociopolitical conditions as historical forces that shaped astronomical science and instrumentation. In his discussion of science in antiquity, he writes, for example, that 'What constituted the character strength of the Romans, their sense of social-political organization, created a mode of time-reckoning destined to dominate the entire future civilized world'.[48] In the book, he carried forward his ideas about the history of science beyond his papers on Neptune and astrology, and made his views accessible to a broader reading public.

46 Tai and van Dongen 2016, 66.
47 Pannekoek 1937, 451. See also Tai 2017, 248.
48 Pannekoek 1961, 146.

In a further nod to the importance of social and material practice in science, he also pursued a novel approach in his practice as a historian. This is reflected in his inclusion of images, a relatively novel departure from other general histories that were being published (on any subject) in the 1950s and 1960s: Pannekoek's popular history was unusually well illustrated with 24 historic maps, photographs and drawings. These images were not merely included for decorative purposes, they reinforced a central theme of the book: the centrality of visual observation and representation in the history of scientific practice.[49] Pannekoek wrote extensively about the importance of the practice of visual representation in the history of science. His *History* arguably contains some of the key historical analysis at mid-century of the role of observation, photography, and drawing in astronomy, including extensive discussions about the benefits of the photographic method in astronomy since 1839, from the first photographs of the sun and moon, to the 'first usable photographs of the starry heavens' in 1864, to the measurement of the position of stars in atlases and beyond.[50] He did not gloss over the practical challenges of photography, or discuss only its virtues. He emphasized the material practices that were associated with stellar photography and put the development of photographic methods in a wider historical context of societal changes, including the transformation of scientific *labour*. He wrote that 'Technical precision in electrical control of gigantic instruments is the material basis of modern astronomy', adding that 'Modern development of astronomical instruments would not have been possible without the growth of techniques in nineteenth-century industry, which revolutionized the entire aspect of society'. The astronomer's labour was like the driver of other colossal machines: 'the small brain of the huge steel organism'.[51]

Just as images were central to his practice of science, they were also central to his practice of history. Similarly, his emphasis on the importance of amateurs in his history of astronomy mirrored his discussion about the significance of amateur observation for opening up new fields in contemporary astronomy.[52] *History of Astronomy*, then, represented a return, in his historical writings, to some of the core epistemic concerns of his scientific writings.

49 Pannekoek's 1951 *History of Astronomy* resonates with British left-wing scientist Joseph Needham's later volumes of *Science and Civilisation in China* (1954-2015).

50 Pannekoek 1961, 337; see on photography, 345, 373-4, 405-6, 434-5, and 485-6; and on photometry, 385-6, 438, 440-1, 446, among others.

51 Pannekoek 1961, 338.

52 Pannekoek 1961, 422.

'The Scientific Worker in Overalls'

A second aspect that differentiates Pannekoek from other contemporary scientists who were writing about the history of science in the post-war period was his insistence on referring to scientists as *workers*. The theme of scientific research as a form of work, with its own relation to changing economic and social conditions, reverberates in his historical writings. In contrast to philosophers and historians who argued for science's internal logic of development (and although he did refer at times to the role of 'genius' in discovery) he refused to describe scientific enterprise as the mere unfolding of truth to superior intellects. The timing was crucial, for Pannekoek's thesis was in sharp contrast to C.C. Gillispie's historical narrative in *Edge of Objectivity: An Essay in the History of Scientific Ideas*, published in 1960, a year before the English edition of Pannekoek's *History of Astronomy*. Gillispie portrayed the rise of modern science as the development of objectivity through the study of nature. From Galileo's analysis of motion to the theories of evolution and relativity, Gillispie evoked personalities over instruments, and individual genius over collective labour.[53]

Pannekoek, on the other hand, complained that in publications of important scientific researches, the labour that had been involved was obscured. In a 1948 essay on Kepler's planetary theory, he praised Kepler for being different from others in this respect:

> Usually in the publication of new important researches only the results with the data and arguments are given; the discoverers keep to themselves how they arrived at them, their fruitless endeavours, their detours, their failures, and exhibit the result as a well-rounded harmonious structure, as a work sometimes of art, constructed straightforwardly, where all traces of the difficult searching have been effaced. Thus Copernicus, Newton, Laplace, Gauss. This is fine for study and admiration. But in this way outsiders get a wrong idea of the making of science; they do not suspect, what every scientific worker knows through his own practice, how many painful failures and long detours one must go through before finally the direct way is found which then afterwards is easily seen as the obvious truth.[54]

Kepler, by contrast, did not hide that, when he did science, he was *working*.

53 Gillispie 1960.

54 Pannekoek 1948b, 63.

> Kepler, differently, exposes his entire course of research, his errors, his false suppositions, and their disclosure, his perplexities and new endeavours, till the simple truth springs forward; all is laid open before the reader.[55]

And, perhaps in a more autobiographical mode, Pannekoek went on to discuss the fact that for years Kepler faced political battles and did not receive a salary. According to Pannekoek, Kepler's *Astronomia Nova*, showed 'a special character different from most of the great works of science'.[56] Kepler's book, Pannekoek argued, offered 'a true image of the growth of scientific discovery; here we see, as it were, the *scientific worker in overalls*'.[57] Pannekoek was talking here about the need for visualizing *astronomical work* – not simply celestial *phenomena*.

Pannekoek's distinctive position was noticed. The Harvard historian of science George Sarton (1884-1956) followed Pannekoek admiringly in his own foundational book in the history of science, *Introduction to the History of Science* (1927-1948).[58] Much later, British sociologist Barry Barnes, one of the founders of the strong programme in the Sociology of Scientific Knowledge, used Pannekoek's analysis of the discovery of Neptune in his account of Kuhn and scientific discovery.[59]

Conclusion

This paper has suggested that historical appraisals of Pannekoek require consideration of broad changes that transformed European astronomy in the early twentieth century, when wider public discourses and political debates focused intently on the role of science in society. Efforts to understand his life and work and to take account of both his scientific and political activities have faced the obstacle that Pannekoek himself tried to keep his two careers strictly separated. Another impediment to thinking about connections across his spheres of work may be that scholarship about the history of politics and history of science themselves both tend to engage

55 Pannekoek 1948b, 63-64.

56 Pannekoek 1948b, 63.

57 Pannekoek 1948b, 64; emphasis added.

58 Sarton 1927-1948.

59 Barnes 1982. See also Barnes 1974; Shapin 1982. For an assessment of these references to Pannekoek, see Bart Karstens 'Anton Pannekoek as a Pioneer in the Sociology of Knowledge', in this volume, 197-217.

separate literatures and assign importance to different facets of his life and career. Recently, however, new attempts have been made to discover links between Pannekoek's science and political ideology through a focus on his biography, including individual methodological decisions and epistemic beliefs or virtues.[60]

This work sees Pannekoek as embedded in the wider fabric of both radical politics and twentieth-century astronomy. Pannekoek engaged the publics of astronomy on many levels. From his early associations with the British amateur astronomers, through his contacts with British political figures such as Sylvia Pankhurst and other supporters of workers' councils in Britain, to his largely neglected prominence in the creation of the field of history and sociology of science in the UK, Pannekoek's explorations of the social conditions of science both shaped and reflected a large public vision of astronomy in a new age of contradictions and political tensions.

Anton Pannekoek straddled both science and social criticism: as a scientist, he was concerned with how we can learn about galaxies beyond our capacity to observe; as a socialist, he wondered how we can imagine and bring into being a better future society. Early in his astronomical career, he concluded that the involvement of a mass of amateur observers was one of the best methods of gathering data to plot the structure of the Milky Way. Similarly, as a socialist he later concluded that the involvement of large numbers of people through workers' councils was the best way to organize social decision-making – an approach that would leave him at odds with many of the centralized solutions favoured by the Bolsheviks who seized power in Russia. To better understand the relationship between Pannekoek's science and his politics, we need to reflect on the period in which he worked. This was a world, as these circumstances clearly illustrate, in which science and astronomy were seen as critical to the elucidation, not just of astronomical discoveries, but also of public understandings of its essence.[61] In his left-wing politics, as in his scientific research, Pannekoek saw history (in his words) as 'only a preamble to the future'. What occupied him and others in his political circle, was not so much the 'past in retrospect' but 'the outlook towards the future' when, in the study of the universe, as in the tumultuous political history of the early twentieth century, technology was the driving force of revolutionary change.[62] Only proper attention to the worker, in astronomy and elsewhere, could capture all developments.

60 Tai and van Dongen 2016; Tai 2017.

61 Pannekoek 1961, 496.

62 Pannekoek 1961, 483.

Archives

API Archive of the Anton Pannekoek Institute, University of Amsterdam.
RAS RAS Letters. Royal Astronomical Society.

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