Preface to the French Edition

Jules Janssen. This D'Artagnan of science, this bard of the Sun, and this audacious master builder, merits far more than just a statue on the public terrace at Meudon, at the opposite end to the observatory gates: a statue subject to the ravages of time. Janssen is actually the founder of astrophysics in France. After confirmation of the triumph of Newtonian theory, and both the subtle and powerful developments of it made by Clairaut, Lagrange, and Laplace, and after Le Verrier and the discovery of Neptune, the need arose to study the nature of the celestial bodies and of that of the

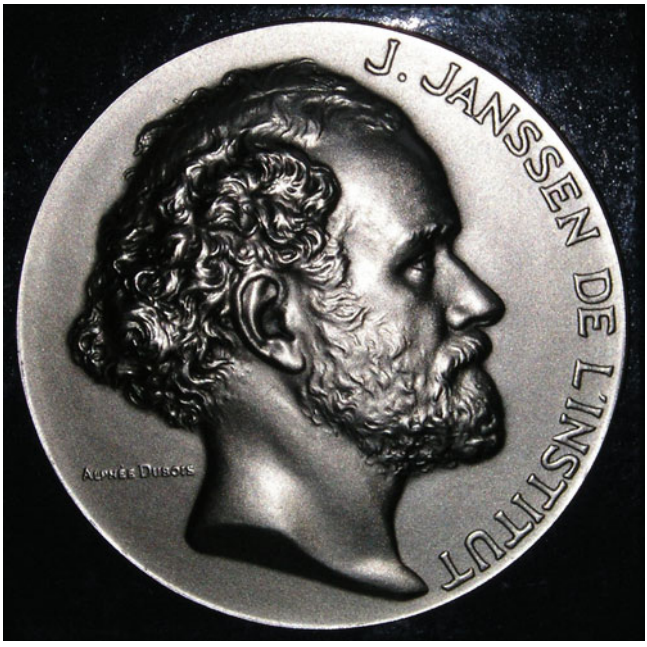

Fig. 8 *The Janssen Medal*
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Sun in particular. What a long delay there was, in our country, where celestial mechanics developed remarkably, but in splendid isolation, relative to the astrophysical work carried out by Anglo-Saxon and German astronomers. There was Herschel with the infrared and the "island universes"; Fraunhofer and the solar spectrum; Wolf and Schwabe and the observation of solar activity…

In this book, which, let us be in no doubt, will become a source of reference, all the aspects of Janssen's rich personality have been covered by Françoise Launay, his attentive and erudite biographer. A physicist, an inventor and instrument builder, crazy about the Sun and travel, Janssen was a sort of "self-made man," who had acquired most of his great knowledge, practically alone, guided by his energy and curiosity. Naturally, a mathematician (he followed the courses given by Cauchy and Le Verrier), he tried (without success) to be recruited by the tetchy director of the Paris Observatory. But luck accompanied his employment as the tutor that he became, and brought him in contact with the future great traveler and geographer, Alfred Grandidier. From this began his great travels around the globe, under various pretexts. Initially, this was an effort directed toward geophysics; in Peru, Janssen measured the magnetic field and determined the magnetic equator. The spirited young man had no hesitation: in preparing for his trips, he made contact with the most competent members of the Académie. He built up, if I may put it this way, a really useful address book… He threw himself into physics: his thesis discussed the propagation of heat. But in what medium? Not in optical laboratories. He became a physiologist: the medium was the eye, which was not damaged by the near infrared (then called "thermal") radiation. It was this that formed the very personal subject of Janssen's thesis, a thesis in which there was no intervention from the hand of any master. Janssen's first invention was, in effect, Janssen himself.

Like all inventors, before arriving at the correct solution, he tried everything. The analysis of the spectrum of sunlight revealed the role of absorption in the Earth's atmosphere. So Janssen's research followed two paths: the Earth's atmosphere and the Sun. And mastery of a technique, spectroscopy, that would enable him to make rapid progress toward those two ends.

Studying the Earth's atmosphere and the Sun encouraged travel, even demanded it. Nothing could have appealed more to the enthusiastic temperament of our physicist. And was it not on a mountain that one had the best of the Sun without being bothered by the Earth's atmosphere? But was it not also there that the purest spectra were available? A high mountain, then. Switzerland, the Alps, Etna, the Himalaya… Janssen was restless. And not just to observe the Sun! A map of the globe devoted to his journeys would be criss-crossed by an extraordinary number of erratic round trips and covered in small flags "Jules Janssen was here." Just look at Janssen's biography, so minutely picked out by Françoise Launay in her "biographical landmarks"! It is absolutely astonishing, given that in Janssen's day there were no TGVs or Airbus 320s… Among this almost Brownian motion, we might pick out two – no, sorry, two groups – of journeys that are particularly memorable.

One was the trip to Japan in 1874 to observe the transit of Venus in front of the Sun. In 1882, recognizing that celestial mechanics was not his strong point, Janssen did not take part in the expeditions for the second transit. The transits of Venus

provided plenty of "grist to the mill" for the specialists in fundamental astronomy. But it was not our astrophysicist's "cup of tea," which he readily recognized. Admittedly, he invented the famous photographic revolver to record the precise instants of the moments of contact during the course of the transits. And it was a success. But it was more of a technical advance rather than an astronomical event.

From a scientific point of view, observation of the Sun during total eclipses, which had to be carried out at the far corners of the Earth, was of far greater significance.

It is true that in the history of astronomy in France, we find a few tentative attempts in solar physics. Lalande was interested in sunspots, which were measured by some of his students, Flaugergues, for example, and whose observations were used to establish the cycle of solar activity. But it was Janssen who really paved the way. Captivated for life by his first encounters with the Sun, Janssen would never relinquish it; he monitored it from the four corners of the Earth. In 1867, it was the eclipse at Trani, the very first. In 1868, the voyage to India, the total eclipse of the Sun, and his results were not only remarkable, but were noticed. This was the beginning of Janssen's great notoriety. Then there came the saga of the total eclipses of 1870 (Oran), 1871 (India), and 1875 (Siam). There were others: in 1883, it was Caroline Island, in the Pacific, a long way away…

It reached the point where Henriette frequently complained of the solitude in which her traveler of a husband left her, caught, poor woman, by having to care for a small daughter and her mother-in-law ("between an old woman and a child"): "There are men who leave their wives for mistresses; you do it for journeys!" He finally took her with him to India in 1871, where she carried out a very sympathetic sociological study of the Todas. Henriette had good reason to want to follow her husband. In many respects, she could have gone before him. But the times were not favorable for wives, who were expected to confine themselves to baby clothes and casseroles.

Françoise Launay accurately describes the progress that Janssen made in an understanding of the Sun. There is no point in recalling here the new knowledge of the spectrum of the corona. There is no point in recalling here the discovery of the solar nature of the prominences, nor of their observation outside eclipses (anticipating the spectroheliograph of Deslandres, his unpleasant successor). Again there is no point in recalling his magnificent work on the disk of the Sun, achieved much later at Meudon, and the success of recording granulation photographically. These major advances are known to all astronomers and marked decisive stages in knowledge of the solar chromosphere and photosphere.

These successive discoveries, achieved thanks to an exceptional combination of a rare instrumental inventiveness and a tireless obstinacy in observing, meant that Janssen was among the world's leaders in astrophysics. Rivalries arose at this level, notably with Secchi, who classified stars according to their color (Janssen had also dipped his toe slightly in that water), but friendships were also established that were more durable. With Norman Lockyer, his rival over the eclipse of 1868; and with William Huggins, the stellar spectrographer. And in France itself, there were connections that were both pleasant and very useful. Ministers, such as Victor Duruy,

Léon Gambetta, and Jules Simon or later, Jules Ferry and Léon Say, the rich senator and astronomer Raphaël Bischoffsheim and the deputy and engineer Ernest Cézanne. And then there were the figures that were well-known in scientific circles: Camille Flammarion, Prince Roland Bonaparte, and Gustave Eiffel. There was the romantic painter Jean-Jacques Henner, who specialized in chlorotic young girls lying, more-or-less extended, on rather indistinct couches, and who also painted portraits of Jules … and many others. We can well imagine Janssen, a key figure of the turn of the century, having pride of place on some sort of flower-bedecked platform, surrounded by all those bearded and triumphant celebrities: Léon Gambetta, Jules Ferry, Charles Gounod, Louis Pasteur, Sully-Prudhomme, Auguste Bartholdi, Camille Saint-Saëns…

But the man was not indifferent to the struggles of his century. During the siege of Paris in 1870, he left the capital in a free balloon, entrusted by Jules Simon, the Minister of Education, in Paris with a mission to Gambetta, Minister of the Interior and of War, who had fled to Tours. We may wonder if Janssen would have attempted this hazardous trip if there had not been a solar eclipse at the end of it. But nevertheless he did it! It seems quite clear that Janssen was a patriot and republican, and that he was open to new ideas.

Basking in the glow of his success, Janssen could attack what was, for him, even more significant than the solar prominences or photospheric granulation; more than the telluric lines of water vapor or optics of the eye; more than the hectic travels of an eclipse observer or of the transits of Venus in front of the Sun – his great work: construction of a great astrophysical observatory. Construction? That's saying a lot! It was first essential to create the observatory on paper, *in the abstract*. That was not easy; Janssen the traveler was not often there to defend his project, and the decision took a long time to materialize from the paperwork. As Hervé Faye said in his enthusiastic report: "Because physical astronomy can no longer be merged with astronomical mechanics, let us give it a separate establishment: the two sciences will thus develop in parallel, without interfering with one another, and using differing expertise." We sense the reluctance of older astronomers, and probably of Le Verrier himself. Among astronomers, Faye was thus the strongest supporter for the creation of the observatory, but Henriette, always the Parisienne, doubtless played a considerable part. She valued the idea of this establishment, the hoped-for stability of which would ensure her comfort from the more constant presence of her rather volatile husband.

The observatory and the directorial pair were finally established at Meudon. It was in the charred ruins of the "Château neuf" at Meudon, which had been converted into a powder magazine during the war, which is never a guarantee of a favorable outcome, that Janssen installed a dome, a large refractor (the largest in Europe, and rivaling the one at Lick – the Yerkes instrument did not yet exist), a reflector, and a spectroscopy laboratory, as well as astronomers of some status: Henri Perrotin, Gaston Millochau, Henri Deslandres, and Albert Nodon.

It remained for this far-sighted astronomer to set up an observatory on a high mountain. This was the foundation of the observatory on Mont Blanc, the astronomical counterpart of the Refuge Vallot, which was devoted to geophysics.

Our indefatigable traveler, still suffering from his limp, took part in the climb on a ladder carried by porters. And this courageous sexagenarian "with his mass of hair and snow-white beard," observed the Sun with a spectrograph and showed that the oxygen lines were of terrestrial origin.

Although the dangers posed by the ice on the peaks forced the authorities to demolish the observatory on Mont Blanc (in 1909), that at Meudon remains one of the pinnacles of astronomy in the world today.

Facing the observatory terrace and the great dome, recently refurbished with a new covering of copper, there is the statue of Jules Janssen. On the base of the monument, three bas-reliefs (unfortunately partially destroyed; their restoration is a duty that ought to be undertaken by the community at large) illustrate the astronomer's life. The one that remains represents the balloon trip during the Siege, another evoked the expedition to the East to observe the eclipse of the Sun in 1868, and the third the dangerous ascent of Mont Blanc: all symbols of the indefatigable and prolific activity of the founder of French astrophysics, Jules Janssen.

Paris, France Jean-Claude Pecker

Preface to the English Edition

Jules Janssen has long been a hero of mine, so it is with pleasure that I introduce the fine biography of this important inventor and astronomer written by Françoise Launay of the Paris Observatory. Ms. Launay has delved into family papers, contemporary newspaper articles and reports, and even stone monuments in Meudon and in Père-Lachaise cemetery in Paris. My comments supplement the earlier preface by the distinguished astrophysicist Jean-Claude Pecker.

Janssen had several triumphs in the early spectroscopy of the mid-nineteenth century. He was able to determine the absorption of water vapor in the air, matching with laboratory spectra and showing the dependency of the absorption on the length of the slanted passage of sunlight through Earth's atmosphere. One can trace back a lot of today's studies of global climate change to this work. He even took spectra of the erupting Santorini volcano.

Janssen has been known to astronomers especially for his pioneering work in taking a spectrograph to the total solar eclipse in India in 1868, at almost 7 min in duration about the longest possible in duration, and for his discoveries there. In particular, Janssen and the contemporary Englishman Norman Lockyer are credited with the near-simultaneous discovery that the solar prominences can be observed even outside of eclipse by looking at the red spectral line of hydrogen now known as H-alpha. We learn in this biography of just how Janssen undertook the expedition to India and about what the various scientists who observed the eclipse actually saw. As might be expected from any excellent biography, the question of who saw what when is more complicated than the traditional naive view. We see that though Janssen saw the yellow spectral emission line soon said to be from "helium," since it existed only on the Sun, he did not single it out or identify it as special. (Launay's section title is "Janssen and the helium that he did not discover.") We see how the question of priority of the discovery of this method of observing prominences, which indeed led to the discovery of the chromosphere itself surrounding the sun (a level named by Lockyer) was resolved in a satisfactory fashion for posterity by sharing the credit. Indeed, the two profiles appear together on a bronze medal struck subsequently in France.

The spectroscopic eclipse work led to the following year's eclipse observations, though it was other astronomers than Janssen who first saw the so-called coronal

green line, for decades said to be from "coronium" in analogy to the "helium" spectral line discovered in 1868. It was this coronal green line along with other, subsequently discovered coronal lines, that eventually led to the identification of the corona as million-degree gas, an idea that would have astounded Janssen.

I had not realized that Janssen was so self-motivated and so-self taught, having been brought to his maturity outside the scientific and academic environment of the French "grand schools" that provided the elite. It was not until his 40s that Janssen arranged independently with the minister to observe the key 1868 solar eclipse, bypassing channels and the official Paris Observatory expedition set up by Le Verrier, whose fame for predicting the position of what turned out to be the planet Neptune had led him to the directorship.

When Janssen decided to observe the 1870 total solar eclipse, he would not let a little thing like Paris being surrounded by the Prussian army stop him! He arranged to escape from Paris in a balloon. His liaison with Lockyer was sufficiently well established that the English arranged a safe passage for him directly with Bismarck. But we learn from Launay that Janssen was carrying a secret political message for Gambetta, whom he went to see before continuing to Algeria for the eclipse. Janssen just did not think it ethical to use Bismarck's safe passage in those circumstances.

Janssen went on to observe several other eclipses, such as the 1871 eclipse in India, at which he concluded that the corona was a self-luminous solar atmosphere, and the 1875 eclipse in Siam, the one that led to the King of Siam (famous for his liaison with his governess, Anna, made known to US audiences through the musical *The King and I*) not only to attend the eclipse but also to die soon after from the malaria contracted from a mosquito at the eclipse site. Those interested in the roles of women in nineteenth-century science will be able to read about the writings of Mme Janssen, who for her description of the natives she met during the 1871 expedition, "in addition to the respect of great men, the article brought Henriette 15 centimes a line."

Launay has discovered the previously unknown or unappreciated background of inventors in Janssen's family, which explains some of the scientist's greatest triumphs. One of the rarest predictable and observed events in astronomy is transits of Venus. They occur in pairs separated by 8 years, with intervals of 105.5 or 121.5 years between the pairs. Nobody alive on Earth had seen a transit of Venus before the one in 2004. Now we eagerly await the June 6, 2012, transit of Venus, which will be visible at sunset in the continental USA (and entirely in Hawaii and Alaska) and at sunrise in Europe (except for Portugal and western Spain) and as far east as India and Western Australia.

For the 1874 transit, Janssen wanted to be able to time accurately the contacts of Venus's limb and the Sun's, something that was foiled the previous century by the "black-drop effect," in which a ligament joined Venus's dark silhouette with that of space outside the solar limb (edge) and took a minute to stretch and pop. The uncertainty prevented timing of the requisite accuracy to meet Edmond Halley's requirements for measuring the distance between the Earth and the Sun and hence the scale of the entire solar system.

Janssen thus worked out an annular daguerreotype with an intricate system of rotating wheels that allowed 48 exposures to be taken at 1.5-s intervals. This

"Janssen revolver" (known in England as simply as a "Janssen") was the forerunner of multiple imaging, beginning the path that led through Muybridge's study of locomotion to the movie cameras of Thomas Alva Edison and the Lumière brothers.

My wife and I were fortunate this spring to see an example of Janssen's revolver on display at the Espace Pierre-Gilles de Gennes (a 1991 French Nobel laureate in Physics), an exhibition space at the location in Paris, l'École supérieure de physique et de chimie industrielles de la Ville de Paris, where Marie Curie had separated out her radium from piles of ore a few decades after Janssen's work and a century before the present. The display cases contained one of Janssen's revolvers, with the gears showing. Alas, the only one annular daguerreotype made of the transit cannot be now found, though three plates from preliminary tests do exist. A few months earlier, my wife and I had seen a different version of the revolver at Sydney Observatory in Australia, a remnant of one of the British expeditions. Janssen himself had observed the 1874 transit of Venus in Japan, while contenting himself with providing apparatus for the 1882 event.

Janssen went on to perfect his high-speed photography enough to capture the best images of solar granulation that were then available.

Janssen left a monument to his achievements in the Meudon Observatory, founded in the late nineteenth century as an independent institution in a suburb of Paris. The observatory includes the "Grande Lunette," the third largest refracting telescope in the world. I was fortunate that Audouin Dollfus, a great French planetary astronomer of this century, arranged for several of us to observe Mars at its 1988 opposition, when it was closest to Earth and therefore largest and brightest in its 26-year period (a synodic period mimicked in our times by the launches of spacecraft to Mars at that interval). The observatory incorporated a chateau made available to Janssen for the project, all on a series of terraces overlooking Paris at a distance. I cannot wait to return to Meudon to see again the monument to Janssen at the end of one of the terraces, no doubt the one from which my family and I once saw the most magnificent fireworks ever to celebrate the 14th of July.

The Meudon Observatory is now jointly run with the Paris Observatory, with the former's monument to Janssen a long way from the statue of Jean-Dominique Cassini, the first of a dynasty of four that left their mark on the latter's, in the museum of that seventeenth-century edifice. It is fitting that Launay's office should now be in the ancient, seventeenth-century observatory building, across the hall from a ceiling mural showing beautiful, naked Venus in her chariot meeting Apollo's chariot as she traverses the sky.

As we come to the planned high-cadence photography of the 2012 transit of Venus, celebrate new high-speed-camera results about insects and flowers, enjoy slow-motion views of sports on television, and follow eruptions on the Sun with the "3D Sun" app on our iPads and iPhones (http://3dsun.org), it is fitting to ponder the contributions from Jules Janssen that have led to these aspects of our modern world. Françoise Launay's book brings us to the appreciation of Janssen's oeuvre that he deserves.

Williamstown, MA Jay M. Pasachoff

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