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Revolutionary poetry and liquid crystal chemistry: Herman Gorter, Ada Prins and the interface between literature and science

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Abstract
In the Netherlands, the poet Herman Gorter (1864–1927) is mostly known as the author of the neo-romantic poem *May* and the "sensitivistic" *Poems*, but internationally he became famous as a propagandist of radical Marxism: the author of influential brochures and of an "open letter" to comrade W.I. Lenin in 1920. During the 1890s, Gorter became increasingly dissatisfied with his poetry, considering it as ego-centric, disinterested and "bourgeois", unconnected with what was happening in the real (material-political) world. He wanted to put his poetry on a scientific footing, notably by endorsing a dialectical materialist worldview. In the communist society he envisioned, science would become poetry and poetry would become science. In his opus magnum *Pan* (11,000 lines of verse, published in 1916), two terms are rather prominent, namely *heelal* ("universe") and *kristal* ("crystal"). These signifiers not only reflect important themes, but also two friendships which began around 1900, namely with prominent astronomer and marxist Anton Pannekoek (who studied the universe) and with Ada Prins, the first woman in the Netherlands who acquired a PhD in chemistry, specialised in liquid crystal research. Whereas Ada Prins is mostly remembered as one of Gorter's secret lovers, she was first and foremost his educated guide into the complex and enigmatic world of twentieth-century chemistry research. Liquid crystal chemistry became an important source of inspiration for Gorter's work and the main objective of this paper is to demonstrate her influence on Gorter's *Pan* as a scientific poem After presenting the two heroes of this paper, and their work in poetry and chemistry respectively, I will analyse the role of liquid crystals in Herman Gorter's *Pan*, highlighting important connections with Ada Prins' research into liquid crystal chemistry.

Keywords Liquid crystal chemistry · History of chemistry · Chemistry and poetry · Chemistry and society · Philosophy of chemistry

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Introduction

In the Netherlands, the Dutch poet Herman Gorter (1864–1927) is mostly known as the author of his neo-romantic poem *May* ("Mei", 4000 vs., published in 1889) and his "sensitivistic" *Poems* ("Verzen", published in 1890). Internationally, however, he is first of all known as a forefront revolutionary, a propagandist of radical Marxism, author of a famous "open letter" to W.I. Lenin (Gorter et al. 1920). During the 1890s, Gorter became increasingly dissatisfied with his poetry, considering it as ego-centric, disinterested and "bourgeois": as a form of art which seemed unconnected with what was happening in the real (material-political) world. He wanted to achieve what Zola (1880/1923) had done for nineteenth-century French prose, by putting his poetry on a scientific footing, notably by endorsing a dialectical materialist worldview. In the communist society he envisioned, science would become poetry and poetry would become science, so that the contradiction between the two would be sublated.

In his opus magnum *Pan* (11,000 lines of verse, published in 1916), two terms are rather prominent, namely *heelal* ("universe") and *kristal* ("crystal"), often appearing together, as rhyme pairs (Zwart 2019a). These signifiers not only reflect two important archetypal themes in *Pan*, but also two friendships which began around 1900, namely with the prominent astronomer and marxist Anton Pannekoek (who studied the universe, especially interested in the statistical distribution of stars in the Milky Way) and with Ada Prins, the first woman in the Netherlands who acquired a PhD in chemistry, specialised in liquid crystal research. While in the scholarly literature Gorter's friendship and collaboration with Anton Pannekoek received much more attention than his liaison with Ada Prins, this paper will focus on the latter. And whereas Ada Prins is mostly remembered as one of Gorter's secret lovers, I will argue that she was first and foremost his educated guide into the complex and enigmatic world of twentieth-century molecular research. Besides erotic "chemistry", chemistry as a research field was an important source of inspiration for Gorter's work. Ada Prins was involved in cutting-edge experimental endeavours: an area of research which eventually prepared the ground for Liquid Crystal Display technologies. Although her thesis was well-received and the version published in a German journal was frequently cited internationally (Prins 1909), her work all but disappeared from the annals of liquid crystal history, which tends to be presented as a men-only endeavour.[1]

The structure of this paper is as follows. First, I will outline the backdrop of their friendship: the period of four decades (between 1880 and 1920) during which both the arts and the sciences in the Netherlands suddenly thrived. Subsequently, I will briefly present the two heroes of this paper and their work in poetry and chemistry respectively. Finally, I will analyse the role of crystals in Herman Gorter's *Pan*, highlighting important connections with Ada Prins' research into liquid crystal chemistry.

[1] A short entry dedicated to her work can be found in *The Biographical Dictionary of Women in Science* (Ogilvie and Harvey 2000). Twenty-three citations to her 1909 publication (in German) are listed by Google Scholar.

Herman Gorter and the "second Dutch golden age"

The period of four decades between 1880 and 1920 is sometimes referred to as the "second" Dutch golden age (Willink 1991; Maas 2001a, b). After decades of mediocracy, the arts and sciences in the Netherlands suddenly thrived. In science, the list of Dutch Nobel Prize winners (first awarded in 1901) is indeed quite impressive at the beginning of the twentieth century, for a country of moderate size (Van't Hof in 1901, Lorentz in 1902, Zeeman in 1902, Van der Waals in 1911, Kamerlingh Onnes in 1913), while famous painters during this period include Vincent van Gogh and Jan Toorop. Dutch poetry (although less well-known abroad) likewise experienced a revival, exemplified by the wave of neo-romantic sonnets produced by the "Tachtigers" ("poets from the nineteen-eighties"). They represent an individualistic counterculture of purity, impressionism and ambivalence vis-à-vis the rapid modernisation of the Dutch socio-economical ecosystem (Ruiter and Smulders 1996, p. 10, p. 128). Their poetry was sensitive and egocentric, voicing aesthetic admiration for pristine nature in an era of industrial development. As their spokesman Willem Kloos phrased it, "Poetry is the most individual expression of the most individual emotion" (Janzen and Oerlemans 2017), and many of their highly personal emotions were triggered by nature phenomena. The highlight of the movement was the poem *May* (4000 vs.), published in 1889 by Herman Gorter. This poem is still generally acclaimed as the acme of Dutch impressionistic nature poetry, and was soon followed by Gorter's (more controversial and less successful) *Verzen* ('Poems'), published in 1890.

Thus, both the arts and the sciences profited from the zeitgeist of renewal and revivification during this period. As Ad Maas (2001a) argued, compared to scholars of previous generations, the scientific avant-garde of the Second Golden Age were seen as "hyper-individualists", much like their poetic counterparts. Initially, the world of neo-romantic literature and the world of technoscientific inquiry seemed completely disconnected.[2] Whereas cutting-edge research was closely involved in modernisation and rationalisation, the neo-romantic poems of the Tachtigers voiced a more distanced and ambivalent attitude towards the high-paced transformations of their socio-economic ambiance. And yet, the importance of social commitment was recognised on both sides of the divide. While many artists (including prominent Tachtigers, such as Frederik van Eeden) became increasingly interested in societal issues, many scientists likewise articulated the need for a "synthesis" to address the disruptive impacts of science and technology on society and culture (Baneke 2008).

Against this backdrop, Gorter himself soon became dissatisfied with his early, hyper-individualistic poetry. In the course of the 1890s, he began to see his debuts as ego-centric, disinterested and bourgeois, unconnected with what was happening on a broader plane. His aim became to put poetry on a more rational and scientific footing. As he later explained in a polemical essay written in response to Willem Kloos and entitled "the rational in the arts" (Gorter 1908/1949), he had come to see the science-poetry divide as a recent phenomenon, a symptom of "bourgeois" culture. Ancient Greek and Latin poetry had aimed to combine the two, giving voice to a poetic worldview that included ideas about the origin and basic constituents of the universe. Gorter not only mentions Lucretius as an example, but also Democritus: the author of a "philosophy in verse" (p. 294). He also emphasises the

[2] A notable exception is Charles Marius van Deventer (1860–1931), a Dutch chemist who was also interested in literature. He published in the literary journal *De Nieuwe Gids* (edited by Willem Kloos) and wrote a play about the Greek sage Thales.

intellectual dimensions of Dante's *Divine Comedy* and praises the novels of the French naturalists, notably Émile Zola, whose realism he highly appreciated (De Liagre Böhl 1996, p. 122). In short, Gorter came to discard the compartmentalisation between science and art as a symptom of bourgeois consciousness (p. 309) and as something which should be overcome.

Gorter's efforts to develop a new type of poetry initially urged him to study Baruch de Spinoza's *Ethica* (1678/1895), a philosophy classic which he translated into Dutch. Soon, however, he converted to socialism and Marxism. He became a prominent radical European Marxist, discussing international revolutionary politics with Lenin, Trotsky, Kautsky, Liebknecht, Luxemburg and others, and acquiring international influence, especially in Germany. His booklet *Historical materialism explained to workers* (Gorter 1908) may well have been the first Marxist text studied by Mao Zedong in China (Knight 2005).

In 1916, he published his opus magnum *Pan*, a 500-page poem (the extended version of a previous, smaller edition, published in 1912): more than 11,000 lines of verse, celebrating the imminent proletarian revolution and the advent of the communist era. Shortly after completing the first version, Gorter suffered a heart attack, the first of a series of attacks, to which he would eventually succumb (in Hotel Terminus in Brussels, in 1927). In the context of this momentous undertaking, Gorter tried to familiarise himself with early twentieth-century science.[3] This was quite a challenge for someone who, descending from a family of Mennonite pastors, had studied classical Greek and Latin but had only received rudimentary training in science and mathematics. In *Pan*, Gorter's exploits into science resulted in the abundant use of two key terms (exemplifying two archetypal themes), often occurring as rhymes, namely *heelal* ("universe") and *kristal* ("crystal") The importance of the signifier *heelal* is not surprising, as this term literally means "the whole" or "everything", which is also the meaning of the Greek title of the poem. And sometimes, Gorter depicts the universe *as such* as an immense crystal. On other occasions, workers are referred to as the living crystals of society, shining brightly in the obscure disruptiveness of capitalist nihilism. Whereas *heelal* conveys the holistic dimension of the poem, *kristal* captures the elementary, molecular level (Zwart 2019a).

The importance of these two signifiers is also reflected in Gorter's personal life, in the form of two close friendships which began around 1900, namely with Anton Pannekoek (1873–1960) and Ada Prins (1879–1977). Anton Pannekoek was an expert in quantitative astronomy and galaxy research (Tai 2017; Tai et al. 2019). He was notably famous for studying the statistical distribution of stars in the Milky Way and became founding director of what is now known as the *Anton Pannekoek Institute for Astronomy* of the University of Amsterdam. Like Gorter himself, he was a radical Marxist. Together, they became prominent international protagonists of a left-wing version of communism known as council communism, i.e. the view that a class-less society can neither be brought about by parliamentarians (social democracy), nor by vanguard elite revolutionaries (communism), but should emerge spontaneously, seeing workers' councils in factories as the paradigm of revolutionary organisation. This view was attacked by Lenin in his booklet *"Left-Wing" communism: an infantile disorder* (published in 1920), although he initially supported the idea (in fact, "soviet" means "council" in Russian).

[3] "Von der Tiefe seines Naturempfindens zeugt jede Seite seiner Dichtungen. Schriftsteller und Historiker durch Veranlagung … wusste er sich später in schwierige Fragen der Naturwissenschaft einzuarbeiten, um seine Weltanschauung allseitig auszubilden und zu begründen" (Pannekoek 1927, p. 2).

Ada Prins was a chemist, the first woman in the Netherlands to earn a PhD in chemistry (in 1908) and active in the budding field of liquid crystal chemistry. Remarkably, however, whereas the work and ideas of Anton Pannekoek are still well known among scholars interested in the history of astronomy and of the labour movement, the work and ideas of Ada Prins have been virtually ignored. If at all, she is solely remembered as Herman Gorter's romantic-erotic Muse,—one of Gorter's *two* extramarital Muses, in fact, for the poet was involved in two secret erotic liaisons, both of which he continued until his death in 1927. As a result, Ada's work as an expert in liquid crystals research and her influence on Gorter's poetry *as a scientist* came to be neglected. A gender bias seems at work here. While Anton Pannekoek is remembered for his intellectual achievements (both as a Marxist and as a scientist), the role of Ada Prins has been reduced to serving as an erotic source of inspiration.

The objective of this paper is to amend this bias. The friendship between Herman Gorter and Ada Prins was first of all an *intellectual* collaboration, I will argue, and the impact of Ada's scientific work in liquid chemistry on Gorter's revolutionary poetry deserves to be brought to the surface. Their "Wahlverwandtschaft" represented a remarkable instance of science-poetry "chemistry". Besides being a political (communist) poem, Gorter's *Pan* was first and foremost a *scientific* poem: a frantic effort to capture the revolutionary scientific insights that emerged during the first decades of the twentieth century in verse.

This, for instance, is an excerpt from Gorter's poem, reflecting his efforts to versify Pannekoek's work in astronomy, discussed in more detail elsewhere (Zwart 2019a). The translation is my own:

En duidlijk zag ik de lichte Sterstelsels	And clearly I saw the bright galaxies
En de donkre, en hun klare maalstroomen,	And the dark ones, and their clear maelstroms
En hoe hun maalstroom was het groot Heelal.	And how their maelstrom was the immense universe
En ik zag hoe het Licht werkte in 't Heelal:	And I saw how the light worked in the universe
Stroomen van Licht gingen er door de ruimte,	Streams of light went through the universe
Vloeden en terugvloeden, ebben en keer. -	Flowing back and forth, ebb and return –
Stroomen van Licht door de Oneindigheen	Streams of light through the infinities
Stuwden de stof heen voor het Lichten uit,	Propelling matter, pushing it ahead of the light,
Verzamelden de stof door kracht des Lichts,	Assembling matter through the force of light,
Deden oplichten Werelden door 't Licht. -	Making worlds light up by the light. –
De stof ebde wanneer het licht verstierf,	Matter ebbed away when the light died away,
De stof viel uiteen achter het licht aan. -	Matter disintegrated in the slipstream of the light. –
De donkre stof werd opgestuwd tot licht,	The dark matter was impelled into light,
Als schoone vlam, als baken in 't Heelal.	Like a bright flame, a beacon in the universe.
Het stof viel uiteen tot een donkren hoop,	Matter disintegrated into a dark heap,
Als blaadren in den herfst, in het Heelal. -	Like leaves in autumn, in the Universe. –
Werelden vergingen en brandden op,	Worlds passed away and burned away,
Weg in 't Heelal, weg voor goed in de ruimte.	Away in the Universe, forever lost in space.
Werelden schitterden in een nieuw licht,	Worlds glittered in a new light,
Stralend in jeugd en van onsterflijke	Gleaming in youth and of imperishable
Schoonheid: Het Heelal (p. 119/123).	Beauty: the Universe

Rather than on stars and the Milky Way, however, this paper will focus on the role of crystals in Gorter's poem, and on the extent to which his poetry echoes the scientific work of Ada Prins. Before doing so, I will first present the concise bios of the two protagonists and briefly summarise the history of their friendship.

Who was Herman Gorter? Who was Ada Prins?

Gorter's biography is quite remarkable, if only because we seem to be dealing with two completely different persons.[4] As was already indicated, in his home country Herman Gorter (1864–1927) is primarily known as the author of *May* and *Poems*, two outstanding works of art still read and studied by literary scholars. Outside the Netherlands, however, his poetry is virtually unknown. Here, he is first and foremost known as a famous revolutionary, a propagandist of radical Marxism, author of influential Marxist brochures and engaged in a polemics with Lenin himself, both verbally and in writing (De Liagre Böhl 1996, p. 11). His massive opus magnum *Pan*, in which both dimensions converge into a synthesis (a total work of art), remains virtually unread up to this day (Sonnenschein 2012, 2018; Zwart 2019a).

Gorter's father had been a Mennonite pastor and a gifted journalist, who published about the prophet Jeremiah. After his premature death, Herman's mother kept a boarding house in Amsterdam, while Gorter studied classical Greek and Latin, defending his thesis on metaphors in Aeschylus in 1889. Shortly after, he accepted a position as a gymnasium teacher in Amersfoort and married Wies Cnoop Koopmans in 1890. He soon became dissatisfied with his formal profession, however, and decided to work at home as a private teacher, providing tutorials in classical languages to students who were preparing themselves for their formal state exams: a mandatory requirement for entering a university. Besides this source of income, Gorter and his wife lived off the inheritance of Wies' wealthy father, who died in 1895.[5]

Two female students tutored by Gorter became secret lifelong lovers. Ada Prins (born in 1879) started her lessons in 1899 in preparation of her studies in physics and chemistry at the University of Amsterdam, where she defended her thesis in 1908. This thesis (written in Dutch) was entitled *Vloeiende mengkristallen in binaire stelsels* ("Liquid mixed crystals in binary systems"). It presented the results of quantitative experimental work in a cutting-edge research area and was well-received by experts.[6] Later, she became a high-school teacher and part-time assistant professor at Leiden University, and published two manuals on analytic chemistry (Prins 1919; Prins and de Groot 1927). Gorter managed to persuade her to reject

[4] Something similar applies to Anton Pannekoek who kept his socialist activities and his scientific career at a distance, and ended up writing two separate autobiographies: one focusing on his involvement in the communist movement, the other discussing his astronomical research (Tai et al. 2019, p. 9). Thus, Pannekoek's memoirs (in Dutch) symptomatically consist of two separate parts: "Memories from the workers' movement" and "Astronomical memories". The tension between his two careers culminated in 1918, when he was about to be appointed as director of the Leiden Observatory. The Dutch Minister of Education intervened because Pannekoek had also been appointed as honorary member of the Hungarian workers' council, proclaimed by Béla Kun that same year. Instead, Pannekoek accepted a position as lector offered to him by the University of Amsterdam (van Berkel 2001). A mirror event was Albert Einstein's visiting professorship at the University of Leiden in February 1920. The appointment was significantly delayed because he was mistaken for Carl Einstein, an avant-garde art critic and radical revolutionary, living just a few blocks away from Albert Einstein in post-war Berlin (Van Dongen 2012).

[5] Ironically, this legacy became worthless after the Russian Revolution (De Liagre Böhl 1996, p. 455), so that Gorter (a widower by now) was forced to sell his house to Jenne Clinge Doorenbosch (one of his two lovers, whom he appointed as his heir). He also lent considerable sums of money from befriended wealthy capitalists, without repaying them, such as the Bendien family (textile manufacturers from Twente) and Ada's brother, the shipbuilder Huibert Prins (Stuiveling-van Vierssen Trip 2003).

[6] As biographer Herman De Liagre Böhl points out, unlike Gorter's own dissertation, which failed to please his supervisors, Ada's thesis received general recognition in university circles, providing her with optimal prospects for a scientific career (1996, p. 282).

Ada Prins and Herman Gorter in front of a panel with painted mountains (1917); Source: geheugen.delpher.nl (Literatuurmuseum); Signature: G 06041 II 011 / NLMD02. https://resolver.kb.nl/resolve?urn=urn:gvn:NLMD01:262414406. Permission obtained (attached) on April 17 2020

marriage requests from other suitors, but kept her in the dark about his friendships with other women, notably with Jenne Clinge Doorenbos.

Jenne Clinge Doorenbos was born in 1886 and started her lessons with Gorter in 1908, in preparation for her studies in Oxford. Eventually, she became a translator (Frerichs 2014). Their liaison began in 1910. After the death of Gorter's wife in 1916, she expected a formal marriage, but when Gorter declined (refusing to give up Ada), Jenne fell seriously ill. She suffered from heavy fatigue for several years and had to be nursed in sanatoriums (De Liagre Böhl 1996, p. 454). Gorter did appoint her as his heir, however, and she supervised the publication of his collected literary writings after his death. Both women met for the first time in 1927, at Herman's funeral. In retrospect, Gorter's practice as a private teacher worked as a trap for these young, ambitious women who, in order to be admitted to the university, were forced to pass this obstacle. Gorter's letters to Ada and Jenne were published some years ago (Frerichs 2014), but only Gorter's own letters were preserved, for he had the habit of destroying all letters he himself received. This not only applied to his love letters, however, but to all other forms of correspondence as well, so that, while Gorter's letters to Lenin were preserved, Lenin's letters to Gorter disappeared without a trace (Stuiveling-van Vierssen Trip 2003).

The remarkable role of crystals in Gorter's *Pan*

In *Pan,* Gorter envisions the communist metropolis as a New Jerusalem, whose centrepiece is a gigantic conference hall: the meeting palace of the people. Gorter describes how, guided by the Golden Girl, the god Pan enters this amazing building:

En zij gingen naar binnen en zij hoorden…	And they went inside and heard…
Der wetenschap de juiste en helle akkoorden:	The clear and precise chords of science:
De Wetenschap was Poëzie geworden (p. 398/447)	Science had become poetry

This is a crucial phrase for understanding was *Pan* is about (Zwart 2019a). Besides being a political poem, Gorter's *Pan* is a poetic laboratory where recent insights in crystallography and astronomy are versified. The poet aspires to demonstrate how, under communist conditions, science as such will be transfigured, will *sublimate* into poetry, while poetry becomes science. In dialectical terms: in the future state of communism, the science-poetry divide will be "sublated" (*aufgehoben*).

It is against this backdrop that the many sections on crystals must be considered. Here are a few examples (the translations are again my own):

En zoo daalde Pan langzaam naar de aarde, Trapsgewijze, naar hare groote gaarde, Uit het klare en kristallen kristal. En eerst kwam hij, in het oneindig licht, In het doorstreepte kristal waar de Goden Zich nog schoon en schemerachtig ophouden… (p. 47/26)	And thus, Pan descended towards the earth Stair by stair, towards her great garden Out of the crystal-clear crystal. And initially he came, in the infinite light, In the striped crystal where the gods Still beautifully and dimply dwell
En Pan hoorde toen de oneindige mensen In 't oneindig Heelal, en zonder grenzen, Hoog in het donkerblauw eeuwig Heelal, In zijn oneindig lichtende **kristal**. En hij daald' neder naar de donkre menschen Uit het Heelal, uit de oneindige grenzen Van het Licht, der Muziek, en uit de Vrijheid Der Natuur, het oneindige Heelal, Het eeuwig bloeiende **Natuurkristal**… (p. 63/43)	And Pan discerned infinite humanity In the infinite, boundless universe High-up in dark-blue space In its infinitely bright crystal, And he descended towards dark humanity From the Universe, from the infinite limits Of Light, of Music, and from the Freedom Of Nature, the infinite universe, The eternally flourishing nature-crystal
Zoo zag ik de slaven gaan. Als stralende **kristallen.** Wat zijn d' Arbeiders anders dan **kristallen**? Welk onderscheid is tusschen hen en **kristallen?** Men zegt het leven. Leven **kristallen** niet? (p. 114/116)	Thus, I saw the slaves move on, like bright crystals For what would the workers be but crystals What would be the difference between them and crystals? Life, they say. Aren't crystals alive?

In Gorter's poem, crystals first of all exemplify physical and chemical perfection, as gleaming particles, on the verge of life. Amidst a sinister terrestrial ambiance (Capitalism), glittering crystals emerge as little stars or flowers. For Gorter, the proletarian workers are the crystals of society. Indeed, a strong connection can be discerned between *crystal* and *worker* in *Pan*. Both workers and crystals are elementary substances, are bodies *and* souls, pushed by the same dialectical laws towards a higher level of order and perfection. As Gorter's friend and biographer, the socialist poet Henriette Roland Holst van der Schalk points out, workers are envisioned in *Pan* as the brightly shining, colourful crystal atoms of the social system (1975, p. 139). In the communist society of the future, they will no longer be dragged along by the unrestrained movements of industrial machinery, as "scattered

atoms" (Gorter 1908), but will be perfectly arranged in immense meeting palaces of the people. Indeed, in Gorter's poem, communism becomes a crystallography or choreography of the masses, turning society into a dialectic-materialistic artwork. During their violent uprising, thousands of proletarian crystals are consumed by fire, sacrificing themselves on the killing fields of the revolution, but in the paradisiacal future state, the glorious dance of the communist workers will be joyfully orchestrated. Thanks to the coming of the communist revolution, the whole universe will participate in this transfiguration, will spiral towards perfection. The proletariat will crystallise into a future humanity, while capitalism transmutes into a perfect society, a golden era.

In the next section, the focus of attention will shift from Herman's poem to Ada's thesis. The quotes cited above should be kept in mind, however, notably the final one:

Zoo zag ik de slaven gaan. Als stralende kristallen. Wat zijn d' Arbeiders anders dan kristallen? Welk onderscheid is tusschen hen en kristallen? Men zegt het leven. Leven kristallen niet? (p. 114/116)	Thus, I saw the slaves move on, like bright crystals For what would the workers be but crystals What would be the difference between them and crystals? Life, they say. Aren't crystals alive?

The work of Ada Prins on liquid crystals

That Herman Gorter was highly impressed, intimidated even, by Ada Prins' scientific work is beyond doubt.[7] In his brochure *Historical materialism explained to workers*, Gorter explains how modern technoscience revolutionises every realm of human existence. Revolutions are not only taking place in society at large, he argues, but first and foremost in industry, where inventions are no longer the products of chance, nor the work of brilliant individual geniuses: they are brought about collectively, by highly trained brain-workers. And the most elevated site of change, according to Gorter, is the scientific chemical testing station, the chemistry laboratory: precisely the kind of place where Ada was performing her daily work. Her topic (liquid crystals) may seem exotic at first glance, but was actually part of a research field which eventually evolved into the information display technologies that have become so ubiquitous today.[8]

At that time, however, liquid crystals drew the attention of chemists notably because they seemed to constitute the intermediary stage between inorganic and organic nature. Their shape and behaviour seemed to mimic primitive organic structures. Therefore, they were described as "apparently living crystals" (Snelders 1997). Although most of the work was done in Germany, liquid crystals also caught the attention of a Dutch researcher, Professor Hendrik Willem Bakhuis Roozeboom (1854–1907) of the University of Amsterdam, who asked his talented student Ada Prins to investigate some aspects in more detail. As he died in 1907, his successor (Andreas Smit) became her supervisor and she successfully defended her thesis in 1908.

[7] "You are now studying those abstruse and incomprehensible cobweb formula? You are so much cleverer than I am" (Letter to Ada, June 1902, Frerichs 2014, p. 12); "About chemistry… I know *nothing*, *naught*"(Letter to Ada, 11 November 1913; Frerichs 2014, p. 234).

[8] "The liquid crystal display or LCD is seemingly everywhere, apparently arriving from nowhere Dunmur and Sluckin (2011, p. xvi)".

The story of liquid crystal research began in 1888 when Friedrich Reinitzer unexpectedly observed "two melting points" for cholesteryl benzoate crystals extracted from the root of a carrot (Mitov 2014, p.1245). At the first melting point, the solid state turned into a milky fluid. At the second melting point (the "clearing point"), the material became perfectly transparent, while upon cooling it exhibited violet and blue colours, which soon disappeared again. Reinitzer consulted Otto Lehmann (1855–1922) who worked at Aachen university and who had developed a special crystallization microscope to enhance his studies.[9] Triggered by Reinitzer's findings, the "flowing crystals" immediately caught Lehmann's attention.[10] He became a prominent liquid crystals pioneer, presenting them as a fourth, intermediary state of matter, between liquid and solid (rather than as a mixture of the two). For Lehmann, liquid crystals constituted an ontological singularity (Lehmann 1906; 1907). They represented a fourth mode of material being, besides the three states of matter (the solid, liquid and gaseous state) that had already been distinguished by Aristotle, twenty-five centuries ago (earth, water, air). In short, liquid crystals were replacing a traditional, Aristotelean view on nature (based on stable, clear distinctions) with a more Heraclitean one: *everything flows*, including crystals (Dunmur and Sluckin 2011). X-ray crystallography did not yet exist at the time, however, and the majority of chemists considered crystallinity and fluidity as logically and physically incompatible: as an ontological oxymoron, so that Lehmann's heterodox views met with much scepticism among colleagues.

Influenced by the work of Ernst Haeckel, moreover, German experts such as Lehmann became convinced that liquid crystals had played a crucial role in the origin of life (Lehmann 1906, 1907). Many of these crystals seemed to move, grow, spread and recuperate in ways comparable to lower life forms. This strengthened the idea that liquid crystals were "seemingly" alive, were behaving "as if" alive, although Lehmann, much more than Haeckel, emphasised the *as if* (Brandstetter 2011). As Mitov (2014) phrases it in his short history of liquid crystal chemistry: seen through a microscope, nematic liquid crystals (the ones that are currently used in flat-panel displays) seemed to resemble a school of fish (p. 1245). They seemed to have "a life of their own" (Dunmur and Sluckin 2011, p. 126). Both crystals and organisms grow, and liquid crystals often grow from a nucleus, absorbing foreign materials, while their shapes resemble living forms (p. 130). Mobile fluid droplets with nuclei inside sometimes coalesce ("copulate", as Lehmann phrased it). They seemed to be able to move on their own accord (p. 131). These observations met with widespread scepticism, but were eagerly endorsed by Ernst Haeckel (p. 132). Lehmann's drawings and pictures (both careful and startling) provided supportive evidence for his claims. Notably, he used cinematic series of pictures of liquid crystals which not only captured their life-like forms but also their life-like movements (Brandstetter 2011). He even envisioned that, in the future, liquid crystals would enable the development of new visualisation technologies, relying on semi-liquid materials and therefore better equipped to convincingly convey the movements of living and seemingly living entities (Brandstetter 2011, p. 120).

[9] Otto Lehmann had a keen interest in the technical part of his research. He not only built his own microscope, but also published a book about constructing research contrivances yourself (DIY technology) (Lehmann 1885).

[10] As Dunmur and Sluckin (2011) rightfully point out, Otto Lehmann had a literary precursor in Edgar Allan Poe who, already in 1843, described an island with liquid crystal waters, presenting to the eye, as they flowed, every possible shade of colour (Poe 1838/1982, p. 705). French philosopher and historian of science Gaston Bachelard casted Poe as an "explorer" and "genius" of the imagination who developed a "poetical chemistry" (Bachelard 1942/1947, p. 63; Zwart 2019b).

Thus, according to Otto Lehmann, liquid crystal molecules not only often looked like nematode worms or cells. Their behaviour, the division and "copulation" of crystals drops, seemed reminiscent of similar processes in living beings (Snelders 1997, p. 135). Liquid crystals seemed to display a formative force (*Gestaltungskraft*, Snelders 1997, p. 143). And this concurred with Haeckel's controversial but influential conviction (building on Goethe's ideas concerning "elective affinities") that, like all atoms, crystals are animated entities endowed with a soul: an *Atomseele* or atom-soul (Haeckel 1917). The more complicated and advanced the crystal is, the more "soul" it has. This scientific version of panpsychism concurred with Spinoza's idea that all entities are part of the world-substance, with *body* and *soul* as attributes. Although such ideas were discarded as highly speculative by sceptics, Haeckel and Lehmann intuited contemporary insights concerning the extent to which liquid crystals are indeed involved in a plethora of cellular biological processes (Mitov 2014, p. 1248).

Crystals in poetry and science

Similar ideas also reverberate in Gorter's poem, which literally raises the question whether crystals are "alive", as we have seen. In *Pan*, workers are "troops" of living crystals, flowing through greyish urban environments, moved by "unknown forces". Although apparently soulless, on closer inspection both crystals and workers are endowed with a soul (Gorter 1916, p. 116; 1916/1951, p. 114). They emerge and fade away like flowers or snowy crystals in a dreary landscape, like stars, while stars are likewise envisioned as gigantic crystals flowing through galaxies. In Gorter's view, and in accordance with the core convictions of council communism, the communist society of the future should emerge spontaneously (bottom-up as it were), through processes of self-organisation, through spontaneous crystallisation. Once Capitalism had been eliminated, optimal conditions would be in place for initiating a drastic renewal of human life on Earth.

Ada Prins was an expert in analytical chemistry. Stylistically, her thesis was evidently more prosaic and less imaginative than Gorter's poem. Her thesis was published in 1908, the year which, according Kelker (1973), represented a transition point in the history of liquid crystal research between the first stage (from the middle of the 19th century until 1908), when "descriptive monographs" were written, into the second stage (from 1908 to 1922): the era of systematic experimental work. In terms of style and design, Ada's thesis clearly represents this second stage. Although she discusses Lehmann's monographs and the work of other predecessors in a short historical overview, she abstains from philosophical reflections concerning the origin of life and other more speculative topics, strictly focussing on her quantitative experiments. She does mention, however, that the occurrence of characteristic crystal properties in liquids is still seen by many as "un-logical" (p. 3). Scientifically speaking, the term liquid crystal was considered oxymoronic. It suggested that a substance can be in two different states (solid and liquid) at the same time. Normal crystals are solid, not liquid, and whereas crystals are characterized by *order* (as regular, periodic structures), a liquid is typically *disordered*. Whereas normal crystals typically assume regular geometrical shapes, liquid crystals seem to flow and spread more randomly. Liquid crystals therefore combine properties of crystals with properties of liquids.

Let me now highlight some aspects of Herman's poem which seem to reverberate with liquid crystal chemistry. In Gorter's *Pan*, workers in capitalist society likewise represent a transitory stage (Canto II and III). They are set in motion, they move and flow, but initially

in a disorganised manner. The question is when these random, blurry movements will reach a clearing point as it were, so that the cloudy fluid becomes colourful and clear, becomes political choreography. This requires a massive and dramatic chemical reaction in the urban crucible of Canto IV. Finally, in the communist paradise, as envisioned in Canto V of *Pan*, we see workers (the shining crystals of society) interacting in a playful manner: *homines ludens* thriving in a socialist ecosystem, but this is the end result of a series of dramatic changes: from stability via disruption and turmoil to stability on a higher level of organisation.

According to dialectical materialism, similar dialectical patterns can be discerned in nature and society (Zwart 2020). Dialectics governs both natural and human history, and it is tempting to discern parallels with Ada's work, in the sense that liquid crystal chemistry offers vivid metaphors for a poetic versification of social change. Crystal fluids have two melting points, as we have seen: temperature T_1 (when their state changes from solid crystal to liquid crystal) and temperature T_2 (the clearing point, when their state changes from liquid crystals to isotropic fluids). From a socialist perspective, this may indeed be seen as a metaphor for societal transitions. A situation of relative stability (agricultural society) gives way to the troubled state of Capitalism (as depicted in *Pan*), until the clearing of communist society (as envisioned in *Pan*) finally sets in. In Canto I, the god Pan is drawn towards planet Earth because something is about to emerge in this global political "laboratory". In Canto II and III, Gorter depicts, in dreary colours, the troubled state of Capitalism, but in Canto IV, as the temperature (the dramatic tension) rises, brightly shining crystal molecules begin to appear, albeit dramatically consumed by politico-chemical turmoil. Until in Canto V a miraculous transition suddenly happens. The sordid dreariness of Capitalism suddenly gives way to the glaring brightness of Communism, where new technologies function perfectly, to the benefit of humankind. Human existence now becomes a playful dance, while research and poetry become happily fused ("lost in each other"). Gorter was trying to envision a new type of machinery, working silently and automatically, hands-free as it were. Meanwhile, Ada was actually contributing, albeit in a much more hands-on manner, to a research practice which, several decades later, would enable the development a completely new type of technology.

An important aspect of liquid crystals, which drew Ada's attention, were their "beautiful colours" (p. 8, etc.). Although liquid crystals tend to be cloudy during their intermediary state (between the two melting points), they may suddenly change colours as the temperature varies and Ada was quite struck by the "colour phenomena" these liquid crystals display (p. 72, p. 84): their "violet-blue colour", their "most beautiful green and red colours", their "violet twilight colours", etc. Depending on the temperature, liquid crystals may suddenly emerge as "shining individuals" within grey and dreary molecular "masses" (p. 74). Ada points out in detail how liquid crystals can be "green-yellow coloured, but with red stripes between them". She describes how "brilliant" and "striking" green, red and violet colours may suddenly be spotted in a cloudy fluid (p. 88, p. 90), and how "green and yellow stripes", "vivid green and red coloured dots" can suddenly be seen. While the temperature is modified, a beautiful green colour may suddenly spread across one's field of vision, and so on.[11] This concurs with how workers are depicted in *Pan* as well, namely as

[11] It is interesting to point out that, while Ada Prins was fascinated by the colour phenomena of liquid crystals emerging amidst milky fluids, Anton Pannekoek was likewise fascinated by the visual aspects of the Milky Way, with its bright spots and dark dust clouds, which he captured in careful and beautiful drawings of artistic quality, as studied by Tai and colleagues (Tai 2017; Tai et al. 2019).

brilliantly shining crystals, as colourful stars or flowers, suddenly coming forward out of the dreary darkness of an industrial urban environment and then dissembling again.

While Ada Prins was conducting her research, the Merck company in Darmstadt (Germany), who had been supporting Lehmann's work since 1904, was beginning to discover the commercial potentials of these colourful liquid crystals. Already in 1907, they were advertising and selling liquid crystals for analytical work in research laboratories (Kawamoto 2002, p. 462). But it was not until the 1960s that Japanese and American engineers, using the colour properties so vividly described by Ada Prins, initiated the development of Liquid Crystal Displays, for gadgets such as pocket calculators. Compared to previous technologies, such as light-emitting diodes (LEDs), LCDs used much less energy and proved much friendlier to the human eye. As Mitov (2014) phrases it, from the mid-1970s onwards, liquid crystals "revolutionized" the worldwide information display industry. Ada Prins was not directly involved in this. She defended her thesis at the time of the shift from the initial (explorative and speculative) stage of liquid crystal research towards a more experimental one, as we have seen. In het sober reports, she refrains from making comments on speculative issues such as the origin of life. Still, her keen appreciation of colour phenomena is interesting in retrospect, given their current technological use in information display technologies.

Liquid crystals and the origin of life

Successful technological applications of liquid crystals in crystal display technologies have obfuscated the fact that the interest of the first generation of liquid crystal researchers was notably triggered by their possible role in the origin of life. As was already mentioned, Lehmann devoted several publications to liquid crystals and their "life-like" behaviour ("Flüssige Kristalle und ihr scheinbares Leben", Lehmann 1921). Most inorganic materials are aggregates of crystals, he explains, but the common use of the term "crystalline individuals" already points to similarities between the growth of crystals and living beings. The analogies between the forces that shape both liquid crystals and living entities led Lehmann to describe them as "seemingly alive", while Ernst Haeckel (1917) really attributed life to them. One day, Lehmann argued, these analogies may reveal a link with biocrystals in living organisms.

These deliberations were also highly relevant from a philosophical, more precisely: dialectical perspective. Hegel already discerned a "semblance" of life in chemical processes (1830/1983, § 335). In contrast to (infinite, inorganic) chemical processes, Hegel argues, life is a self-sustaining chemical process (§ 336). Whereas inorganic substances are continuously exposed to entropic, pulverising pressures, living beings (although similarly exposed to the forces of "negation") are able to endure the tension (to "negate" this negativity) and to maintain themselves for quite some time. This raises the question where exactly the link between the inorganic and the organic can be found, and for some of the early pioneers, liquid crystals seemed to fill the gap. In his *Dialectics of Nature*, Friedrich Engels (1925/1962), explicitly inspired by Hegel, likewise considered the missing link between chemistry and life (Zwart 2020). According to Engels, it is inevitable, dialectically speaking, that scientists will one day artificially produce biomaterials, notably albumin (egg-white) in their laboratories, so that chemistry will become *bio*-chemistry. Engels' views concurred with those of his scientific friend, the "red" chemist Carl Schorlemmer, who likewise argued that organic chemistry will one day

synthesise sponge-like, albuminous compounds artificially (1879, p. 122). And should chemists succeed in this, he argues, these albuminous bodies will be in the state of living protoplasm, perhaps even "in the state of those structureless beings which Haeckel calls the *Monera*" (Schorlemmer 1879, p. 122).

Initially, liquid crystals became a focus of scholarly interest against this backdrop: the desire to understand the origin (the *generatio aequivoca*, the spontaneous generation) of life (Marx and Engels 1983, 3, p. 339). In the course of the twentieth century, however, the focus of attention gradually shifted from liquid crystals to RNA and DNA bio-polymers. For quantum physicist Erwin Schrödinger (1944/1967), the aperiodic biopolymer now known as deoxyribonucleic acid (DNA) replaced liquid crystals as the bridge between the organic and the inorganic (Zwart 2013). But in recent years, research into the role of liquid crystals in the origin of life on Earth has met with a revival. In 2014 for instance, in the journal *Liquid Crystals*, Gordon Stewart (2014) argued that a number of naturally occurring liquid crystalline substances possess the ability to polymerize and replicate spontaneously and to perform a number of metabolic functions associated with plankton and other primitive life forms that once may have emerged in prebiotic terrestrial pools, where interaction in ecological niches may have promoted biochemical evolution and self-organisation. These phenomena, Stewart argues, reveal "plausible, natural mechanisms" that can be causally linked to "early steps in animation of matter" (p. 443).

Research groups are currently studying how liquid crystals polymerise into RNA (ribonucleic acid) chains via self-assembly in a non-enzymatic (spontaneous) manner (Todisco et al. 2018). They aim to understand the "spontaneous formation of nucleic acid polymers" (p. 9750) by studying non-enzymatic reaction pathway based on supramolecular assemblies that favour the formation of long linear RNA chains via polymerisation of liquid crystals. This type of work is carried out against the backdrop of the "RNA world" hypothesis (p. 9751), which posits a hypothetical stage in the early evolution of life on Earth in which self-replicating RNA molecules proliferated before the evolution of DNA and proteins.

Liquid crystals took a long time to discover, not only because of their size, but also because they are notably found in living things which, because of their complexity, are less open to in vitro manipulation that inorganic substances tend to be, so that more insight and dexterity is required. Many biological structures, notably cell membranes, are composed of liquid crystals (Dunmur and Sluckin 2011). Eduard Kostetsky, explicitly referring to the "revolutionary idea" of Marxist researcher John Desmond Bernal (1951) that the living cell is "per se a liquid crystal", calls the cell "an aperiodic, homeostatic, self-regenerational liquid crystal" (Kostetsky 2005, p. 608, p. 634). Thus, in a number of recent publications, crystal liquids are once again seen as a key step in the process which led to the origin of life, so that the ideas of liquid crystal pioneers (Haeckel, Lehmann, etc.) seem very much alive again. Ada Prins, however, exemplified a stage in liquid crystal history when the focus of attention shifted from quandaries concerning the origin of life to the colour phenomena associated with them.

Whenever we use mobile phones or colour TVs, we are actually using technologies for which generations of researchers including Ada Prins prepared the ground. My argument is not that we should credit her in retrospect for having significantly contributed to the development of LCD technologies. As was already indicated, when writing her thesis, the spectacular successes of LCD technologies were still decades away. And contrary to previous researchers such as Otto Lehmann, she consistently refrained from speculation. Still, when rereading her 1908 thesis from a contemporary perspective, her fascination with colour phenomena of liquid crystals is quite fascinating, in view of these later developments.

Reflection

Like most science histories, tales about liquid crystal history tend to be androcentric. In the historical publications about liquid crystals consulted by me (Kelker 1973; Kawamoto 2002; Sluckin et al. 2004; Brandstetter 2011; Dunmur and Sluckin 2011), male scientists are predominantly given the floor, and Ada Prins is mentioned only once (by Kelker). According to the traditional narrative, while science history is allegedly made by "great men", women primarily feature as spouse, friend, lover, muse or nemesis: e.g. Watson's staging of crystallography expert Rosalind Franklin as 'Rosy', carefully guarding her crystallographic treasure cove against male intruders (Watson 1968/1996; Zwart 2015, 2019c). My claim is not that Ada's scientific work should be considered as being on an equal footing with the work of Marie Skłodowska Curie, Anton Pannekoek or Rosalind Franklin. She was a capable chemist, whose textbooks went through several editions, not a potential Nobel laureate. Still, I find it remarkable that, while she is mainly remembered as Gorter's muse, so little attention has been given to her scientific work and to her impact on Gorter's poetry *as a chemist*. In Dutch literature studies, Ada Prins is staged as the famous poet's deceived Muse, but the scientific content and quality of her experimental work, conducted in a cutting-edge area of research, is never addressed. That she was the first woman in the Netherlands to receive a PhD in chemistry is only mentioned in passing (if mentioned at all), while the content of her thesis is systematically ignored. And this is quite remarkable given the exceptional nature of her achievement. For comparison: Elsa Neumann (1872–1902) defended her thesis in Berlin in 1899, while Marie Sklodowska-Curie (1867–1934) defended her thesis in Paris in 1903, indicating that Ada Prins was conducting her work in the same time zone as these much more famous female contemporaries. Although the importance of her scientific work was less grand compared to the impact and visibility of contemporaries such as Neumann or Curie, for a woman to defend a chemistry thesis was an exceptional achievement in 1908. In the course of their friendship, the former pupil (a talented young woman approaching Gorter to receive mandatory training in ancient Greek and Latin) increasingly assumed the role of expert and teacher. She became Gorter's Virgil in the emerging landscape of twentieth-century molecular science, thereby playing a role comparable to the type of guidance Anton Pannekoek offered him, during the same period, into the budding world of astronomy and astrophysics.

Gorter's scientific poetry may be seen as the poetic counterpart of the scientific-political novels written by Émile Zola (De Liagre Böhl 1996, p. 122). In his essay *The experimental novel*, the French novelist Zola (1880/1923) discerned a basic similarity between naturalistic novels and experimental research. Inspired by Claude Bernard's understanding of the experimental method, Zola argued that novels adhere to an experimental design, by systematically exposing literary characters to various social and cultural conditions, in order to study their responses (Zwart 2014). The novelist should not merely *describe* the world, but actively intervene, to analyse the behaviour of their protagonists under various challenging circumstances. Novels function as literary laboratories, where social phenomena may be systematically analysed.

If we apply this principle to Gorter's *Pan*, his poem becomes a "poetic laboratory" where workers (as the flowing, polymerising crystals of society) are exposed to a series of challenging conditions (the industrial revolution, modern Capitalism, World War I, revolutionary speeches by communist leaders, the call for revolution, etc.) to study their behaviour in response. We notice how, in the course of *Pan*, the dramatic tension (the dramatic temperature) gradually increases. After the first melting point, the workers' desire for

justice seems to fade in the dreary landscape of industrial Capitalism and global warfare. The world freezes over as it were, with only a limited number of dispersed, brilliantly shining groupings of congregating workers scattered here and there. The second melting point is a clearing point, however, when capitalism suddenly gives way to the paradisiac ecosystem of council communism, where art, science and technology join forces, in service of humankind. In this final state, science becomes poetry and poetry becomes science, as we have seen, while nature and industry (the two titanic forces which had been colliding with one another during the industrial revolution) finally become reconciled again.

This scenario is also reflected in the vicissitudes of the two key protagonists: Pan (the ancient god who returns to Earth) and his guide, the Golden Girl, who are literally "lost in each other", who become fused in the chemistry of their interminable erotic embrace. Whereas Gorter's early socialist poetry such as *Een klein Heldendicht* ("A Small Epic", published in 1906) and the much smaller first version of *Pan* (published in 1912) can be considered as social realism, the "big" *Pan* (1916) should rather be considered as *social surrealism*. The world as we know it from everyday experience has given way to an enigmatic ambiance, disclosed by twentieth-century technoscience, both on the stellar and on the crystalline level. As an artwork, it materialises a fascinating liaison between poetry and science.

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