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***Hippolyte Fizeau: Physicist of the light.* By James Lequeux (Paris, EDP Sciences, 2020). Pp vi + 142. ISBN 978-2-7598-2045-0 (paperback), 160 × 228 mm, €29.00.**

James Lequeux is an outstanding historian of physics whose period of specialisation is the long nineteenth century. He has written definitive biographies of François Arago (1786–1853) and Urbain Le Verrier (1811-1877). James served for 15 years as editor-in-chief of *Astronomy and Astrophysics*. When he began research in radio astronomy in 1954, the discipline scarcely existed in France. His doctorate was awarded in 1962 for interferometric observations of discrete radio sources. He then devoted his long professional life variously at Nançay, the Observatoire de Paris, and Marseille where he served as the observatory director. That background has ably served as the launchpad for his exceptional contributions to the history of physics and astronomy in post-revolutionary France.

From this vivid biography of Armand Hippolyte Louis Fizeau (1819–1896) we learn that he probably attended Arago's hugely successful lectures at the Observatory on popular astronomy. At the Collège de France, Fizeau took the course on optics taught by Henri Victor Regnault (1810–1878). Arago and Regnault were important influencers of Fizeau's future in science. In 1839 Arago gave a presentation in Paris on the new field of photography and the daguerreotype process, the novelty of which attracted a worldwide following. Young Fizeau, set to immediately, discovering how to improve the process by fixing the image and making it more brilliant. From 1843 Fizeau and Foucault collaborated: their first project, suggested by Arago, concerned with applying the daguerreotype to photometry.

With its 130 pages of narrative this relatively short biography of "a pillar of French physics" is accessible to a wide general readership. Lequeux knows how to package outstanding scholarship to the public. The book is neatly organised into eight chapters, all cleverly arranged so that each chapter is a self-contained outline of a major investigation. Following the first chapter on the daguerreotype, we are informed of the successive stages in Fizeau's long career: interferometry and the nature of light; the Doppler-Fizeau effect; the velocity of light and electricity; and the velocity of light in air and water; the ether drag; and his ingenious suggestion (which he never published!) that the phenomenon of interference might possibly be applied to measure the diameters of stars.

In 1845 the Fizeau-Foucault collaboration extended Thomas Young's double slit experiment by introducing a monochromatic light, the E and F lines of the solar spectrum. With one set up they obtained interference with a path difference of 1.4 mm, which could be explained readily by the wave theory of light: they had demonstrated the coherence of light. Two years later their interference experiments confirmed that no essential difference exists between light and heat rays. Curiously their results did not attract much interest, which Lequeux attributes their modesty, their hesitation to make large claims. In the course of these experiments Fizeau's in-depth knowledge of spectral analysis guided him to his next project.

In 1842 Christian Doppler (1803–1853) had speculated that the reason why some stars appear blue (e.g., Rigel) whereas others are red (Betelgeuse) is due to their motion relative to the observer. He claimed a velocity of about 100 km/s would be sufficient to cause a perceptible colour change. Fizeau would have none of this. He gave a physically accurate description of the effect of the motion of a light source: relative motion alters the wavelength of light. Thus:

> Considered in the spectrum this effect will result in a shift of the lines corresponding to the change in the length of the undulations (page 37).

Fizeau next calculated the change in the sodium D line for sunlight reflected by Venus due to the orbital motion of Earth, observational confirmation of which lay in the future. Two decades passed before stellar spectroscopy developed to the point where Sir Williams Huggins (1824–1910) succeeded in measuring the radial velocity of a star for the first time: Sirius in 1868. Lequeux informs us:

> It is Fizeau who first saw clearly … how to measure the relative velocity of the source and observer … using spectral lines. It is therefore legitimate to associate their names [for] the Doppler-Fizeau effect. However in the late nineteenth century already, one no longer spoke of Doppler-Fizeau, only of Doppler (page 38).

So within only two decades the effect was neither well known nor widely accepted, at least as far as light was concerned.

In 1849-50 Fizeau devoted his energy to measuring the velocity of light by employing a toothed wheel rotating very rapidly. This set up directed a stream of pulsed light at a distant mirror (8,633 m) and reflected it back to the source. Fizeau's result, close to the value already known from astronomical observations, was the first direct measurement, and his reward was elevation to the Légion d'Honneur. Foucault was full of praise for his friend, "a man of genius."

By the mid-nineteenth century Fizeau was the world's most accomplished experimentalist on the velocity of light. In 1850 he succeeded in a comparison of the velocity of light in air and water, just seven weeks after Foucault. The following year he staged another big hit by measuring the variation in the velocity of light in a stream of water. Scepticism about how to interpret Fizeau's findings lingered on for half a century. Michelson and Morley improved Fizeau's experiment in 1886, concluding that:

> The result of Fizeau is essentially correct … the luminiferous aether is entirely unaffected by the motion of the matter which it permeates…(page 87).

Pieter Zeeman (1865–1943) repeated Fizeau's experiment in 1914, with far greater accuracy. He considered it:

> One of the most ingenious experiments of the whole domain of physics (page 87).

The book includes 70 illustrations variously sourced from manuscripts and letters, contemporary photographs and portraits, and diagrams of apparatus. All figures are accompanied by detailed and highly informative captions, thus deftly avoiding a clutter of technical detail in the main narrative. Back matter includes a handy genealogy of Fizeau and his wife; a neat chronology illustrating Fizeau's world line; letters between Fizeau and Foucault in 1850; bibliography; and a proper index. The book is nicely designed with a clear font that is easy on the eye. Its white matte paper is of high quality that is adequate for the reproduction of the halftones.

Lequeux's conclusion (page 126) vividly encapsulates Fizeau's enormous impact on French physics and astronomy.

> In a world where science was becoming a full-fledged profession, Fizeau was one of the last amateurs: his personal fortune allowed him to conduct his research as he saw fit. … [The] optical work of Fizeau assures him an honoured place in the history of [optical] science, and his fertile ideas are still sources of inspiration for physicists.

This excellent biography is written in a lively manner that will delight public readers and inform historians. Lequeux succeeds magnificently in bringing Hippolyte Fizeau out of dark shadows and into brilliant light.

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