

In Memoriam Cornelis de Jager

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Summary. Cornelis (“Kees”) de Jager, co-founder of *Solar Physics*, passed away in 2021. He was an exemplary human being, a great scientist, and had 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 PhD thesis on the hydrogen lines in 1952 to the book on cycle-climate relations completed in 2020.

Life and career. De Jager was born on April 29, 1921 in Den Burg on the island of Texel in The Netherlands and passed away in the same village on May 27, 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. Always friendly, cooperative, attentive, positive and optimistic. A wonderful person and a great scientist.

At 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 detail on his happy childhood in Indonesia, studentship at Utrecht University during World War (hiding from deportation to Germany at Sterrewacht Sonnenborgh), graduation in 1946, PhD thesis with M.G.J. Minnaert in 1952, professorship in 1960, succeeding Minnaert as observatory director in 1963 and moving into the director’s mansion at Sonnenborgh with his wife Duotsje (always called Doetie) and their four children, and also

¹In addition he wrote monthly reminiscence columns in the Dutch amateur journal *Zenit* (which he co-founded when reorganizing Dutch amateur astronomy) from 2006 and collected 180 in 2014 and 2020 in two books *Terugblik* (looking back, De Jager 2017, 2020) [order page]. They are a marvelous read – in Dutch.



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 this time built a self-recording photometer for it ([de Jager, 1953](#)) starting a variable star program (PhD theses of A.C. de Landtsheer and R.H. van Gent) later utilizing 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 diplomatic feats as Taiwan + China ICSU membership. *Right:* Kees at his Bilderberg meeting in 1967 (photo R.J. Rutten).

for detail 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 employees, starting the Utrecht space research laboratory quickly growing to over 100 employees, involvement in ESRO, ESA, the Dutch astronomical satellite ANS and more space instrumentation, starting *Space Science Reviews* and co-starting *Solar Physics* (more below), co-founding JOSO (more below), being IAU General Secretary, president of COSPAR twice, president of ICSU, and much more. His role in ESRO and early ESA is well described by [Bonnet \(1996\)](#) in the same *Solar Physics* issue.

After turning 75 he turned Sterrenwacht Sonnenborgh into a successful science museum, during many years giving monthly lectures on anything astronomical in the news during the weeks before and turning these into books, also after his return to Texel in 2003. He also co-founded and chaired the Dutch and European skeptical societies debunking pseudoscience².

On Texel he delved into local history, also lecturing on that, and became guest researcher at the Dutch institute for maritime research (NIOZ) there, turning to

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

relations between solar activity and climate in a dozen publications while also co-authoring further studies on hypergiants. He put the first together in *Solar magnetic variability and climate* in 2020 (more below).

Among many other awards he received the Karl Schwarzschild Medal in 1974, the Prix Jules Janssen and the Gagarin Medal in 1984, the Ziolkowski Medal in 1987, the Hale Prize and the RAS Gold Medal in 1988, honorary citizenship of Texel in 2006 – and he also held the age record for Dutch marathon runners (New York at 75 after starting long-distance running at 50).

At Utrecht University he was PhD (co-)adviser to 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 to C.W.H. De Loore (1968), E.L.J. van Dessel (1973), M. Burger (1976) and A. Lobel (1997).

PhD thesis. Kees³ used his years of hiding at Sterrewacht Sonnenborgh to work through most of the astronomy–physics–math curriculum and graduated in 1946. Minnaert suggested a PhD 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). Kees had hoped to venture further out in the universe⁴ then just eight minutes but set himself to the task.

The resulting thesis *The hydrogen spectrum of the sun* is now available at 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 by Minnaert, Houtgast, and Mulders, 1940) after determination of non-linear plate density to intensity calibration curves from spectra taken through a step weakener, and then applying extensive corrections for grating ghosts, straylight 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 Jungfrauoch. Then 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 per

³We use the familiar “Kees” on purpose. Everybody at the Utrecht observatory and Kees’ space research laboratory called him that (in the 1960s the former called the latter “ruimtekezen” = space Keeses), in contrast to formal M.G.J. Minnaert (1893–1970) who was called “Professor” by everybody including professor Kees, even by J. Houtgast (1908–1982) whom Minnaert called “Mijnheer” throughout their four-decade collaborations.

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

mechanical calculator, slide rule, logarithm tables, (logarithmic) graph paper, 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 $H\alpha$, admittedly more speculative and suggesting that spicule motions must be an important but unknown ingredient.

In hindsight Kees commented that it was all wrong by 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.

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 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 adjustment 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 quit these efforts. One-dimensional continuum modeling moved to Harvard, first the HSRA of [Gingerich et al. \(1971\)](#) and then the long sequence of models constructed by E.H. Avrett and coworkers, earning the “standard-model” standing that Kees had anticipated as major need. At Utrecht solar atmosphere studies were taken over in the 1970s by C. Zwaan (1928–1999) and students (adding solar–stellar activity), in the 1990s by R.J. Rutten and students, in the 2000s by C.U. Keller and students.

Meanwhile Kees maintained his interest in turbulence, proposing better descriptions (mesoturbulence next to micro and macro) and also in stellar applications when he extended his research beyond solar physics to mass loss, supergiants and hypergiants⁷ prompted by starting stellar ultraviolet spectroscopy as

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 Brussel, going there (by train, Kees had no driving license) on Fridays to teach his courses (*Stellar structure and evolution* the most inspiring), spending the night at the observatory which had guest rooms, and on Saturdays working there with Neven before his return.

⁶For more on the Bilderberg meeting and these modeling efforts see [Rutten \(2002\)](#) in a JAD issue celebrating Kees’ 80th birthday.

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. Nieuwenhijzen who was Kees’ main coworker after his 1986 “retirement” and co-author on 18 ADS entries,

Table 1. Overview of *Structure and Dynamics of the Solar Atmosphere*. These are only the major headers. Third column: topic numbers (paragraph headers). Last column: page numbers printed in [de Jager \(1959\)](#).

Part A	The undisturbed photosphere and chromosphere		80
	I. The undisturbed photosphere	2-14	80
	II. The chromosphere	15-30	106
Part B	The disturbed parts of the photosphere and chromosphere		151
	I. Sunspots	31-39	151
	II. Photospheric and chromospheric faculae	40-47	173
	III. Flares and associated phenomena	48-59	191
	IV. Filaments and prominences	60-69	224
Part C	The corona		248
	I. Optical observations	70-81	248
	II. Radio emission from the Sun	82-95	283
Part D	Solar rotation and the solar cycle	96-105	322
Part E	Solar and terrestrial relationships	106-110	344

a non-solar space research activity with the S59 spectrometer on ESRO's TD-1A satellite ([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](#)).⁹ It furnishes a brilliant, complete inventory of solar physics in Kees' clear style at the time when the computer and space eras were starting. 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 on offer.¹⁰

Flares. Flare¹¹ monitoring started in The Netherlands in the 1950s with Lyot-filter H α observations by the Dutch telephone service for predicting solar distur-

mostly on stellar mass loss and giant stars and more recently on cycle–climate connections until A.C.T. Nieuwenhuizen took over.

⁸ADS lists 166 citations but no full-text source. However, Springer sells a scan, as for the 27 other *Geophysics and Astrophysics Monographs* published by Reidel.

⁹Springer sells a scan but without activating crossreferences nor hyperlinking citations.

¹⁰When Thomas and Athay wrote *Physics of the Solar Chromosphere* mostly debating NLTE line formation ([Athay and Thomas, 1961](#), wrong author order at ADS) Kees wrote a scathing review (at ADS wrongly labeled [Thomas and Athay, 1962](#) with the tail wrongly in [Waldmeier, 1962](#)) that a glance through an H α filter makes one wonder about waves, shocks and magnetism – 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 held 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.

¹¹The Dutch term “zonnevlam” came also from Kees.

bances of overseas radio connections. Kees organized a direct telephone line to get warned the moment an $H\alpha$ flare was detected and streamlined the Sonnenborgh start-up procedure to yield $H\alpha$ 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 that blossomed in the 1960s and 1970s¹², culminating in J. van Nieuwkoop's fast 60-channel radio spectrograph at the Dwingelloo 25-m antenna (*e.g.* millisecond flare spikes in [Slottje, 1978](#)).

At the launch of *Sputnik* Kees recognized the potentialities of space research, became involved in starting ESRO (later ESA) and convinced Dutch funding agencies to start the Utrecht space research laboratory (ROU, later national SRON) with X-ray flare studies as major topic, plus stellar ultraviolet spectroscopy and non-solar X-ray research. The ESRO-2 satellite (1968) got a soft X-ray monitor for flare studies but already before launch Kees realized that soft X-rays show only the gradual phase after ignition, while he wanted to study triggers in the onset phase always missed in his $H\alpha$ spectrometry (which he therefore never published). The ESRO TD-1A satellite (1972) got a hard X-ray monitor but there was a clear need for imaging to locate impulsive-phase bursts. This was realized with a train of collimator grids in the *Hard X-ray Imaging Spectrometer* (HXIS, [van Beek et al., 1980](#)) on the *Solar Maximum Mission* (SMM), which was launched early in 1980. The finding of association between $H\alpha$ flare kernels and impulsive X-ray bursts by [Hoyng et al. \(1981\)](#) for the May 21, 1980 flare remains Kees' most cited (presently 223) ADS entry. The May 30, 1980 limb flare became known as “Queens flare” because 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 fuse failure and was put in 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 footpoint heating (*e.g.* [Martens and Kuin, 1989](#)). Kees then got involved in *Yohkoh* flare studies (*e.g.* [Sakai and de Jager, 1996](#)). The collimator mask technology (nowadays “photon sieves”) that was started with HXIS and precursor projects trying Fresnel zone plates became a major SRON asset, also in X-ray spectroscopy.

Solar Physics The Sun's central role in stellar science motivated Kees to start the journal *Solar Physics* in 1967. A. Reidel, the publisher with whom Kees had started *Space Science Reviews* ([de Jager, 1962](#) 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 symposium¹³ ([de Jager, 1965](#)), urged Kees that another journal from him would be welcome – but Kees hesitated until Zdeněk Švestka reacted enthusiastically and proposed teaming up. They then started the journal together (editorial [de Jager and Švestka, 1967](#)). They

¹²PhD 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).

¹³For photographs taken by H. Nieuwenhuijzen see his [symposium album](#).

became a strong editorial team, further strengthened when Bob Howard joined them in 1987. Kees served as co-editor during 29 years and then, as honorary member of the Editorial Board for the next 25 years, kept providing essential contributions and support to the journal. It became a mainstay in solar physics.

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* in Budapest organized by K.O. Kiepenheuer, he 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 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 presidents. Labor-intensive site-testing campaigns became possible with 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 the most outstanding.

Subsequently JOSO became involved in developing new telescope technology for these excellent sites. Kees' Utrecht colleagues C. Zwaan and R.H. Hamerschlag 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 DKIST on Maui, Hawaii are based on open solutions, also chosen for the 4 m *European Solar Telescope* (EST) currently in development for the DOT site on Roque de los Muchachos.

JOSO has also been actively involved in coordinating observations between ground-based solar facilities and instruments in space as SOHO and TRACE. Overall, the somewhat unusually organized JOSO has contributed notably to solar physics in past decades.

Cycle and climate. As a guest worker at the Dutch institute for maritime research NIOZ on Texel, Kees returned to solar physics, at their suggestion studying possible relations between solar activity and Earth climate. In [de Jager \(1981\)](#) he had already plotted Dutch winter temperatures (derived from ice-skating¹⁴ records) against sunspot numbers and found at most 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](#), 44 pages, 44 citers, abstract concluding “The future of such a chaotic system is intrinsically unpredictable”) while skeptically repudiating planetary attraction periodicities as significant contribution ([de Jager and Versteegh, 2005](#); cf. [Calebaut, de Jager, and Duhau, 2013](#)). Then [de Jager and Usoskin \(2006\)](#) concluded that ultraviolet irradiance variations have larger effect than cosmic ray shielding variations. The

¹⁴Growing up in Indonesia had made Kees a non-skater whereas J.H. Oort took the Leiden observatory on long skating tours at every opportunity.



Figure 2. *Left:* Doetie and Kees watching terns at Propokou Lagoon on the coast west of Patras during the 1982 General Assembly of the IAU. They were avid birders (Texel offers the best opportunities in The Netherlands) and spent all free time on their travels on such excursions. Here they arrived on mopeds, new to 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 April 4, 2012 at the farewell ceremony in the medieval Utrecht university hall (where the Treaty of Utrecht started The Netherlands in 1579; Utrecht astronomy started in 1642, see [de Jager, 2013](#)). Kees gave an emotional and moving speech: “Here in Utrecht I raised a beautiful daughter. I enjoyed watching her develop and grow into splendid maturity – but then she was brutally murdered”. The Utrecht University logo has the Sun as emblem (yellow *Sol Iustitiae Illustrat Nos* at lower right) but now undeservedly (photo H. Nieuwenhuijzen in his [farewell album](#)).

importance of energetic particle and spectral irradiance variations as potentially more climate-effective than the minute total irradiance modulation is now recognized by the IPCC.

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 \(2002\)](#). It lasted the rest of his life and resulted in ten more publications recapitulated in *Solar magnetic variability and climate* (De Jager, Duhau, and Nieuwenhuijzen, 2020).¹⁵ Main themes are:

- cycle phase diagrams plotting modulation of toroidal magnetism (spots, plage, active network) with sunspot number maxima as proxy against modulation of poloidal magnetism (polar mixed-network faculae, polar coronal bright points) with geomagnetic minima as proxy. These show looped tracks with time that differ between grand minima (as the Maunder minimum), grand maxima (as the recent one) and regular episodes, with the transitions related to the Gleissberg cycle;

¹⁵Submitted to Springer in June 2020 but in autumn Kees became impatient at lack of response and sent it instead to the publisher of *Zenit* and his *Terugblik* books [[contents overview](#)] [[order page](#)].

- wavelet decomposition identifying eight oscillatory cycle modes (including planets after all) 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 degree amplitude until the onset of anthropogenic heating around 1920. Up to 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 1–2 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 reason to delve deeper. His work is already motivation to delve deeper.

Utrecht farewell. An unexpected drama unfolded abruptly in 2011. For unknown reasons the board of Utrecht University suddenly decided to close the prospering Sterrekundig Instituut Utrecht (renamed from “Sterrewacht” after leaving Sonnenborgh in 1987). Director C.U. Keller orchestrated a deal in which most Utrecht astronomers were relocated to astronomy departments at Leiden, Nijmegen and Amsterdam. Kees’ space research laboratory SRON sought better connections, first in Amsterdam, then moved to the Leiden campus. The DOT is mothballed since. Utrecht solar physics, effectively Dutch solar physics, is gone. However, a university board terminating its astronomy program cannot undo the sky-high record of a most illustrious scientist built in his hundred rounds around the Sun.

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