Chapter 4
The First Observations and Photographs (1898–1904)

Commissioning the Visual Refractor (1896)

When, in 1896, astronomical observations began, the equatorial had already been assembled beneath the dome for three years. But, in 1893, as we have seen, the great dome could not yet be moved. Several preliminary technical observations had been carried out through the still fixed slit, to check out the various parts of the instrument.

Jules Janssen had invested heavily to put this exceptional project into working operation [1]. In 1896, at the time of its first phase of active service, he was found to be fully occupied in the creation of his new observatory at the summit of Mont Blanc.

Nevertheless, as soon as the instrument was functioning correctly, he wished to check the suitability of the Grande Lunette by means of visual observation, in order to prove the high quality of its images.

The astronomer Joseph Perrotin (1846–1904), from the Nice Observatory, had already made plenty of planetary observations. He had a good experience of the 76 cm refractor which had been in operation at Nice since 1887, and of that of its high altitude branch of Mont Mounier. He came to an arrangement with Janssen who paid him to come to observe from Meudon for several months and to compare the merits of the three instruments [2].

At the end of 1896, the planet Mars made a close approach to the Earth. Upon the surface of the planet, it had already been possible to recognise the threadlike streaks; the very enigmatic 'canals'. Moreover, the patches and mottlings upon the surface had shown evidence of change.

In 1896 December and 1897 January, Perrotin made use of nine favourable nights for observing Mars. His results were presented to the French Academy of Sciences at its meeting of 1897 February 15 [3] and also in *l'Astronomie*.

The drawings of Perrotin are not very skilfull and their analysis remains descriptive. But from their evidence, in spite of the great distance of the planet from the Earth, he saw really very fine details upon Mars (Fig. 4.1). Janssen, satisfied, emphasised the favourable diagnosis by means of remarks made later in an academic communication.

A little later, in 1898 January, as we have seen, the young and ardent student of the Ecole polytechnique Henri Deslandres was named as the astronomer at Meudon

A. Dollfus, *The Great Refractor of Meudon Observatory,*
Astrophysics and Space Science Library,
DOI 10.1007/978-1-4614-7288-9_4, © Springer Science+Business Media New York 2013

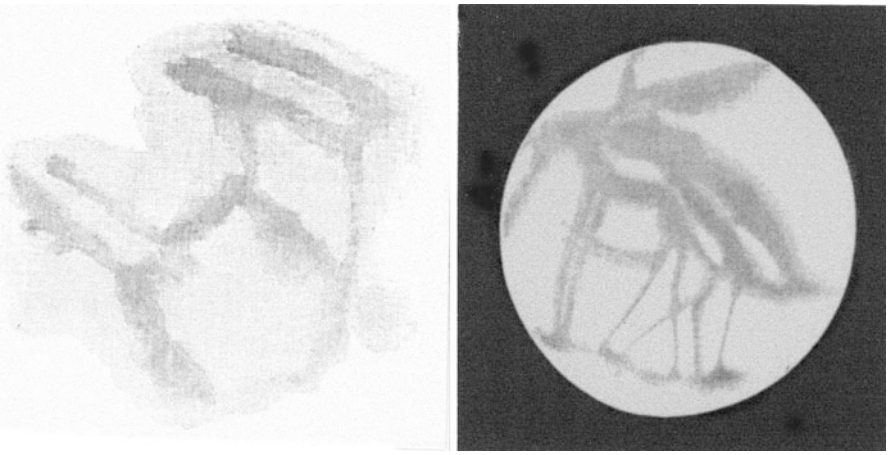

Fig. 4.1 The surface of Mars in 1896. Drawing by J. Perrotin. First observation with the Grande Lunette of Meudon. To the *left*, the region of Elysium, December 15, 1896, at 01 h 00 m, under high magnification. To the *right*, a whole disk drawing from January 3, 1897. (*Translator's note*: unless stated to the contrary, south is uppermost in this and in all the other telescopic images in this book.)

and came to live there. He had carried out spectroscopic research upon stars and the Sun at the Paris Observatory, and had become known through his invention of the spectroheliosco pe at the same time as the American, George Ellery Hale (1868–1938). Very interested in the Grande Lunette, he had contributed towards the final cost of putting it into operation out of his own pocket. He succeeded in being entrusted with the management of the instrument. He would play a remarkable part in all its aspects and would remain its principal user up till 1904.

Gaston Millochau (1866–after 1919), assistant to Deslandres at the Paris Observatory, had followed his boss to Meudon. He made use of the instrument in 1898 April and May to make four drawings of Jupiter, published in *l'Astronomie* in 1899 October (Fig. 4.2). Other observations of Jupiter would follow in 1904: "In several instances, at Meudon, in spite of the immediate vicinity of a great city and most notably on 1904 October 15, I was able to make upon Jupiter, with M. [Monsieur] Hansky, observations to the contrary, under conditions of such still images that one could have thought to have been observing a drawing illuminated by artificial light [4]."

The young Russian A. Hansky, from the Odessa Observatory, had come to Meudon to train in Astronomy under Janssen. He had shown himself as a talented artist, even to reproduce all the detail seen at the eyepiece (Fig. 4.3). He made remarkable drawings in 1904, published the following year in *l'Astronomie* [5].

Thus, the first years were marked by an intense activity which would become all-round. Between 1897 and 1903, ten communications would be presented to the Academy of Sciences. Besides the planets, observations would involve photography and spectroscopy. Their authors were J. Perrotin, G. Millochau, G. Tikhoff, A. Hansky and six communications were from H. Deslandres. Other articles and results would appear in the *Bulletin astronomique* of the Paris Observatory as well as in the review *l'Astronomie*.

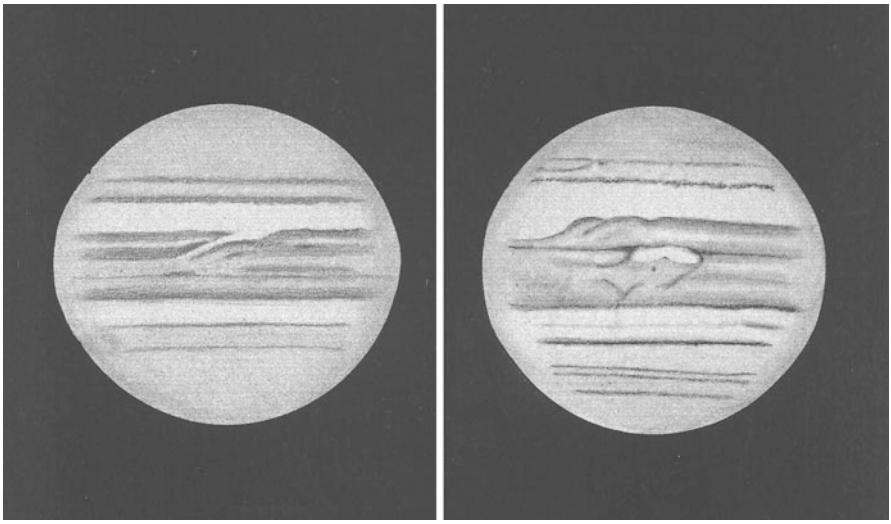

Fig. 4.2 Jupiter in 1898. Grande Lunette of Meudon. Drawing by G. Millochau. At *left*, May 9, 1898 at 22 h 35 m. *Right*, April 6, 1898 at 21 h 35 m

Fig. 4.3 Jupiter in 1904. Grande Lunette of Meudon. Drawings by A. Hansky. *Left*, October 14, 1904, 23 h 40 m. *Right*, October 15, 1904, 23 h 20 m, in excellent seeing

Analysis of the Surface of Mars (1901–1903)

At the start of the 20th Century, the study of planets was essentially left to visual observation at the eyepiece. The planet Mars, in this context, offered a special interest. The surface of the planet was directly visible. There one could study characteristics attributable to the present of life.

The Italian Giovanni Virginio Schiaparelli (1835–1910) in 1877 had thought that he had seen fine streaks upon the planet's surface, of a character that was hardly natural. In America, Percival Lowell (1855–1916) had studied the properties of these canals. Numerous other observers had confirmed them. Interpretations circulated, invoking signs of an intelligent life. In France, Camille Flammarion (1842–1925) had developed the subject in his great monograph *La Planète Mars* [6] and in numerous articles which had appeared in *l'Astronomie*. In 1898 he had come to produce a Mars globe, fixing the surface features as well as the positions of a great number of canals.

At Meudon too, Léopold Trouvelot (1827–1895) had studied the mottlings of the planet's surface and their variations, with a 38 cm refractor [7]. He had helped to recognise in such changes a seasonal character. He proposed, at the same time as Émile Liais, Director of the Rio de Janeiro Observatory in Brazil, to attribute them to expanses of vegetation.

Deslandres came to decide upon the replacement at Meudon for Trouvelot, who had recently died. He could do no better than to encourage Millochau to re-examine these problems of Mars with the Grande Lunette, more powerful than that of Trouvelot and all the other refractors in Europe.

Mars approached the Earth in 1901, although it again remained rather distant. But the planet had a very high altitude in the sky, which favoured stable images and the use of a high power. Millochau made four observations [8]. The following opposition came in 1903, with a disk diameter reaching 16 arcseconds. Seven nights were used to advantage, from which the Meudon Observatory has preserved 18 drawings [9].

The drawings of Millochau do not convey the full detail of the telescopic image. He could see much finer details than he was able to draw. From this acuity, he extracted an important conclusion:

> The canals which, in refractors of average power, are seen as weak lines, very narrow, but a little fuzzy, lose that appearance in the Grande Lunette; they then seem composed of dark broken masses, with irregular borders, formed like a string of beads which are lined up by the eye when the vision is not concentrated upon a point. [. . .] This aspect [. . .] must stem from the great separating power of the objective, which allows to better define the tiny details. [10]

Commissioning the Photographic Refractor (1898)

In 1898 January, from taking up his position as astronomer at Meudon, Deslandres quickly gave priority to the commissioning of the photographic refractor coupled to the visual instrument. The great device, whose objective measures 62 cm in diameter, offers a remarkably long focal length of 15.9 m.

From February, Deslandres carried out long exposure photographs with the instrument. These could exceed one hour, although: "With these large instruments, the least wind is a nuisance, as also is the slightest pressure upon the extremities [11]."

Fig. 4.4 The central part of the Orion Nebula. Photograph taken with the photographic objective of the great Meudon equatorial, February 22, 1909

Deslandres first attacked the great nebula in Orion, M42. He obtained three plates of the central part, then another very remarkable photograph the following year (Fig. 4.4) [12].

The invention of the gelatine-silver bromide photographic plate goes back to 1871. But the first pictures in silver of the Orion Nebula had not made their appearance until 1881, under the signature of Jules Janssen, then a little afterwards by Henry Draper. A very beautiful image had been obtained on 1883 February 28 by Andrew Ainslie Common (1841–1903), then came others by Isaac Roberts. All these images were obtained with very short focal lengths. They only showed the nebulosity as a whole.

Several larger images had allowed closer study of the central part. In 1895 the Harvard Observatory had published a print by Pickering, with a focal length of 4.50 m. Then in 1898 Sheiner at Potsdam came to produce an image of 3.0 m focus.

The Meudon images, with a 15.9 m focal length, were much bigger than all those that had preceded them. They were incomparably more detailed. According to Deslandres, preoccupied with the questions of Astronomy of the time: “These large plates thus seem to tell how to decide the longtime controversial question of variations in the nebulae [13].” New photographs of M42 would be taken for comparison purposes in 1909.

The Photography of Planetary Surfaces (1898–1899)

Above all else the photography of planets demands an extremely fine grain with very short exposures. Deslandres carried it out as follows: "A simple shutter mechanism was adopted, the lightweight shutter moved by the help of a foam rubber bulb. The observer follows the planet with the eyepiece of the Grande Lunette and squeezes the bulb when the image is least affected by the atmospheric undulations and the vibrations of the refractor [14]."

The first attempts were made with the Moon, at the prime focus, with the photographic emulsion coated upon glass plates of 18 × 24 cm format. The first plate was secured on 1898 February 26. The image of the Moon had a diameter of 14 cm. Six other plates are preserved at Meudon [15].

The detail upon the photographs is at least comparable with the best plates obtained at the Paris Observatory by Loewy and Puiseux. The great coudé instrument used at Paris from 1894–1907 to make their *Photographic Atlas of the Moon*, was of comparable power (60 cm objective, 18 m focal length) but was much less well situated. From Meudon, the photographic objective towers above the site, above the atmospheric disturbances caused in the vicinity of the ground.

For planetary photography, in 1898, the technique was again faltering. A first photograph of Jupiter had been obtained by Common on 1878 September 3 and showed a dark band and the Great Red Spot. On 1885 December 11, the brothers Paul and Prosper Henry had captured Saturn with its rings well separated from the globe [16]. On 1890 April 9 and 10, William H. Pickering obtained very small images of the disk of Mars [17]. The same year, at Lick Observatory, William Wallace Campbell sought to organise a photographic surveillance of planetary surfaces [18].

At the prime focus of the Grande Lunette, Jupiter measures 2 mm in diameter. Deslandres made attempts with different enlargements of the image. Between 1898 March 21 and May 13, twenty-one photographs were made, of which 15 plates have been preserved today. Modern prints from them are reproduced in Fig. 4.5.

Millochau drew the planet through the visual objective at the same time as Deslandres made the photographs behind the photographic objective. The prints of the photographs in Fig. 4.5 may be compared with the visual observations of Fig. 4.2.

According to Deslandres: "[The prints] were very good, and certainly superior to those of Lick Observatory, whose positives had been published by the Royal Astronomical Society of London [19]."

For Saturn, the exposure times were three to four times longer. Between 1898 May and July, four photographs were made, but the length of the exposures rendered them mediocre (Fig. 4.6, above). Nevertheless they show the exterior ring darker than the inner ring. Then, the angle of opening of the rings decreased. At the same time, the sensitivity of the emulsions improved. In 1909, a very good print was obtained, probably by Millochau (Fig. 4.6, below), although he had left Meudon for the Paris Observatory in 1907.

In 1899, the planet Mars was photographed on five occasions. But the image on the plate did not exceed 1.3 mm in diameter. Attempts were made with Venus, on four

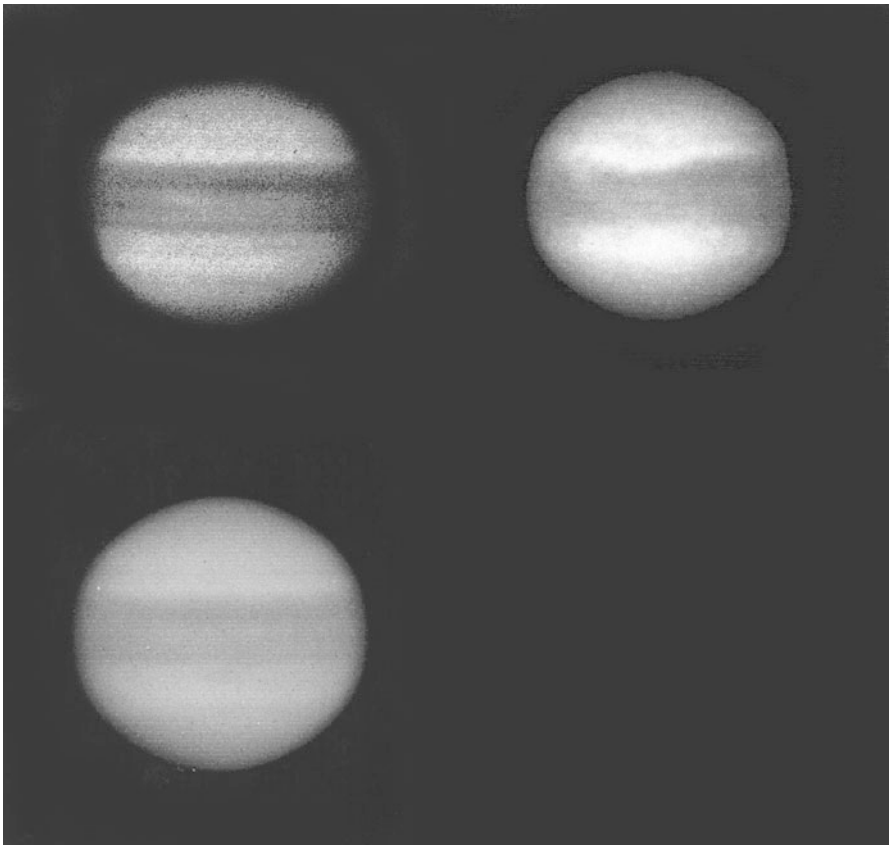

Fig. 4.5 Jupiter in 1898. Photographs made with the photographic objective of the great Meudon equatorial. Above, April 6, 1898 (*left*) and May 13, 1898, LB plate (*right*). Prints on paper from negatives obtained at the prime focus made by combining two images in order to reduce the grain of the photographic plate, a method unknown at the time the photos were taken. *Below*, April 13, 1898. Print taken from a single, prime focus image enlarged 4x. The grain is much weaker, but the duration of the exposure was 16 times longer

occasions, in full daylight or in twilight, but the dome heated by the Sun disturbed the images.

Deslandres presented his planetary photographs to the French Academy of Sciences [20]. Four prints of Jupiter and two of Saturn were reproduced by heliogravure in the *Bulletin astronomique de l'Observatoire de Paris* [21], as well as in the *Notice sur les titres et travaux scientifiques* of Deslandres of 1902 [22]. In spite of these presentations, these images of planets, nevertheless among the best of that epoch, would remain little known.

These fine results allowed consideration to be given to a systematic surveillance of planetary surfaces within the framework of the observatory's operations. But Meudon did not possess the necessary means. For Deslandres: "A regular and continuous study

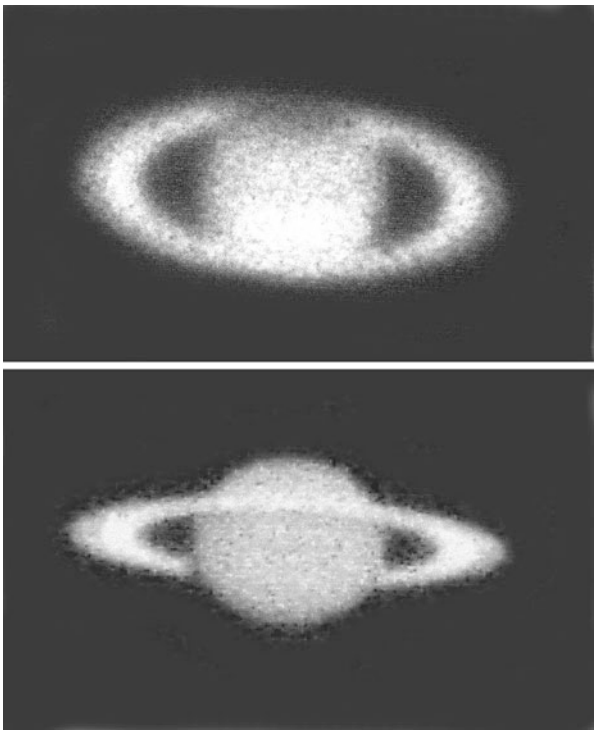

Fig. 4.6 Saturn in July, 1898 (*above*) and in 1909 (*below*). North is uppermost. Photos with the photographic objective of the great Meudon equatorial. Plates sensitive to blue and violet light. The improvement in image quality between the two dates is noticeable. (*Translator's note*: North is uppermost in these two pictures.)

of the planets by photography seems to me to be reserved for those observatories of which the stellar images are always steady [23]." The systematic study of the planets by photography would for years to come to be left to the privilege of the Lick Observatory in the USA.

All the photographs from that epoch showed the planets in blue and violet light, for which the emulsions then were alone sensitive. These aspects are different from the eyepiece impression. Jupiter, in particular, shows much more contrasty belts. Some years later, photographic emulsions would become sensitive for all colours of the visual waveband. Planetary photography no longer needed a refractor specially designed for blue light, like that of Meudon; it could be carried out with a normal refractor whose objective is optimised for the sensitivity of the eye. It would become practicable at numerous observatories.

In 1907, Lowell Observatory began in the USA a long-term planetary photographic program, in the visual waveband and in blue light. From 1941 onwards, planetary photography would become the privilege of the Pic du Midi Observatory, where the altitude of the mountain favoured obtaining very high quality telescopic images.

Fig. 4.7 The global cluster Messier 92 (NGC 6341) in Hercules, May 19, 1909. Photo with the photographic objective. Plate LΣ. Exposure 2 h 00 m

The Photography of Star Clusters (1898–1909)

At the end of the 19th Century, great concentrations of stars called *globular clusters* had been identified in the sky thanks to observations at the eyepiece with the great reflecting telescopes with metallic mirrors of Herschel, Rosse and Lassell [24].

Several photographs of short focal length began to be attempted. At Meudon, Louis Rabourdine (1858–1936) conducted a programme of photography of stellar and nebular objects with the Janssen reflecting telescope, an instrument of high light-gathering power, of 1 m aperture and 3 m focal length. The small image scale did not enable stars to be resolved in the hearts of star clusters [25].

Deslandres profitably employed the great focal length of the photographic refractor to attempt to partially or completely resolve the concentration of stars around the centres of the clusters [26].

Assisted by Millochau, Deslandres first photographed the globular cluster in Hercules, M13 (NGC 6205), upon the large-scale 24 × 24 cm LZ plates. In 1898, then in 1899, exposures reached 90 minutes. The nucleus, of which the integrated magnitude is 5.5, gathered numerous separate stars in a space 3 arcminutes in diameter (a tenth of that of the Full Moon).

Other exposures were obtained upon the clusters M3 in Canes Venatici (NGC 5272), M56 in Lyra (NGC 6779) and M11 in Scutum. In 1899 July and August, four plates were exposed on M92 in Hercules (NGC 6341).

The observations upon global clusters were taken up again in 1909, with even better results, upon the more sensitive LΣ and HΣ plates, of 13 × 18 cm format. Three plates would be obtained upon the globular cluster in Hercules, M92 (Fig. 4.7)

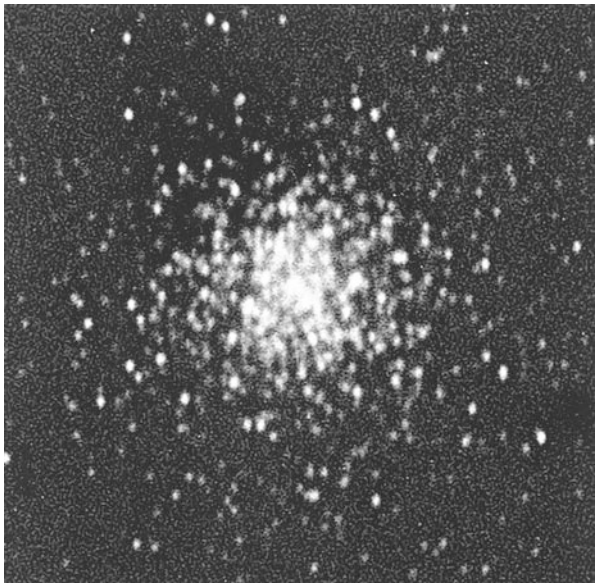

Fig. 4.8 The central part of the Messier 3 (NGC 4272) cluster in Canes Venatici, May 8, 1909. Photographic objective. Plate LΣ. Exposure 2 h 00 m

and four upon M3 in Canes Venatici, of which one was exposed for two hours (Fig. 4.8).

In 1895, from the Arequipa (Peru) branch of the Harvard Observatory, M. S. Bailey had showed that 3 % of the stars of the globular cluster in Centaurus were variable in brightness. Then William H. Pickering from Harvard had recognised more than 14 % of the stars of M3 were variable, although he had noted only 0.2 % as the case for M13. These results concerned the majority of stars in the cluster, excepting those of the centre which were unresolved.

The detailed photographs of Deslandres allowed research in stellar populations to be extended even to the hearts of the clusters. In M13, four variables were discovered in the central part, out of 300 stars counted, or 1.3 %. The result confirmed a strong increase in the proportion of variables towards the centre of the cluster [27].

The importance that the study of variables in clusters would later take on is well known, leading the American Miss Leavitt to discover in 1912 the relation between the period and absolute magnitude, for the class of stars called Cepheids, a relationship which allowed the determination of the distances of stars.

The Photography of Nebulous Stars (1898–1899)

Certain stars had been recognised as being enveloped in nebular material. Discovered by William Herschel (1738–1822), and called by him *planetary nebulae*, they could only be examined visually, at the eyepieces of the great reflecting telescopes with metallic mirrors.

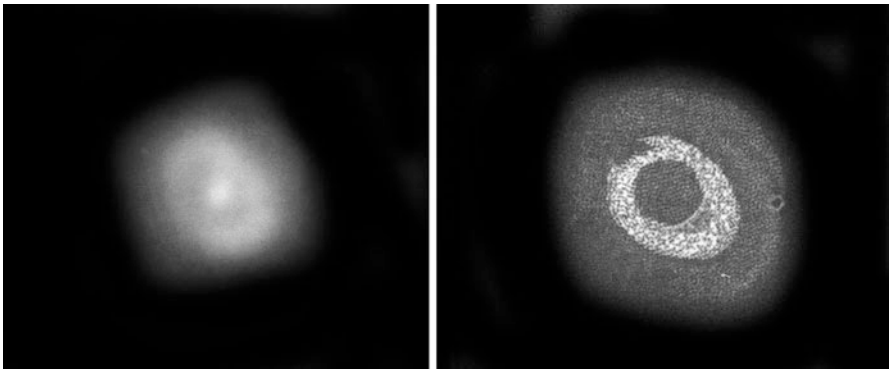

Fig. 4.9 The planetary nebula NGC 7662 in Andromeda, September 12, 1899. To the *left*, photograph with the photographic objective of the great Meudon equatorial. Plate LB. Exposure 1 h 53 m. To the *right*, the visual appearance through the great 183 cm reflector of Lord Rosse

It was generally thought that it was a case of stars in formation, at the stage where the material assembles around the nascent star and converges to increase its mass. We now know that contrarily it is a question of the final phase in the life of a star, when the explosion of the star propels its constituents into space.

For Deslandres, with the Meudon refractor, these stars surrounded by material were "all the more interesting since they escape, by reason of their small dimensions, from small and medium instruments [28]."

The planetary nebula NGC 7662 in Andromeda, of magnitude 8, covers a diameter of 30 arcseconds, a little less than the apparent disk of Jupiter. It was recorded photographically at Meudon on three occasions. We must note that these were the first known photographs taken of that object. Figure 4.9 compares the photographic image obtained with the best previous visual representation, by Lord Rosse (1800–1867). The central star, very blue, does not show up in the visual examination.

The object NGC 6523 in Saggitarius (wrongly identified by Deslandres as NGC 6543 in Draco) is now known under the name of the *Lagoon Nebula*. It was also photographed by him for the first time on 1899 May 30. The nebulous patch, of magnitude 4, is hardly larger than the preceding one.

It was the turn of the *Saturn Nebula*, NGC 7009, in Aquarius, very similar, on 1898 August 19. In Hercules, NGC 6229, a small fuzzy patch, reveals a weak neighbouring component.

NGC 7027 in Cygnus shows no more than faint extensions. NGC 6210 in Hercules, as well as NGC 6570 in Ophiuchus, in comparison with nearby stars, are revealed to be quasi-stellar. NGC 6905 in Delphinus, of magnitude 12, is too faint.

Much larger and brighter, the Ring Nebula in Lyra had been photographed with less powerful instruments. At Meudon the photographs showed around its centre the luminous filaments previously seen visually by Lord Rosse (Fig. 4.10).

These photographs, completely novel for their time, were presented at a meeting of the Academy of Sciences [29]. Two planetary nebulae were illustrated in the

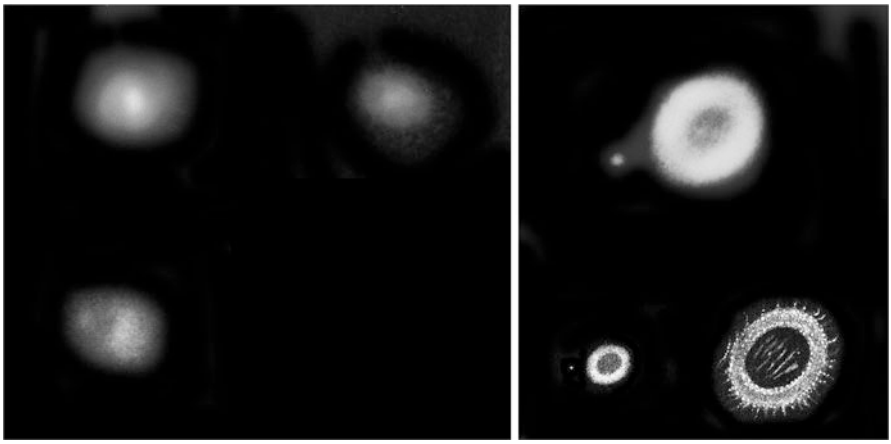

Fig. 4.10 The Ring Nebula in Lyra. *Above*, a print from a glass copy negative, date unknown, Grande Lunette of Meudon. *Below*, the visual aspect drawn by W. Herschel (*left*) and by Lord Rosse (*right*)

Bulletin astronomique de l'Observatoire de Paris [30] and then in the *Notice sur les titres et travaux scientifiques of Deslandres* in 1902 [31]. But these results too would very rarely be cited.

Deslandres did not draw any conclusions about the physics of planetary nebulae. It was more a question of proving the capabilities of the great instrument. His aim was to explore new fields of research in which the power of the great equatorial was bound to break new ground.

Final Stellar Photography (1909)

In 1898 and 1899, the photographic observing campaign had been intense. But Deslandres did not follow this line of research any further. He was above all a spectroscopist, and his invention of the spectroheliograph had pushed him to the forefront of solar physics [32]. As a result, he would use the resources of the Observatory for developing these two fields.

A new series of photographs would again be obtained in 1909, probably again under the coordination of Millochau, in spite of his differences with Deslandres. They concerned Mars, Saturn, the Orion Nebula, and the globular clusters mentioned earlier. These results would profit from the considerable improvement in the performance of the new photographic plates over the past decade.

From 1905 onwards, we have seen that for planetary photography, the new photographic emulsions would become sensitive to the same range of wavelengths as the human eye. They would permit long exposures with ordinary refractors, designed for visual observation, like the great instruments of the Lick, Yerkes and Lowell

Observatories in the USA, and plenty of others, destroying the specificity of he great photographic objective of Meudon.

In 1896, Common's old 90 cm reflector, which had been a little more powerful than the Meudon instrument, had been transferred from England to the Lick Observatory in America, under the name of the Crossley reflector. From 1898 onwards, James E. Keeler (1858–1900), then Charles D. Perrine and later Hubert D. Curtis (1872–1942) would make remarkable use of the instrument for the photographic exploration of distant objects. They would essentially lead the research in this field [33].

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3. *Ibid.*
4. G. Millochau, "Les observations de planètes avec les grands instruments", *l'Astronomie*, **19**, 404–417 (1905).
5. Four drawings of Jupiter by A. Hansky are reproduced in *l'Astronomie*, **19**, 363 (1905).
6. The majority of the observations of Mars from this period are summarised in the two-volume monograph of C. Flammarion, *La Planète Mars et ses conditions d'habitabilité*, **1**, Gauthier-Villars, Paris, 1892, and **2**, Gauthier-Villars, Paris, 1909.
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8. The drawings by Millochau in 1901 are reproduced in C. Flammarion, *ibid.*, **2**, p. 529.
9. Meudon Observatory Archives (Paris Observatory Library).
10. G. Millochau, "Observations de Mars a la grande lunette de l'Observatoire de Meudon", *Comptes rendus de l'Académie des Sciences*, **137**, 1903 October 27.
11. H. Deslandres, "Photographies stellaires avec la Grande Lunette de l'Observatoire de Meudon", *Comptes rendus de l'Académie des Sciences*, **128**, 375 (1899). The stability of the Grande Lunette is examined in A. Dollfus, "La Grande Lunette de Meudon a cent ans", *Bulletin de la Société des amis de Meudon*, 1995 December.
12. The photograph in Fig. 4.4 is from 1909. One of the photographs from 1898 is reproduced in "Photographies stellaires avec la Grande Lunette de l'Observatoire de Meudon", *Bulletin astronomique de l'Observatoire de Paris*, 1900 February, pp. 69–73, and in H. Deslandres, *Notice sur les titres et travaux scientifiques de M. H. Deslandres*, Gauthier-Villars, Paris, 1902. The negatives taken in 1909, preserved at Meudon, have never been previously published.
13. H. Deslandres, "Photographies stellaires avec la Grande Lunette de l'Observatoire de Meudon", *Comptes rendus de l'Académie des Sciences, op. cit.*
14. *Ibid.*
15. The labels upon the photographic plates are in the hand of Lucien d'Azambuja. In 1898, Deslandres proposed to a school, the Écoles des Frères de Bellevue, to pay a young pupil for some practical tasks at the Observatory. Lucien d'Azambuja (1884–1970) was recruited in that way in 1899, at the age of 15 for, in his words "affixing the labels at the top and to the right of the glass plates". D'Azambuja finished his astronomical career as *astronome titulaire* of the Observatory, and President of the Solar Commission of the International Astronomical Union.
16. The two photograhs of Jupiter and Saturn mentioned are reproduced in E.C.Slipher's, *A Photographic Study of the Brighter Planets*, Northland Press, Arizona, 1964.
17. The two photographs of Mars by Pickering were reproduced in C. Flammarion, *op. cit.*, volume **1**, p. 464.

18. The majority of photographic images collected at the various observatories of the world from 1905 until 1975 have been assembled by the IAU at Meudon. (The database can be consulted at: http://megasn.obspm.fr/bdip.html)
19. In 1891 Edward Emerson Barnard (1857–1923) and William Wallace Campbell (1862–1938) had obtained a photograph of Jupiter considered as the first to be of a really useful quality.
20. H. Deslandres, "Photographies stellaires avec la Grande Lunette de l'Observatoire de Meudon", *Comptes rendus de l'Académie des Sciences, op. cit.*
21. H. Deslandres, "Photographies stellaires avec la Grande Lunette de l'Observatoire de Meudon", *Bulletin astronomique de l'Observatoire de Paris, op. cit.*
22. H. Deslandres, *Notice sur les titres et travaux scientifiques de M. H. Deslandres*, Gauthier-Villars, Paris, 1902.
23. H. Deslandres, "Photographies stellaires avec la Grande Lunette de l'Observatoire de Meudon", *Bulletin astronomique de l'Observatoire de Paris, op. cit.*
24. Numerous drawings of star clusters and nebulae observed visually are reproduced in A. Guillemin, *Les Nébuleuses, notions d'astronomie sidérale*, Hachette, Paris, 1889.
25. The work of Rabourdin is given by A. Dollfus, *"Le grand télescope de Janssen de l'Observatoire de Meudon", l'Astronomie*, **114**, 246 (2000), in which a print of the globular cluster in Hercules, M13, of 1897 August 2, is reproduced.
26. H. Deslandres, "Photographies stellaires avec la Grande Lunette de l'Observatoire de Meudon", *Comptes rendus de l'Académie des Sciences, op. cit.*
27. *Ibid.*
28. *Idem.*
29. H. Deslandres, "Photographies stellaires avec la Grande Lunette de l'Observatoire de Meudon", *Comptes rendus de l'Académie des Sciences, op. cit.*
30. H. Deslandres, "Photographies stellaires avec la Grande Lunette de l'Observatoire de Meudon", *Bulletin astronomique de l'Observatoire de Paris, op. cit.*
31. H. Deslandres, *Notice sur les titres et travaux scientifiques de M. H. Deslandres, op. cit.*
32. An historical survey of early first solar work of Deslandres was given by A. Dollfus, "Henri Deslandres et le spectrohéliographe. L'épopée d'une recherche", *l'Astronomie*, **119**, 150–159 (2005).
33. See R. P. S. Stone, "The Crossley Reflector: a Centennial Review I, II", Sky & *Telescope*, 1979 October, pp. 307–311 and 1979 November, pp. 396–400.