Cornelis de Jager: In Memoriam

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Abstract

Cornelis (“Kees”) de Jager, the co-founder of the journal *Solar Physics*, passed away on 27 May 2021. He was an exemplary human being, a great scientist, and he had a large impact on our field. In this tribute, we first briefly summarize his life and career and then describe some of his solar activities, from his Ph.D. thesis on the hydrogen lines in 1952 to the book on cycle–climate relations that he completed last year.

1. Life and Career

De Jager was born on 29 April 1921 in Den Burg on the island of Texel in The Netherlands and passed away in the same village on 27 May 2021. He was a giant in our field and far beyond, ranging widely through the spectrum in solar physics and through stellar physics, educating many astrophysicists, traveling widely as an inventive and effective science diplomat, founding institutes, journals, and societies, intensely active in popularization, and running marathons as well. Kees was always friendly, cooperative, attentive, positive, and optimistic. He was a wonderful person and a great scientist.

On the occasion of his 75th birthday, *Solar Physics* published a special volume in which he wrote a highly recommended, characteristically well-written, and humorous overview of his rich life and career until then (*A red and a white star*: de Jager, 1996).¹ We refer to this for details about his happy childhood in Indonesia; studentship at Utrecht University during World War II (hiding from deportation to Germany at Sterrewacht Sonnenborgh); graduation

¹In addition, he wrote monthly reminiscence columns in the Dutch amateur journal *Zenit* (which he co-founded when organizing Dutch amateur astronomy) from 2006 and collected 180 columns in 2014 and 2020 in two books entitled *Terugblik* (“Looking Back”). They are a marvelous read – in Dutch.

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Figure 1 *Left:* Kees at the entrance and exit plane of the vertical solar spectrograph at Sonnenborgh in 1944. He adjusts the tilt of the declination mirror of the rooftop heliostat feeding the vertical 15-cm refractor spanning two floors; the sandbag preloads the clock-controlled hour-angle mirror drive. The monk robe is against the cold. *Center:* Kees at the 25-cm Merz refractor at Sonnenborgh in 1953. He used it in his first publication finding fine structure on Jupiter's moons (de Jager, 1946), and at that time he built a self-recording photometer for it (de Jager, 1953) starting a variable-star program (Ph.D. theses of A.C. de Landtsheer and R.H. van Gent) later utilized a 40-cm telescope built in the Utrecht workshop under Kees' guidance (Minnaert required solid training in using workshop machinery) and stationed in Greece and Switzerland. In the 1950s, scientists wore white lab coats. Kees' hair turned white prematurely, perhaps contributing to his diplomatic feats such as facilitating Taiwan and China becoming members of ICSU. *Right:* Kees at his Bilderberg meeting in 1967 (photo R.J. Rutten).

in 1946; Ph.D. thesis with M.G.J. Minnaert in 1952; professorship in 1960; succeeding Minnaert as observatory director in 1963; moving into the director's mansion at Sonnenborgh with his wife Duotsje ("Doetie") and their four children; and also for details on his research and on his founding astrophysics at the Brussels Free University; directorship of the Utrecht Observatory with rapid expansion from 5 to 50 staff; starting the Utrecht Space Research Laboratory, which quickly grew to a staff of over 100; involvement in the European Space Research Organisation (ESRO), the European Space Agency (ESA), the Dutch Astronomical Spacecraft (ANS), and more space instrumentation; founding the journal *Space Science Reviews* and co-founding the journal *Solar Physics* (Section 5); co-founding the *Joint Organization for Solar Observations* (JOSO, Section 6); serving as General Secretary of the International Astronomical Union (IAU); president of the Committee on Space Research (COSPAR) twice; president of the International Council of Scientific Unions (ICSU); and much more. His role in ESRO and early ESA is well described by Bonnet (1996) in the same issue of *Solar Physics*. He also co-founded and chaired the Dutch Foundation of Skeptics (Stichting Skepsis) and the European Council of Skeptical Organisations dedicated to debunking pseudoscience.²

He received many awards, including the Karl Schwarzschild Medal of the German Astronomical Society (Astronomische Gesellschaft) in 1974, the Prix Jules Janssen of the French Astronomical Society (Société Astronomique de France), and the Gagarin Medal of the So-

²Entry "Kees de Jager" of Wikipedia presents his tongue-in-cheek descriptions of Cyclosophy, the bicycle-based, holistic, four-dimensional religion he created for the New Age of Aquarius. Earlier, he showed that many dimensions of his Sonnenborgh home had cosmic proportions well beyond those of the Cheops pyramid that forecast the end of the world on 16 March 2674 at 03:56 UT.

viet Federation of Cosmonauts in 1984, the Ziolkowski Medal of the Russian Space Agency (Roskosmos) in 1987, the Hale Prize of the American Astronomical Society's Solar Physics Division and the Royal Astronomical Society's Gold Medal in 1988, and honorary citizenship of Texel in 2006. He also held the age record for Dutch marathon runners (finishing the New York Marathon at 75 after starting long-distance running at age 50).

At Utrecht University, he was Ph.D. (co-)adviser for M. Kuperus (1965), L.D. de Feiter (1966), E.P.J. van den Heuvel (1968), J. Roosen (1968), A.C. Brinkman (1972), R.C.P. van Helden (1972), H.F. van Beek (1973), H.J.G.L.M. Lamers (1974), P. Hoyng (1975), G.C.M. Reijnen (1976), K.A. van der Hucht (1978), E.H.B.M. Gronenschild (1979), A.J.F. den Boggende (1979), J. Heise (1982), A. Duyveman (1983), A.C. de Landtsheer (1983), P.P.L. Hick (1988), and R.H. van Gent (1989). At the Free University of Brussels, he was Ph.D. (co-)adviser for C.W.H. De Loore (1968), E.L.J. van Dessel (1973), M. Burger (1976), and A. Lobel (1997).

After turning 75, he turned Sterrenwacht Sonnenborgh into a successful science museum, where for many years he gave monthly lectures on anything astronomical in the news during the weeks before and captured these lectures in books. He continued this after his return to Texel in 2003.

On Texel, he delved into local history, also lecturing on that, and became a guest worker at the Dutch Institute for Maritime Research (NIOZ) there, turning to relations between solar activity and climate in a dozen publications (while also co-authoring further studies on hypergiants). He put these together in *Solar magnetic variability and climate* in 2020 (de Jager, Duhau, and Nieuwenhuizen, 2020, see Section 7).

2. Ph.D. Thesis

Kees³ used his years of hiding at Sterrewacht Sonnenborgh to work through most of the astronomy–physics–mathematics curriculum and graduated in 1946. Minnaert suggested a Ph.D. thesis on the solar Balmer lines using the spectrograph at Sonnenborgh that Minnaert had moved from the Physics Laboratory when reviving the observatory in the 1930s (Figure 1). Kees had hoped to venture further out in the universe⁴ than just eight light-minutes but set himself to the task.

The resulting thesis entitled *The hydrogen spectrum of the sun* is now available at the Astrophysical Data System (ADS) (de Jager, 1952). The description of his data gathering is a good reminder of practices before electronic detection and computing. At Utrecht he collected center-to-limb spectra of many Balmer lines on a hundred photographic plates. After development in the observatory darkroom followed scanning with Houtgast's ingenious double-galvanometer, intensity-recording microdensitometer (diagram in the introduction to the *Utrecht Atlas*), after determination of the non-linear plate density-to-intensity calibration curves from spectra taken through a neutral-density step filter, and then applying extensive corrections for grating ghosts, stray-light, and the instrumental profile. The final results are line profiles given in tables. He similarly collected H α spectroheliograms and off-limb spectra at Meudon and Paschen and Brackett line profiles at the Jungfrauoch (where

³We use the familiar “Kees” throughout. Everybody at the Utrecht Observatory and the Space Research Laboratory called him that (in the 1960s, the former called the latter “ruimtekezen” = space Keeses), which was in contrast to the formal M.G.J. Minnaert (1893–1970) who was called “Professor” by everybody including Kees.

⁴Kees coined the beautiful term “oerknal” for “big bang” in the Dutch language.

M.V. Migeotte claimed similar dryness as above Antarctica). Then there follows a careful comparison with other published Balmer-line profiles resulting in summarizing profile figures drawn by the observatory drafter.

Kees then constructed a sequence of solar-atmosphere models starting by fitting visible continua and their limb darkening, then hydrogen-line wings for deep layers, and finally the line cores for high layers. All this with a mechanical calculator, slide rule, logarithm tables, (logarithmic) graph paper, and mental arithmetic (also in logarithms!). The main problem was that he could not reconcile the wings with the cores without adding ad-hoc line broadening increasing with wavelength – too much for invoking deficiencies of Stark-broadening theory. The last chapters address chromospheric modeling with the off-limb profiles of $H\alpha$, which was admittedly more speculative and suggested that spicule motions must be an important but unknown ingredient.

In hindsight, Kees commented that it was all wrong because of assuming LTE. Indeed the hydrogen lines are scattering lines with attendant source-function darkening and, of course, chromospheric inhomogeneity is a major ingredient. Nowadays, the approach would be to compare high-resolution observations and simulations with 3D spectral synthesis. Such studies have not yet been done for multiple Balmer, Paschen, and Brackett lines as comprehensively as Kees did in his pioneering thesis.

3. Solar Atmosphere

Kees continued working on the Paschen and Brackett lines with L. Neven at the Royal Observatory of Belgium⁵ and refining solar atmosphere models with H. Hubenet and J.R.W. Heintze at Utrecht. The highlight became his “International study week” in 1967 at the famous hotel De Bilderberg in which he gathered the foremost solar physicists and promising youngsters to jointly derive a definitive model. The decision there was to use only the continuum, lines being too difficult, and there was much debate about whether microturbulence, the problematic adjustable parameter to broaden lines as much as observed, increases or decreases with height. The result was the Bilderberg Continuum Atmosphere of Gingerich and de Jager (1968).⁶ Kees then stopped these efforts; 1D continuum modeling moved to the Harvard–Smithsonian Center for Astrophysics, first as the Harvard–Smithsonian Reference Atmosphere (HSRA) of Gingerich et al. (1971) and then the long sequence of models constructed by E.H. Avrett and co-workers, attaining the “standard-model” standing that Kees had anticipated as a major need. At Utrecht, solar-atmosphere studies were taken over in the 1970s by C. Zwaan (1928–1999) and collaborators (adding solar–stellar activity), in the 1990s by R.J. Rutten and collaborators, and in the 2000s by C.U. Keller and collaborators.

Meanwhile, Kees maintained his interest in turbulence, proposing better descriptions (mesoturbulence between micro- and macro-) and also in stellar applications when he

⁵ADS lists 35 joint publications spanning 1950–1982 (46 in total for Neven). During 1961–1972, Kees taught astronomy weekly at what became the Vrije (non-catholic Flemish) Universiteit Brussels, going there (by train, as Kees had no driver’s license) on Fridays to teach his courses (*Stellar structure and evolution* was one of the most inspiring), spending the night at the observatory which had guest rooms and working there on Saturdays with Neven before returning to Utrecht.

⁶For more on the Bilderberg meeting and these modeling efforts see Rutten (2002) in a *Journal of Astronomical Data* issue celebrating Kees’ 80th birthday.

Table 1 Overview of *Structure and Dynamics of the Solar Atmosphere* (de Jager, 1959). These are only the major headings.

	Topic	Page
Part A	The undisturbed photosphere and chromosphere	80
	I. The undisturbed photosphere	2 – 14
	II. The chromosphere	15 – 30
Part B	The disturbed parts of the photosphere and chromosphere	151
	I. Sunspots	31 – 39
	II. Photospheric and chromospheric faculae	40 – 47
	III. Flares and associated phenomena	48 – 59
	IV. Filaments and prominences	60 – 69
Part C	The corona	248
	I. Optical observations	70 – 81
	II. Radio emission from the Sun	82 – 95
Part D	Solar rotation and the solar cycle	96 – 105
Part E	Solar and terrestrial relationships	106 – 110

extended his research beyond solar physics to mass loss, supergiants, and hypergiants⁷ prompted by starting stellar ultraviolet spectroscopy as a non-solar space-research activity with the S59 spectrometer on ESRO's TD-1A spacecraft (de Jager et al., 1974) and writing *The brightest stars* (de Jager, 1980)⁸ to thoroughly master the subject.

Kees' trick of writing a comprehensive review to learn a field inside-out started with *Structure and Dynamics of the Solar Atmosphere*, a 280-page overview establishing him as major solar physicist (de Jager, 1959). It furnishes a brilliant, complete inventory of solar physics in Kees' clear style, at the time when the computer and space eras were starting. It contains over 100 succinct essays surveying the state of solar physics in a wide range of topics. Table 1 summarizes the contents. Compiling it gave Kees detailed knowledge of the rich complexities that the solar atmosphere has to offer.⁹

4. Flares

Flare¹⁰ research started in The Netherlands in the 1950s with Lyot-filter H α observations by the Dutch telephone service for predicting solar disturbances of overseas radio connections.

⁷Hypergiants were named after a Dutch cartoon character proposed by A.M. van Genderen. Kees' last entry on ADS is van Genderen et al. (2019). The co-authors include H. Nieuwenhuijzen, who was Kees' main co-worker after Kees' 1986 "retirement" and co-author on 18 ADS entries, mostly on stellar mass loss, giant stars, and more recently on cycle–climate connections until A.C.T. Nieuwenhuizen took over.

⁸ADS lists 166 citations.

⁹When Thomas and Athay wrote *Physics of the Solar Chromosphere*, mostly debating NLTE line formation (Thomas and Athay, 1961), Kees wrote a scathing review (de Jager, 1962a) that a glance through an H α filter makes one wonder about waves, shocks, and magnetism, which were altogether ignored in the book. Indeed the book and Kees' review describe utterly different stars. The five-page critique also demonstrates Kees' fluency in German – the high school he attended with Doetie in Surabaya maintained the high standard of Dutch education at the time. He also learned proper Dutch there; his principal languages had been the Texel dialect and Minahasan.

¹⁰The Dutch term "zonnevlam" came also from Kees.

Kees organized a direct telephone line to be warned the moment an H α flare was detected, and he streamlined the Sonnenborgh start-up procedure to yield H α spectrograms within a minute.

At this time, Kees also became interested in solar radio “storms” during flares and measured them on fast recordings collected by C.L. Seeger at Cornell (de Jager and van’t Veer, 1958). This led to the Utrecht solar radio group, which blossomed in the 1960s and 1970s,¹¹ culminating in J. van Nieuwkoop’s fast 60-channel radio spectrograph at the Dwingeloo 25-m antenna; e.g. millisecond flare spikes (Slottje, 1978).

At the launch of *Sputnik*, Kees recognized the potential of space research and became involved in starting ESRO (later ESA). He convinced Dutch funding agencies to start the Utrecht Space Research Laboratory (ROU, later the national SRON) with X-ray flare studies as the major topic, along with stellar ultraviolet spectroscopy and non-solar X-ray research. The ESRO-2 spacecraft (1968) acquired a soft X-ray monitor for flare studies, but already before launch, Kees realized that soft X-rays show only the gradual phase after initiation, while he wanted to study triggers in the onset phase, which were always missed in his H α spectroscopy (and he therefore never published them). The ESRO TD-1A spacecraft (1972) was equipped with a hard X-ray monitor, but there was a clear need for imaging to locate impulsive-phase bursts. This was realized with a sequence of collimator grids in the *Hard X-ray Imaging Spectrometer* (HXIS: van Beek et al., 1980) onboard the *Solar Maximum Mission* (SMM), which was launched early in 1980. The finding of an association between H α flare kernels and impulsive X-ray bursts by Hoyng et al. (1981) for the 21 May 1980 flare remains Kees’ most cited (presently 223) ADS entry. The 30 May 1980 limb flare became known as the “Queens flare” because on that day, Dutch Queen Juliana was succeeded by Queen Beatrix (van Beek et al., 1981; de Jager et al., 1983). Later that year SMM suffered a failure and was put on standby until partial repair by shuttle astronauts in 1984. HXIS was not revived but the flares observed during 1980 helped establish the standard flare scheme of loop-top reconnection with particle-beam foot-point heating (e.g. Martens and Kuin, 1989). Kees then became involved in *Yohkoh* flare studies (e.g. Sakai and de Jager, 1996). The collimator-mask technology started with HXIS and other projects trying Fresnel zone plates (now referred to as “photon sieves”) became a major SRON asset, used in X-ray spectroscopy as well.

5. Solar Physics

The Sun’s central role in stellar science motivated Kees to start the journal *Solar Physics* in 1967. Kees, together with the publisher Anton Reidel, established *Space Science Reviews* (de Jager, 1962b), with a wise Erasmus opener, and the *Astrophysics and Space Science Library* book series with the proceedings *The Solar Spectrum* of the 1963 Minnaert-farewell symposium (de Jager, 1965). After that, Reidel suggested that another journal from Kees would be welcome – but Kees hesitated until Zdeněk Švestka reacted enthusiastically and offered his cooperation. Thus, in 1967, they started the journal together (de Jager and Švestka, 1967). They became a strong editorial team, further strengthened when Bob Howard joined them in 1987. Kees served as co-editor for 29 years and then, as honorary member of the Editorial Board for the next 25 years, and he kept providing essential contributions and support to the journal.

¹¹Ph.D. theses T. de Groot (1966), J. Roosen (1968), J. van Nieuwkoop (1971), J. Rosenberg (1973), J.M.E. Kuijpers (1975), A. Kattenberg (1981), and C. Slottje (1982).

6. JOSO

The need for higher-resolution observations of the Sun became a major concern in the 1960s. At the 1967 IAU Symposium *Structure and Development of Solar Active Regions*, held in Budapest and organized by K.O. Kiepenheuer, Kiepenheuer and Kees agreed to form a collaboration to find an outstanding site for a new European solar observatory. In 1969, a group of leading European solar physicists from seven countries established a convention to collaborate towards achieving this goal under the name *Joint Organization for Solar Observations* (JOSO). All expenses were covered by voluntary contributions from adhering institutes. Kiepenheuer, Kees, and Edith Müller were successive early presidents. Labor-intensive site-testing campaigns became possible with an enthusiastic participation of solar scientists and students from all over Europe. After testing close to 40 sites in the Mediterranean and Atlantic coastal areas, the searches focused on mountain sites in the Canary Islands with Izaña in Tenerife and Roque de Los Muchachos on La Palma being the most outstanding.

Subsequently, JOSO became involved in developing new telescope technology for these excellent sites. Kees' Utrecht colleagues C. Zwaan and R.H. Hammerschlag tested the non-vacuum, open-telescope principle by installing the 45 cm *Dutch Open Telescope* (DOT) on La Palma. The later German 1.5 m GREGOR at Izaña and the 4.2 m *Daniel K. Inouye Solar Telescope* (DKIST) on Maui, Hawaii, USA are based on open solutions, also chosen for the 4 m *European Solar Telescope* (EST) currently under study for Roque de los Muchachos.

JOSO has also been actively involved in coordinating observations between ground-based solar facilities and instruments in space such as the *Solar and Heliospheric Observatory* (SOHO) and the *Transition Region and Coronal Explorer* (TRACE). Overall, JOSO has contributed notably to solar physics in the past decades.

7. Cycle and Climate

As a guest worker at the Dutch Institute for Maritime Research (NIOZ) on Texel, Kees returned to solar physics, at the institute's suggestion, studying possible relations between solar activity and the Earth's climate. In de Jager (1981) he had already plotted Dutch winter temperatures (derived from ice-skating records) against sunspot numbers and found at most a weak correlation, concluding "More thorough efforts, using sophisticated statistical methods, will not yield more reliable results".

Characteristically he started with a thorough review (de Jager, 2005), of 44 pages, which has garnered 44 citations, and whose abstract concludes "The future of such a chaotic system is intrinsically unpredictable" while skeptically repudiating planetary-attraction periodicities as a significant contribution (de Jager and Versteegh, 2005; cf. Callebaut, de Jager, and Duhau, 2013). Then de Jager and Usoskin (2006) concluded that ultraviolet-irradiance variations have a larger effect than cosmic-ray shielding variations.

Kees then started a collaboration with S. Duhau (Buenos Aires) inspired by her inclusion of polar fields and her cycle-phase diagram plotting wavelet-fitted geomagnetic versus sunspot-number modulations in Duhau and Chen (2002). This collaboration lasted the rest of his life and resulted in ten more publications assembled in *Solar magnetic variability and climate* (de Jager, Duhau, and Nieuwenhuizen, 2020).¹² The main themes are:

- cycle-phase diagrams, plotting modulation of toroidal magnetism (spots, plage, active network) with sunspot number maxima as proxies against modulation of poloidal magnetism

¹²Available at zenitonline.nl/product-categorie/boeken.

Figure 2 *Left:* Doetie and Kees watching terns at Propokou Lagoon on the coast west of Patras, Greece, during the 1982 General Assembly of the IAU. They were avid birders (Texel offers the best opportunities in The Netherlands) and spent all of their free time during their travels on such excursions. Here they arrived on mopeds, which were new for them; Kees in running attire (photo R.J. Rutten). Earlier that week Kees gave an Invited Discourse on solar flares in the Roman Odeon in Patras – a spectacular setting. *Right:* Kees on 4 April 2012 at the farewell ceremony in the medieval Utrecht university hall, where the Treaty of Utrecht started The Netherlands in 1579 and Utrecht astronomy started in 1642. Kees gave an emotional and moving speech. (See de Jager, 2013) (photo courtesy of H. Nieuwenhuijzen).

(polar mixed-network faculae, polar coronal bright points) with geomagnetic minima as a proxy. These show looped tracks with time that differ between grand minima (such as the Maunder minimum), grand maxima (such as the recent one), and regular episodes, with the transitions related to the Gleissberg cycle;

- wavelet decomposition identifying eight oscillatory cycle modes permits extrapolation to predict that a regular episode started around 2006 with maxima specified up to 2140;
- regression analysis correlating the toroidal and poloidal solar proxies with northern-hemisphere Earth temperatures using 18-year smoothing yields good correspondence with 0.3° amplitude until the onset of anthropogenic heating around 1920. Up until then, the toroidal component contributed about 43%, the poloidal component about 32%. The remainder is tentatively attributed to a non-cyclic surface dynamo producing small magnetic concentrations coalescing into mixed-polarity network. The best match is obtained using a one- to two-decade delay that recently diminished, perhaps related to glacier area.

Kees liked to say that he should get another century to see how the cycle and these predictions fare – failure would be welcomed as a reason to delve deeper. His work is already motivation to delve deeper.

8. Utrecht Farewell

In 2011, the board of Utrecht University closed the Sterrekundig Instituut Utrecht (renamed from “Sterrewacht” after leaving Sonnenborgh in 1987) (Figure 2). The space research laboratory SRON left Utrecht in 2021 and moved into a new building next to the Leiden Observatory.

Data Availability No data were used in this article.

Declarations

Conflict of Interest The authors declare that they have no conflicts of interest.

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