

ORCHESTRATING OBSERVATORY, LABORATORY, AND FIELD:
JULES JANSSEN, THE SPECTROSCOPE, AND TRAVEL

DAVID AUBIN*

Max-Planck-Institut für Wissenschaftsgeschichte
Berlin

In the summer of 1862, Robert Bunsen and his colleague at the university of Heidelberg, Gustav Kirchhoff, stopped by in Paris on their way to London, where Manchester chemistry professor Henry Roscoe had invited them. The three men wished to visit the International Exhibition at Kensington Palace, as well as to popularize their new method of spectrum analysis. On August 18, they attended the weekly meeting of the Paris Académie des sciences, where their presence was a sensation, not least because the Heidelberg pair had just published a series of important studies on the analysis of spectra emitted by metal gases and the sun: "The most remarkable scientific discovery of the year 1861."¹

But the adoption of their technique by others was by no means straightforward. Thus, the rapidity of its assimilation by practitioners in diverse fields was both surprising – and not. It was not surprising considering the widespread technical expertise extant among optical physicists who already possessed a delicate mastery of spectroscopic techniques.²

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¹ LOUIS FIGUIER, *L'analyse spectrale, nouvelle méthode d'analyse chimique de MM. Bunsen et Kirchhoff*, «L'Année Scientifique et Industrielle», VI, 1862, p. 106. See FRANK A. J. L. JAMES, *The establishment of spectro-analysis as a practical method of quantitative analysis, 1854-1861*, «Ambix», XXX, 1983, pp. 30-53. About this trip, see HENRY E. ROSCOE, *The life and experiences of Sir Henry Enfield Roscoe*, London, MacMillan, 1906, pp. 62, and 72-74.

² In particular FRANK A. J. L. JAMES, *The creation of a Victorian myth: the historiography of spectroscopy*, «History of Science», XXIII, 1985, pp. 1-14; M. A. SUTTEN, *Spectroscopy, historiography, and myth: the Victorians vindicated*, *ibid.*, XXIV, 1986, pp. 425-432; and JAMES, *Spectrochemistry and myth: a rejoinder*, *ibid.*, pp. 433-437.

But, on a theoretical level, it is rather astonishing that Kirchhoff's daring hypotheses about the chemical constitution of the sun faced so little resistance. The French astronomer Hervé Faye, for one, wrote that they had merely performed a bold, but largely unsubstantiated, "literal translation" of a laboratory experiment to the sun and that additional observations were necessary.³ The objection had also been raised, echoing the earlier position taken by Scottish physicist David Brewster, according to which lines in the sun spectrum were attributes, not of an hypothetical solar atmosphere – whose very existence was hotly contested at the time – but of the terrestrial atmosphere. Between extreme positions, "there was room for a less exclusive and more complete doctrine which would distinguish between both causes and show the double origin of the lines discovered by [William Hyde] Wollaston and [Joseph von] Fraunhofer in the prismatic image of the sun."⁴ This was the task that French physicist Jules Janssen (1824-1907) set out to address (Fig. 1).

In Janssen's opinion, "telluric lines" were those that could not be attributed to celestial bodies, but which had their origin in the earth's upper atmosphere.⁵ He had discovered them by noticing changes in intensity of certain groups of absorption lines in the red and orange portions of the solar spectrum depending on the sun's position: telluric lines were darker at dawn and dusk, and fainter when the sun was high up in the sky. Not only was this a crucial step in scaling up Kirchhoff's laboratory experiment, by eliminating one cause of possible confusion it also strengthened the interpretation according to which solar dark lines indeed had an extra-terrestrial origin, and therefore bolstered the precarious outsiders' position of those who promoted the new "celestial chemistry."⁶ Much more than the translation of an experimental result into the language of astronomy, more than the accommodation of laboratory practices (spectroscopy and photography) to astronomical observation routines, the "new astronomy," I want to show here, acquired its prominent, if often ambiguous status, by successfully orchestrating the

³ HERVÉ FAYE, *Spectre de l'auréole des éclipses totales*, «Comptes-rendus des Séances de l'Académie des Sciences» [hereafter «CRAS»] LIII, 1861, pp. 679-683.

⁴ JULES JANSSEN, *Notice sur les travaux de M. J. Janssen*, Paris, Gauthier-Villars, 1872. AdS, Janssen Biographical File. On Janssen, G. BIGOURDAN, *Janssen*, «Bulletin Astronomique», XXV, 1908, pp. 49-58; and JACQUES LÉVY, s.v. in CHARLES C. GILLESPIE (ed.), *Dictionary of scientific biography*, VII, New York, Scribner, 1973, pp. 73-78.

⁵ JULES JANSSEN, *Note sur les raies telluriques du spectre solaire*, «CRAS», LIV, 1862, pp. 1280-1281.

⁶ JULES JANSSEN, *La chimie céleste*, 1873. Repr. in JULES JANSSEN, *Lectures académiques, discours*, Paris, Hachette, 1903, pp. 20-28.

rapid movements of three ancient traditions, that are, the observatory, the laboratory, and the scientific expedition. At this time, each of these secular institutions were undergoing significant shifts. In a new political economy of science, where precision measurement, the expansion of empires, and increased State disciplining and control went hand in hand, astrophysics established itself as a place where these shifting traditions could be coordinated with one another.⁷

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As I will suggest by following Janssen's early trajectory, the kind of astronomy that emerged following Kirchhoff and Bunsen's work was located at the intersection of several traditions then undergoing radical transitions. Ever since it became clear that the character of astronomy had mutated, people started to speculate about the origins of the "new astronomy" or, as it soon became known, "astrophysics."⁸ But what early astrophysicists and historians alike have failed to notice is that from the perspective of the 1880s, astronomy was hardly the only science that looked "new," as Charles A. Young emphasized: "One might almost say, that, since 1848, «all things have become new» in the scientific world. There is a new mathematics and a new astronomy, a new chemistry and a new electricity, a new geology and a new biology."⁹ Indeed, if astrophysics came to occupy a central position within astronomy, it was, I argue, because it succeeded in tapping into three ancient, but rapidly expanding, traditions – the observatory, the laboratory, and the scientific expedition.

The view that astrophysics was resisted "with a certain contempt" by

⁷ Recent historiography of science has emphasized these cultures of precision in the late 19th century; see, e.g., CROSBIE SMITH and M. NORTON WISE, *Energy and empire: a biographical study of Lord Kelvin*, Cambridge, Cambridge University Press, 1989; THEODORE PORTER, *Trust in numbers: the pursuit of objectivity in science and public life*, Princeton, Princeton University Press, 1995; and M. NORTON WISE (ed.), *The values of precision*, Princeton, Princeton University Press, 1995. For astronomy and imperialism, see LEWIS PYENSON, *Civilizing mission: exact sciences and the French overseas expansion, 1830-1940*, Baltimore, Johns Hopkins University Press, 1993. For State and discipline, see MICHEL FOUCAULT, *Discipline and punish: the birth of the prison*, New York, Vintage, 1979.

⁸ SAMUEL PIERPONT LANGLEY, *The new astronomy*, Boston, Houghton Mifflin, 1884; Reed, 1889; AGNES M. CLERKE, *A popular history of astronomy in the nineteenth century*, Edinburgh, Adams & Charles Black, 1885. See ARTHUR J. MEADOWS, *The new astronomy*, in OWEN GINGERICH (ed.), *The general history of astronomy IV, astrophysics and twentieth-century astronomy to 1950*, Part A, Cambridge, Cambridge University Press, 1984, pp. 59-72; and DAVID H. DEVOR-KIN, *Astrophysics*, in JOHN LANKFORD (ed.), *History of astronomy: an encyclopedia*, New York, Garland, 1997, pp. 72-80.

⁹ CHARLES A. YOUNG, *Pending problems of astronomy*, «Science», IV, 1884, pp. 192-203.

“orthodox astronomers of the old guard” was recently revisited by Simon Schaffer who has argued that astrophysicists “set out to change the culture of astronomical observatories into that of the laboratory.”¹⁰ This is an old argument, going back to Huggins who once produced a famous description of the laboratory world of the astrophysical observatory. The old guard, according to Schaffer, resisted not so much the goals of astrophysics, as a laboratory practice organized around the calibration of spectrometers that was foreign to them. In an 1874 report to the Academy, Faye also emphasized the contrast with traditional observatories. “Everything, in these new Observatories – instruments and personnel – has had to be adjusted... Instruments are not meridian circles, gigantic equatorials, clocks of incomparable precision... [They] rather look like a Chemistry laboratory... This is no longer a matter of Celestial Mechanics, but of Celestial Physics and Chemistry: stellar matter is analyzed as if it were in a crucible.”¹¹ The rhetorical function of such discourses has not enough been taken into account: distributed to Members of Parliament, this report was designed to gain their approval for setting up, at great cost, a new observatory for Janssen.

To my knowledge, the opposite claim has rarely been made, but is just as arguable. Indeed, astrophysics partook in a wider process of introducing the practices of the astronomical observatory into the laboratory. Until the middle of the century, for that matter, the term “physical observatory” was often used interchangeably with “physical laboratory,” especially in programmatic statements.¹² The culture of the large chemical laboratories among the first to adopt spectrum analysis, like Bunsen’s or Henri Sainte-Claire Deville’s at the École normale supérieure, was in the same decades going through such rapid changes that this process has been called an ‘institutional revolution.’ In chemistry, but also in physics and physiology, laboratory cultures were borrowing heavily from the observatory

¹⁰ SIMON SCHAFFER, *Where experiments end: tabletop trials in Victorian astronomy*, in JED Z. BUCHWALD, *Scientific practice: theories and stories of doing physics*, Chicago, The University of Chicago Press, 1995, pp. 257-299. The above characterization of astrophysics is taken from CLERKE, *op. cit.*, p. 2.

¹¹ HÉRVÉ FAYE, *Rapport de la Commission nommée le 17 août pour préparer une réponse à la Lettre adressée par M. le Ministre de l’Instruction publique, au sujet de l’opportunité de la création d’un observatoire d’astronomie physique aux environs de Paris*, Paris, Gauthier-Villars, 1874. AN F¹⁷ 3645.

¹² See, e.g., JEAN-BAPTISTE DUMAS, *Rapport sur l’enseignement des sciences*, «Journal des Débats», 6 November 1846; WILHELM WEBER to Col. SABINE (February 20, 1845); quoted by MATTHIAS DÖRRIES, *Balances, spectrometers, and the reflexive nature of experiment*, «Studies in the History and Philosophy of Science», XXV, 1994, pp. 1-36, on p. 19.

sciences.¹³ Just like it had for several decades been the case in large national observatories in Greenwich or Paris, laboratory work in Paris, London, or Heidelberg was increasingly compartmented and organized hierarchically on the model of a factory coordinating different levels of skill among laborers.¹⁴ Just like observatory scientists had constituted vast networks of observers, experimental scientists were increasingly involved in international collaboration and coordination.

Arguments about the introduction of the laboratory in the observatory hinge on preconceived notions that actors had of both institutions. What exactly was the laboratory that was introduced in the observatory? In the early 19th century, experimental physics had been carried out extensively in the Paris Observatory. In 1854, Léon Foucault (supported by director Urbain Le Verrier) argued for the usefulness of a physicist being adjoined to the *Observatoire*. He would put “all resources from modern physics in the service of observation” and “tackle physics questions whose study requires the use of astronomical instruments.” Scores of physics studies could be done in an observatory, the only place where “one could hope to bring them to the highest degree of precision they require.”¹⁵ With astrophysics, it was not simply the laboratory that entered the observatory – it had been there for some time – but a new kind of laboratory (Fig. 3).

What first impressed people in 1860 about Kirchhoff and Bunsen’s work, perhaps as much as their results, was their laboratory. Before he accepted the Heidelberg position, Bunsen had requested that new installations be built for him.¹⁶ Opening the first volume of his *Annuaire scientifique* with

¹³ DAVID CAHAN, *The institutional revolution in German physics, 1865-1914*, «Historical Studies in the Physical Sciences», XV, 1985, pp. 1-65; ANDREW CUNNINGHAM and PERRY WILLIAMS, *The laboratory revolution in medicine*, Cambridge, Cambridge University Press, 1992; and PETER BORSCHIED, *Naturwissenschaft, Staat und Industrie in Baden, 1848-1914*, Stuttgart, Ernst Klett, 1976. About changes in nineteenth-century observatories, ALLAN CHAPMAN, *The astronomical revolution*, in JOHN FAUVEL, RAYMOND FLOOD, and ROBIN WILSON (eds.), *Möbius and his band: mathematics and astronomy in nineteenth-century Germany*, Oxford, Oxford University Press, 1993, pp. 32-77; and DAVID AUBIN, *The fading star of the Paris Observatory in the nineteenth century: astronomers’ urban culture of circulation and observation*, in JENS LACHMUND, SVEN DIERIG, and ANDREW MENDELSON (eds.), *Science and the city*, «Osiris», XIX (forthcoming 2003).

¹⁴ The observatory as factory is described in SIMON SCHAFFER, *Astronomers mark time: discipline and the personal equation*, «Science in Context», II, 1988, pp. 115-145.

¹⁵ LEON FOUCAULT to URBAIN LE VERRIER (August 19, 1854). BIF, Le Verrier Papers, Ms. 3711, 40.

¹⁶ ROSCOE, *The life and experiences*, cit., p. 51; FRANK A. L. JAMES, *Science as cultural ornament: Busen, Kirchhoff and Helmholtz in mid-nineteenth-century Baden*, «Ambix», XLII, 1995, pp. 1-9. See also MARGOT BECKE-GOEHRING and EKKEHARD FLUCK, *Die Zeit nach Gmelin im 19. Jahrhundert*, in WILHELM DOERR (ed.), *Semper apertus. Sechshundert Jahre Ruprecht-Karls-Universität Heidelberg 1386-1986*, II, Berlin, Springer, 1985, pp. 337-347.

spectroscopy, Pierre-Paul Déherain wrote that Kirchhoff and Bunsen's "elegant and delicate researches could not have been undertaken in a more suitable place."

Heidelberg is such a lovely town! A true nest for *savants* where one would like to live, had one not tasted this bitter fruit, [that is] the Parisian life... Professors are kings in this world inhabited by students, Heidelberg. Kings need palaces; the beautiful monument in which the chemistry laboratory is established can hardly be called otherwise.¹⁷

In fact, Kirchhoff was quite unhappy about his laboratory. Shaken by traffic, the building hardly offered the stability required for delicate experiments. On December 9, 1859 – a mere six weeks after Kirchhoff's first talk at the Berlin Academy on spectrum analysis – the authorization was given for a new building. Hosting physics, mineralogy, mathematics, technology, and physiology, it opened in September 1863.¹⁸ In Paris, in contrast, few laboratories existed that could compete with Heidelberg, besides, as we shall see, Sainte-Claire Deville's.

Sympathetic to the *savants'* pleas, minister of public instruction Victor Duruy fought to increase his budget at a time when government deficits were the norm. To argue his case, he appealed to utilitarian and nationalistic sentiments. Without proper laboratories, he wrote the emperor in 1865, "Before long, to compete with foreign science, French science will be in the position where His Majesty would find himself if he only had Louis XIV's vessels to fight England's armored battleships... The countless riches of industry flow out of the chemists' laboratory and the physicists' and naturalists' cabinets like a river flows from its source."¹⁹ With the creation of the *École pratique des hautes études* in 1868, Duruy impelled the rapid development of laboratories in France.²⁰

In parallel, astrophysics hinged on the coordination of both the

¹⁷ PIERRE-PAUL DÉHERAIN, *Analyse chimique de l'atmosphère du soleil: deux nouveaux métaux*, «Annuaire scientifique», I, 1862, pp. 5-20, on p. 10.

¹⁸ FRANZ WERNER, *Hermann Helmholtz' Heidelberger Jahre (1858-1871)*, Springer, Berlin, 1997, pp. 92-97; ARLEEN MARCIA TUCHMAN, *Science, medicine, and the state in Germany: the case of Baden, 1815-1871*, Oxford, Oxford University Press, 1993, pp. 168-170; BORSCHIED, *op. cit.*, pp. 62-71; and BETTINA ALBRECHT, *Die ehemaligen naturwissenschaftlichen und medizinischen Institutgebäude im Bereich Brunnengasse, Hauptstraße, Akademiestraße und Plöck*, in PETER ANSELM RIEDL (ed.), *Semper apertus*, cit., V, 1985, pp. 336-365.

¹⁹ VICTOR DURUY, *Notes et souvenirs*, I, Paris, Hachette, 1901, p. 204.

²⁰ JEAN ROHR, *Victor Duruy, ministre de Napoléon III. Essai sur la politique de l'instruction publique au temps de l'empire libéral*, Paris, Librairie générale de droit et de jurisprudence, 1967, pp. 116-121.

laboratory and observatory traditions with the shifting customs of scientific travel. In the age of steamships and railways, at the highpoint of State centralization, colonialism, and imperialism, scientific missions took on a new meaning, and their value for metropolitan powers increased greatly.²¹ In 1862, Déherain could still claim that travel was the chore of the naturalist, while chemists enjoyed the calmness of their laboratories.²² One decade later, biologists and geologists went along with astronomers on a great number of observation sites for the transit of Venus, whose organizing committee was headed in France by the chemist Jean-Baptiste Dumas. Again, observatories shared a long tradition in organizing, and partaking in scientific expeditions. But the rise of astrophysics hinged on the ability, made possible by technological and social developments associated with European imperialism, to orchestrate observatory and laboratory practices in the field, at the same time as it accommodated the routines of scientific expeditions into astronomical communities. Moreover, important characteristics of field science massively made their way in astronomy: frequent international meetings, the redaction of long, detailed, and public reports constant cultural translation of scientific objects, more ambiguous distinction between amateurs and professional, public display of results, visual representations valued as art, etc.²³

To illustrate my claims, I first discuss the French reception of Kirchhoff and Bunsen's work in spectrum analysis, showing the borderland nature of the communities that picked it up. The crucial mediating role of a singular location, namely Sainte-Claire Deville's laboratory at the *École normale*, appears clearly. I also insist on the overwhelming importance of the optical physics experimental community, which nurtured Janssen. My discussion of his trip to Italy exhibits the way in which these different traditions could be coordinated with those of the observatory and scientific travel.

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²¹ HENRIKA KUKLICK and ROBERT E. KOHLER (eds.), *Science in the field*, Special Issue «Osiris», XI, 1996; DAVID AUBIN, *La métamorphose des éclipses de soleil*. «La Recherche», no. 321, juin 1999, pp. 78-83; S. SCHAFFER, *Laboratories ashore*, talk delivered at the conference on *La science 'fin de siècle'*, Centre Alexandre-Koyré, Paris, December 8-9, 2000; and MARIE NOËLLE BOURGUET, CHRISTIAN LICOPPE, and H. OTTO SIBUM (eds.), *Instruments, travel, and science: itineraries of precision from the seventeenth to the twentieth century*, London, Routledge, forthcoming.

²² PIERRE-PAUL DÉHERAIN, *La chimie à l'Exposition de Londres*, «Annuaire Scientifique», II, 1863, pp. 304-325, on p. 325.

²³ KUKLICK and KOHLER, *Science in the field*, cit., pp. 3-6.

In France, the reception of Kirchhoff and Bunsen's work apparently was almost immediate and enthusiastic. From the most prominent down, scientists lauded the accomplishment of the Heidelberg pair. In the *Moniteur*, Dumas exclaimed: "today, light... becomes... a universal instrument of analysis with infinite sensitiveness, which discloses the existence of new elements." From now on, he dreamed, "no element whether known or unknown will be able to escape the investigation of chemistry; the gaps still remaining in the list of simple elements that hinder the completion of their classification will be filled; the analysis of mineral waters will be less incapable of accounting for their therapeutic properties." After having explained how the method had led to the discovery of new metals, Dumas went on to describe its astronomical uses: "it is no longer necessary to touch a body to determine its chemical nature: to see it is enough."²⁴ In a lecture at the annual meeting of the *Société des amis de la science* in 1862, physicist Jules Jamin was equally enthusiastic. To him, the fact that this method could reveal the constitution of the sun's atmosphere was simply "merveilleux."²⁵

At first sight, this enthusiastic reception stands in strong contrast with nationalistic controversies in Britain where some scientists were not ready to accept Bunsen and Kirchhoff's priority claims. By the summer of 1861, Roscoe's passionate reports had been countered by William Allen Miller's critical lecture on "The New Method of Spectrum Analysis" at the British Association for the Advancement of Science Meeting in Manchester.²⁶ The priority debate has shown at least one thing: that the importance of the work was from the start widely recognized.²⁷ This being granted, one must also insist on the various local cultures in which the 1859-1860 papers landed when they reached Britain. Indeed, the debate could only take place because some scientists – and not the least in the country – could actually claim credible rights to substantial portions of the breakthrough.

But was the French situation so different? No less prone to stir nationalistic sentiments than the British, French commentators could have

²⁴ JEAN-BAPTISTE DUMAS's article quoted *in extenso* in LOUIS FIGUIER, «Année Scientifique», VI, 1862, pp. 108-110.

²⁵ That is, 'marvellous.' JULES JAMIN, *Analyse spectrale. Exposé des découvertes récentes de MM. Bunsen et Kirchhoff, faite à la séance annuelle de la Société des Amis de la science*. Summ. by HENRI BUIGNET in «Journal de Pharmacie», XLII, 1862, pp. 9-20.

²⁶ For a detailed chronology, see BARBARA J. BECKER, *Visionary memories: William Huggins and the origins of astrophysics*, «Journal of the History of Astronomy», XXXII, 2000, pp. 43-62.

²⁷ JAMES, *The creation*, cit., 15; and DAN M. SIEGEL, *Balfour Stewart and Gustav Kirchhoff: two independent approaches to 'Kirchhoff's radiation law', 'Isis', LXVII, 1976, pp. 565-600.*

chosen to emphasize the domestic roots of spectrum analysis. As was widely acknowledged, and underlined by George G. Stokes, at least one highly original French experimental physicist and skilled craftsman could have claimed to have preceded Kirchhoff on a significant respect: Foucault.²⁸ On January 20, 1849, Foucault had delivered a prescient paper at the *Société philomathique* in which he showed that the double line at the limit of the yellow and orange portions of the spectrum emitted by a carbon arc exactly coincided with the D lines of the solar spectrum. The arc moreover darkened the solar D lines and absorbed D rays from a continuous spectrum emitted by incandescent coal. "Thus the arc offers us a materiel that emits by itself D rays and that, at the same time, absorbs them when these rays come from elsewhere."²⁹

Interestingly, Foucault, himself a regular science chronicler in the *Journal des débats*, published his own account of Kirchhoff and Bunsen's work. As opposed to most other French commentators, he paid attention to the history preceding this discovery. "Prismatic analysis," Foucault wrote, without mentioning that he himself had made the same observation in 1849, "showed that, in almost every luminous sources where incandescent gas entered, there were two lines very close to one another that were singular by the excess or lack of brightness." Only Kirchhoff and "M. Svan [*sic*]" in Scotland, Foucault explained, were able to provide an independent explanation for this phenomenon: the D duet was due to sodium. Having had the chance of observing solar prominences during the 1860 eclipse, Foucault rhetorically wondered: "How could we refuse to believe that the pinkish atmosphere of the sun indeed contains a certain proportion of sodium?"³⁰

The modesty of Foucault's report is remarkable. There is not a single hint

²⁸ GEORGE G. STOKES, *On the simultaneous emission and absorption of rays of the same definite refringibility; being a translation of a portion of a paper by M. Léon Foucault, and of a paper by Professor Kirchhoff*, «Philosophical Magazine», XIX, 1860, pp. 193-197. On Foucault, see STÉPHANE DELIGEORGES, *Foucault et ses pendules*, Paris, Éditions Carré, 1990; WILLIAM TOBIN, *Foucault's Invention of the silvered-glass reflecting telescope and the history of his 80-cm reflector at the Observatoire de Marseille*, «Vistas in Astronomy», XXX, 1987, pp. 153-184; and WILLIAM TOBIN, *Léon Foucault*, «Scientific American», July 1998, pp. 52-59.

²⁹ LÉON FOUCAULT, *Physique. Lumière électrique*, «L'Institut», XVII, 1849, pp. 44-46; repr. *Note sur la lumière voltaïque, communiquée à la Société philomathique le 20 janvier 1849*, «Annales de Chimie et de Physique», LVIII, 1860, p. 477; and MICHEL SAILLARD, *Histoire de la spectroscopie. De la théorie de la lumière et des couleurs de I. Newton (1672) à la découverte de l'effet Zeeman (1897)*, «Cahiers d'Histoire et de Philosophie des Sciences», XXVI, 1998, pp. 120-122. On Foucault's spectroscopic work, see F. A. J. L. JAMES, *The study of spark spectra, 1835-1859*, «Ambix», XXX, 1983, pp. 137-162.

³⁰ LEON FOUCAULT, «Journal des Débats»; repr. in LOUIS FIGUIER, «Année Scientifique», VI, 1862, quotes on pp. 113 and 115.

that its author was ever involved in the topic, much less that his contribution was deemed significant by others. This striking omission could be accounted for by Foucault's character. In 1858, he wrote: "I have no ambition to get an eminent position, I only wish to preserve the possibility of working and modestly fulfilling my destiny."³¹ In the early 1860s, Foucault was moreover busy with a large telescope for the Paris Observatory. Finally, compared to Kirchhoff and Bunsen's extensive studies, Foucault's two-page paper was much more limited in scope. He had simply registered the persistence of the D lines in emission spectra, but had offered no explanation for it, nor for the coincidence between bright and dark spectrum lines. With more pressing matters on his mind and such weak credentials, Foucault had neither time, incentive, nor inclination to embark on a priority debate for the sake of a long-forgotten piece of his.

But Foucault was not the sole French physicist who might have claimed some priority in spectroscopy. Antoine-Philibert Masson, Edmond Becquerel, Frédéric Hervé de la Provostaye, Paul-Quentin Desains, and Ignazio Porro had all touched on important aspects of spectroscopy. But, in the French physics culture, in which optics played a prominent role, the prismatic decomposition of rays was just one of the multitude of experiments with light that had become increasingly common. In this culture, to apply spectra to chemical analysis was a foreign idea that no one could claim for himself. But once this possibility was recognized, many skilled experimenters and instrument-makers brought up in this tradition were in a good position to use the techniques pioneered by Kirchhoff and Bunsen.

The investments in skills and instruments needed to get involved in spectrum analysis were indeed not trivial. In Britain, following the publication of Kirchhoff and Bunsen's work, a whole new generation of spectroscopists seized the new method and developed it in several directions (Crookes, Frankland, Huggins, Lockyer, etc.). Building on a strong optical tradition, the French led the way in at least one respect – the projection of lines on a screen. The instrument-maker Jules Dubosq was immediately able to market spectroscopes not inferior to Carl August Steinheil's. Together with the chemist Henri Debray, he assisted Jamin in live performances of spectral experiments in front of large audiences – a feat that Roscoe, despite many attempts, failed to implement for his 1861 lecture at the Royal Institution.³²

³¹ Copy of a letter from LEON FOUCAULT to URBAIN LE VERRIER (January 4, 1858), BIF, Le Verrier Papers, Ms. 3711, 41.

³² FÉLIX HÉMENT, *Spectre et spectroscopes. Application des phénomènes optiques à l'analyse*

In strong contrast to the publicity given to Bunsen and Kirchhoff's ceremonial visit to Paris in 1862, the trip that Louis Grandeau made from Heidelberg to Paris two years earlier drew no one's attention. Yet, it was Grandeau who played Roscoe's role in France, bringing the news of spectrum analysis back from Heidelberg and translating Kirchhoff and Bunsen's memoirs into French. A pharmacist born in 1824, Grandeau went to Bunsen's laboratory to work on the presence of cesium and rubidium in various natural substances. Back in Paris, he was made a lecturer at the École normale and enjoyed space and support in Deville's laboratory. In 1863, Grandeau published the first treatise on spectrum analysis.³³ Through Grandeau, Deville's chemical laboratory became a radiating center for spectrum analysis. Like its German counterparts in Heidelberg, this laboratory was a training ground for a new generation of researchers. There, Deville welcomed *normaliens* such as Claude Auguste Lamy and Eleuthère Mascart to pursue their spectroscopic work.³⁴ Even experimented opticians like Hippolyte Fizeau went to Deville's laboratory, admittedly looking not for expertise in the use of optical instruments, but for pure substances to do spectroscopy.³⁵

A remarkable feature of this group is the apparent flexibility with which they moved from one discipline to another. Having worked for Claude Bernard, Grandeau was in 1868 appointed to a chair in chemistry and physiology applied to agriculture in Nancy. By and large, his spectroscopic work was geared towards the detection of minerals in spring waters in view of determining their curative agents. Like Deville, Debray was heavily involved in metallurgic research, and Lamy's work was undertaken for the benefit of his father-in-law's sulfuric acid factory. Alone, the notorious

chimique, «Annuaire scientifique», II, 1863, pp. 278-292; HENRI DEBRAY, *Sur la projection des raies brillantes des flammes colorées des métaux*, «Annales de Chimie et de Physique», XLV, 1862, pp. 331-340; ROSCOE, *The life and experiences*, cit., p. 69. On Dubosq, see PAOLO BRENNI, *19th-Century French scientific instrument makers XIII: Soleil, Dubosq, and their successors*, «Bulletin of the Scientific Instrument Society», LI, 1996, pp. 7-16; and FRANÇOIS-NAPOLÉON-MARIE MOIGNO, *Une médaille d'honneur. Appareils d'optique et de photographie de M. Jules Dubosq*, «Cosmos», VII, 1855, pp. 490-496.

³³ On Grandeau, see AUGUSTE LAUGEL, *Le Soleil d'après les découvertes récentes de MM. Kirchhoff et Bunsen*, «Revue des Deux Mondes», XXVII, 1862, pp. 402-420, on p. 408; HÉMENT, *op. cit.*, 284; and DÉHERAIN, *Analyse chimique*, cit., p. 16; and LOUIS FIGUIER, «Année Scientifique», VII, 1863, pp. 102 and 112.

³⁴ LOUIS PASTEUR, *Sur la lumière phosphorescente des cucuyos*, «CRAS», LIX, 1864, pp. 509-510; repr. *Œuvres de Louis Pasteur*, Paris, Masson, 1939, VII, 16-17. On Deville's laboratory, see LOUIS PASTEUR, *Œuvres de Louis Pasteur*, cit., VII, 196-204 and 319-321.

³⁵ HIPPOLYTE FIZEAU, *Sur la lumière émise par le sodium brûlant dans l'air*, «CRAS», LIV, 1862, pp. 493-495.

blurriness of disciplinary affiliations in mid-19th century France may not fully account for this flexibility. Experimental spectrum analysis indeed required a mixture of skills, the ability to manipulate optical instruments and purify chemical substances.³⁶

Still another boundary discipline allied those skills – experimental physiology, then emerging in the borderland between physics and medicine. Albeit in great uprising, physiology still was at pains to secure adequate material resources, as witnessed by no less a figure than Claude Bernard. This tradition was able to nurture the scientist who in the early 1860s dominated the spectrum analysis field in France – Janssen. On January 16, 1862, he wrote in his diary: «Meditation in bed this morning.» The nature of his thoughts will probably never be known but this lazy morning might have led him to carry on, two days later, his first spectroscopic experiments.³⁷ Having written a doctoral thesis on the absorption of infrared radiation under Desains, he came from a rich experimental tradition in optical physics.³⁸ He was not foreign either to the chemical tradition mentioned above and counted the geologist Charles Sainte-Claire Deville, Henri's brother, among his powerful patrons. Having crossed paths with photography, physiology, and astronomy, Janssen had accumulated a delicate combination of chemical, optical, and observational skills needed for launching his astrospectroscopic career. On April 30, he had discovered telluric lines and had conceived the project of going to Italy and Algeria to verify whether they retained their character under drier climates. One must admire his opportunism in selecting destinations where French political interests were heavily invested at the time.³⁹ In August 1862, while Bunsen and Kirchhoff were honored by the Académie des sciences, Janssen was summoned to official appointments in various ministries and was granted a paid “mission”.⁴⁰

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³⁶ MATTHIAS DÖRRIES, *Easy transit: crossing boundaries between physics and chemistry in mid-nineteenth-century France*, in CROSBIE SMITH and JON AGAR (ed.), *Making space for science: territorial themes in the shaping of knowledge*, London, MacMillan, 1998, pp. 246-262.

³⁷ JULES JANSSEN's diary at BIF, Janssen's papers, 4126, 8^e carnet.

³⁸ JULES JANSSEN, *Sur l'absorption de la chaleur rayonnante obscure dans les milieux de l'œil*, «CRAS», LI, 1860, pp. 128-131; and in «Annales de Chimie et de Physique», LX, 1860, pp. 71-93. On Desains as a precursor for spectroscopy, see SIEGEL, *op. cit.*, pp. 574-575.

³⁹ On the *Service des missions*, see MARIE-ÉLISABETH ANTOINE, *Un service pionnier au XIX^e siècle: le Bureau des travaux historiques d'après ses papiers aux Archives nationales*, «Bulletin de la section d'histoire moderne et contemporaine», X, 1977, pp. 5-72.

⁴⁰ JANSSEN's diary at BIF, Janssen's papers, 4126, 8^e carnet.

There are many reasons for scientists to travel: to explore and map unknown territories, to collect rock samples, assemble herbaria, hunt down new species, and observe savages, to exchange information, instruments, and practices with colleagues, and forge international communities. The two scientific journeys Janssen made in 1862 and 1863 to Italy and the Alps, respectively, were significant in many respects: not only was Janssen then able to trace precisely the fine differences between telluric lines and others, but moreover he succeeded in carving his own professional niche as traveling astrospectroscopist between the established astronomer in his observatory, the experimental physicist in his laboratory, and the field scientist, as well as clearly demarcating himself from the instrument-maker in his workshop. During his trip to Italy, Janssen clashed with a number of people on whom he depended for his scientific work. As a result, his relationship with them shifted significantly.

HOFMANN: INSTRUMENT-MAKER

On October 6, 1862, Jacques Babinet displayed in front of the Paris Académie, a pocket direct-vision spectroscope in Janssen's name. It was built on Giovanni Amici's principle according to which a central flint prism was bounded by two crown prisms. But to improve the dispersion – not “as energetic as we could desire” – Janssen suggested to use two 90° dispersion flint prisms and three crown prisms. The instrument was light, autonomous, easy to transport. Its dispersion power was very respectable for the time (Fig. 2). In concluding his report, Janssen acknowledged that “all [three] instruments came from M. Hoffmann's [sic] workshop, who took great care of the optical work.”⁴¹

Very little biographical information is known about Ignazio Hofmann. A foreman in was Porro's *Institut technomatique*, he partook in his master's invention of the Cornet-Porro spyglass, or “*lunette cavalier*,” whose length was cut by half by a combination of reflection prisms. Developing this idea, Hofmann produced in 1857 the prismatic spyglass, adopted by the emperor Napoléon III in his Italy campaign.⁴² Capitalizing on this success,

⁴¹ JULES JANSSEN, *Note sur trois spectroscopes*, «CRAS», LV, 1862, pp. 576-578. A 5-prism direct-vision spectroscope is already mentioned in JULES JANSSEN, *Note sur les raies telluriques du spectre solaire*, «CRAS», LIV, 1862, pp. 1280-1281.

⁴² FRANÇOIS-NAPOLÉON-MARIE MOIGNO, *Une médaille de bronze!*, «Les Mondes», XIV, 1867, pp. 717-726; DEBORAH JEAN WARNER, *Direct-vision spectroscopes*, «Rittenhouse», VII, 1993, pp. 40-48.

Hofmann established his own workshop around the time when Porro returned to Italy. After 1860, Hofmann's earlier experience in manipulating combinations of prisms became precious when he turned his attention to direct-vision spectroscopes.

Invented by Amici, cursorily mentioned by Giovanni Donati, sketched out by Janssen, the direct-vision spectroscope was first built by Hofmann. This was a versatile, powerful instrument, but to whom did it belong? To Hofmann, the answer was clear: "The spectroscope usually used by M. Janssen is his, in the sense that he has paid for it; I built it by trial and error."⁴³ "At a late period of the Exhibition" in London in 1862, he had no qualms sending "an ingeniously-contrived pocket spectroscope, in the form of a straight tube" without mentioning Janssen's name.⁴⁴ According to the abbé François-Napoléon-Marie Moigno, Hofmann had not only turned Janssen's idea into a working instrument, but had also improved it. Hundreds of spectroscopes of this type were sold and exported throughout the world.

Janssen however was dismissive of Hofmann's pretensions. He reiterated that the instrument-maker "ha[d] built this small apparatus on the basis of my sketches and with my daily indications – indications which were many since M. Hoffman [*sic*] did not seize them with all desirable ease." By claiming that he was the inventor of the direct-vision spectroscope, Hofmann had betrayed the trust Janssen had placed in him when he provided him with blueprints and models.⁴⁵ Without patents, Janssen forfeited all right to the apparatus. As his letter to *Les Mondes* shows, Janssen had decided to "break" with him. But this was not so easy. Once in Italy, he had found that his own success hinged on this instrument, and his ability to procure it to Italian scientists. Janssen assigned the task of circumventing Hofmann's distrust to his wife Henriette:

You should go to Hofmann's and take 3 or 4 pocket spectroscopes like the one I took with me and paid 30 f[rancs]. You should not pay more for them, without pleading for it, but only say that you have not been allowed to pay more and talk as little as possible. It is important that I have instruments for these *Messieurs* [scientists] and in this way I shall be more free vis-à-vis Hofmann and will not anymore be forced to go to him.

⁴³ *Spectroscope à vision directe*, «*Les Mondes*», I, 1862, p. 554.

⁴⁴ Reports by the juries quoted by JAMES A. BENNETT, *The celebrated phaenomena of colours: a history of the spectroscope in the nineteenth century*, Cambridge, Whipple Museum, 1984, p. 8.

⁴⁵ JULES JANSSEN, *Réponse de M. Janssen à M. Hoffman [sic]*, «*Les Mondes*», I, 1862, p. 636; JANSSEN's diary at BIF, Janssen's papers, 4126, 8^e carnet.

The spectroscope trade could be quite profitable. At the Roman Academy of Sciences, Janssen's instruments were greatly admired. Some wanted to buy them "at all cost. I could have won my voyage." But, as he had spelt out to his wife, Janssen was after fame, not profit, and could not let go of the instruments he used on a daily basis.

From his brush with Hofmann, Janssen concluded: "More and more, in the future, I will build [my instruments] myself. This will provide me tranquility and economy."⁴⁶ In the French 19th-century physics culture, great pride was laid by scientists on the self-production of instruments.⁴⁷ What distinguished them from instrument-makers rested more on the use than the design of instrument. By in effect relinquishing his rights to an instrument he thought he had invented, Janssen adhered to an ethos placing value in disinterested over practical knowledge, and indeed in theory over practical manipulations even while experiments were concerned. The instrument could help open doors, but it was his skillful use of it that would make him a *savant*, if not an astronomer. Therein lies, for me, the significance of the episode. Not clinging on to a single instrument, Janssen was more interested in adapting it to different purposes. In this respect, it was the ability he displayed in using different types of spectroscopes in different environments, not the instrument itself, that allowed him to navigate across disciplines.

SECCHI: PAPAL ASTRONOMER

Traveling to foreign lands provide opportunities to forge precious scientific contacts. In Florence, where the sun shone less than expected, Janssen visited astronomers Giovanni Donati and Gilberto Govi. In November 1862, he reached Rome. While waiting for the sunshine and pure sky he needed, "everywhere difficult in November,"⁴⁸ Janssen built a new spectroscope for himself and paraded around with his (or Hofmann's) pocket spectroscope, with the result that many orders were sent to Paris. At about this time, he contacted the director of the Observatory of the *Collegio Romano*, Father Angelo Secchi.

⁴⁶ The three quotes above, respectively, from JULES to HENRIETTE JANSSEN (December 16 [and 20], 1862, late March, 1863, and January, 1863), BIF 4133, 46, 58, and 49.

⁴⁷ CHRISTINE BLONDEL, *Electrical instruments in 19th century France, between makers and users*, «*History and Technology*», XIII, 1997, pp. 157-182; and *Les physiciens français et l'électricité industrielle à la fin du XIX^e siècle*, «*Physis*», XV, 1998.

⁴⁸ JULES to HENRIETTE JANSSEN (November, 1862). BIF, 4133, 43.

"Each time that physics has created a new instrument or a new method," Faye once wrote, "Secchi was among the first ones to seize it, often he was the first one."⁴⁹ There could hardly have been an astronomer more sympathetic to the kind of work pursued by Jansen. A student of the sun since 1851, Secchi photographed the solar eclipse of 1860. For Janssen, his warm welcome "as a colleague" meant that he could for the first time enter the world of professional astronomy.⁵⁰ According to his notebooks, the young *savant* had in 1853 contemplated a collaboration with Urbain Le Verrier. Named director of the Paris Observatory in 1854, Le Verrier had apparently let down his young colleague. Although astronomy retained its attraction for Janssen, Le Verrier's sway had become so strong as to leave little space outside the *Observatoire*.⁵¹ In Rome, the institutional climate was no less fair than the weather. Secchi let Janssen step into his astronomical sanctuary:

It is a beautiful spectacle to see those astronomers in their observatories amidst the night's silence and in the presence of the starry vault, maneuvering, with the help of machines, gigantic telescopes close to which man looks like a fly. There is, in this silence, in this big apparatus lighted by a half-obscurity, something mysterious and grandiose that elevates the soul and leads it with enthusiasm towards the great laws of the Universe to probe its essence!...⁵²

On November 19, at long last, the Roman sky was clear and Janssen's excitement palpable: "Since yesterday a wind from the North is reigning, which in Rome means pure sky and Sun. I take advantage of this, and so well that re-writing you this, I see double. If I always had sun, I would blind myself. God did well what he did."⁵³ Soon, Secchi placed his large telescope and technicians to manipulate it at his disposal. Perceiving the promise of stellar spectroscopy, but also motivated by his desire of being trained by Janssen, Secchi assisted the physicist.

"I just came back from the Roman College where I obtained one of the most beautiful and unexpected results. The spectra of stars! But beautiful spectra with colors and magnificent lines. Still another step and the chemical composition of the Universe will be revealed to us." Impressed by the lunar spectrum that Janssen had shown him, Secchi thought of

⁴⁹ HERVÉ FAYE, Handwritten report on Secchi's work. AdS, Secchi's Biographical File.

⁵⁰ JULES TO HENRIETTE JANSSEN (November, 1862). BIF, 4133, 43.

⁵¹ On Le Verrier's turbulent tenure as director of the Paris Observatory, see AUBIN, *The fading star*, cit.

⁵² JULES TO HENRIETTE JANSSEN (December 16 [and 20], 1862). BIF, 4133, 46.

⁵³ JULES TO HENRIETTE JANSSEN (November 20, 1862), BIF, 4133, 43.

placing Hofmann's spectroscope at the ocular of his telescope and direct it towards stars. The first one they observed was Vega and "we saw a spectrum." Fiddling with the montage, Janssen found a way to increase the light intake and "then we saw with great joy magnificent spectra with undeniable lines, ... which will give us magnificent notions on the nature of these far Suns. The father was still more enthusiastic than I."⁵⁴ Although not the goal of his mission, Janssen's opportunistic turn to stellar spectroscopy manifested the field scientist's characteristic flexibility.

In March, Secchi suddenly informed Janssen, who had not yet completed his stellar spectral maps, that he needed his telescope for his own work. In the second half of the month, he realized why:

It was an excellent idea I had, my dear Henriette, to publish my work as soon as possible at the Academy of Rome... There was a part of this work on stars that could not be published because it was not completed. Father Secchi, jealous of seeing me getting so many results and having for that matter learned from me how to do these studies, suddenly told me that he could no more loan me his telescope. He started to work to complete and publish [this work] in a German journal, not daring to do so in Rome, nor in Paris. This dishonest conduct has stirred indignation here because *my friends* publicized it, but I did not consider it opportune to make a public scandal. I have enough in my hands to prove his perfidy in Paris and to unmask him.⁵⁵

Once again, as with Hofmann, Janssen was angry to have been short-circuited in print. But most importantly, he found himself without the powerful instruments of an observatory. Unable therefore to compete with the Papal astronomer, his antipathy for Secchi only grew. For years they would bitterly argue in print about the cause of telluric lines.⁵⁶

* * *

Without independent means, Janssen wrote, the difficulties of a scientific career "are multiplied by ten."⁵⁷ Back to Paris on April 25, 1863, the young physicist was facing an uncertain future. But he was confident that both his ingenuity and work would be rewarded by the government. Traveling

⁵⁴ Quotes above are from JULES TO HENRIETTE JANSSEN (December 6, 1862), BIF, 4133, 45.

⁵⁵ JULES TO HENRIETTE JANSSEN (March 1863). BIF, 4133, 58.

⁵⁶ JULES JANSSEN, *Remarques à l'occasion d'une communication du P. Secchi sur les spectres prismatiques des corps célestes*, «CRAS», LVII, 1863, pp. 215-217; JULES JANSSEN, *Raies atmosphériques*, «Les Mondes», VII, 1865, pp. 41-42; JULES JANSSEN, *Mémoire sur les raies telluriques du spectre solaire*, «CRAS», LX (1865), 213-216; and ANGELO SECCHI, *Raies spectrales atmosphériques*, «Les Mondes», VII, 1865, pp. 144-145.

⁵⁷ JULES TO HENRIETTE JANSSEN (n.d., 1859). BIF, 4133, 22.

scientists were often characterized by “problematic definitions of social identity.”⁵⁸ As Janssen’s case show, back home these problems were hardly solved. Upon his return in Paris, his professional status was more ambiguous than ever. In the 1860s, few means of living other than teaching were available for scientists and Janssen was hired as physics professor at the *École d’architecture*. But wishing to pursue his spectroscopic researches, he solicited a new mission.⁵⁹

This time, Janssen squarely positioned himself as an astronomer. Asked for his advice, Faye underscored that “astronomy... was no less part of your work than physics and chemistry.”⁶⁰ The program of Janssen’s second mission was more detailed than previously, and more extensive. He would go to the Alps to see whether telluric lines thinned out at high altitude, to le Havre where the light of a lighthouse would be used to test his hypothesis, and finally to Marseille where, using Foucault’s telescope, he would pursue his stellar work. Only partly fulfilled, Janssen’s program was nonetheless a success. Climbing up the Faulhorn mountain and analyzing the flame of a bonfire across Lake Geneva, he wrote the memoir that would insure him the prix Bordin.⁶¹ To ascertain these results, Janssen carried out in 1866 an impressive manipulation at the *Compagnie des Gaz de la Villette*. Filling up a 37m-long tube with water vapor at a pressure of 7 atmospheres, he analyzed beams of light traversing it. This, at long last, supplied a strong enough basis for asserting that telluric lines were mostly due to water vapor.

Despite this, Janssen’s professional situation remained shaky for years. The ambiguous character of his specialty was largely responsible for this. According to Fizeau his work was not “precise” enough for a physicist.⁶² He was an astronomer without an observatory. Above all, Janssen was a *missionary* and he relied on State support. In 1867, for example, he observed an annular solar eclipse in Trani, Italy, and an erupting volcano in Santorin, Greece. The next year, Janssen traveled to India and became famous for discovering a spectroscopic technique for drawing solar prominences.⁶³ In November 1868, he suggested that a special observatory

⁵⁸ KUKLICK and KOHLER, *Introduction*, *op. cit.*, p. 10.

⁵⁹ JULES JANSSEN to the Minister (November 26, 1863). AN, F¹⁷ 2977, Janssen File.

⁶⁰ HERVÉ FAYE to JULES JANSSEN (November 24, 1863). BIF, 4135, 146.

⁶¹ JULES JANSSEN, *Rapport d’une mission dans les Alpes confiée par M. le Ministre de l’Instruction publique* (1865), in JEAN-PIERRE VERDET (ed.), *Astronomie et astrophysique: textes essentiels*, Paris, Larousse, 1993, pp. 755-765.

⁶² HYPOLITE FIZEAU, *Rapport sur les travaux de M^r Janssen* (1868), manuscript in AdS, Janssen File.

⁶³ AUBIN, *La métamorphose des éclipses*, *cit.*; and SEYMOUR L. CHAPIN, P. J. C. Janssen and the advent of the spectroscope into astronomical prominence, «Griffith Observer», XLVIII, July 1984, pp. 2-15.

for astrophysics be set up by the French government. After the Franco-Prussian War – and other expeditions – Janssen was elected to the Académie and an *Observatoire d’astronomie physique* was set up for him in 1875 at government’s expense in Meudon, near Paris. This was hardly sufficient for him to stay in place, however. In the 1890s, he for instance established an observatory on the summit of the Mont Blanc.⁶⁴ Why did he not resolve to stay in the Meudon castle and enjoy the quietness of Parisian suburbs? As I have suggested, the association of astrophysics with travel was no less accidental than its reliance on the laboratory.

As Rodolphe Radau introduced the Meudon Observatory to the public in 1900, he depicted Janssen’s “experimental astronomy” as a hybrid where the monumentality of the astronomical observatory, the materiality of huge 100m-long laboratories crammed with steel tubes filled with compress gas, and the excitement of field expeditions completed one another.⁶⁵ At the intersection of the laboratory, the observatory, and the field, astrophysics was constituted as a crucial disciplinary node where the transformations of some of the most important institutions of 19th-century science were coordinated. It was in the early 1860s, that, by traveling to Italy so that he could plug his spectroscope into Secchi’s telescope, Janssen had physically brought three mutating worlds together.

SUMMARY

In the last third of the nineteenth century, astrospectroscopy played a prominent part in orchestrating transitions undergone by three sites of knowledge production: the observatory, the laboratory, and the field expedition. Early astrophysicists carved out for themselves a specific social space by adopting experimental techniques and practices stemming out of the laboratory, and adapting them to the observatory and the field traditions, and more generally by easing the back-and-forth transfer of practices from one site to another. Taking advantage of the circulation culture constitutive of the observatory sciences, the ‘new astronomy’ provides a useful standpoint from which historians can examine anew the ‘institutional revolution’ in the laboratory sciences in chemistry, physics, and physiology. To exemplify this process, the French reception of Bunsen and Kirchhoff’s work and Jules Janssen’s trip to Italy in 1862-1863 are here discussed.

⁶⁴ CHARLIE BUFFET, *Bataille au sommet: Les aventures de Joseph Vallot au mont Blanc* (3), «Libération», August 12, 1998, pp. II-III.

⁶⁵ RODOLPHE RADAU, *L’astronomie expérimentale et l’Observatoire de Meudon*, «Revue des Deux Mondes», CLVI, 1900, pp. 809-825.

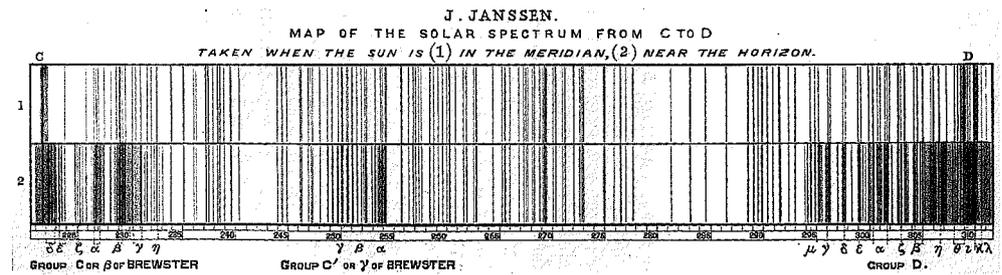


Fig. 1. Janssen's Solar Spectrum Map Showing Telluric Lines. From Henry E. ROSCOE, *Spectrum Analysis: Six Lectures Delivered in 1868, Before the Society of Apothecaries, London, New York, D. Appleton and Co., 1869.*

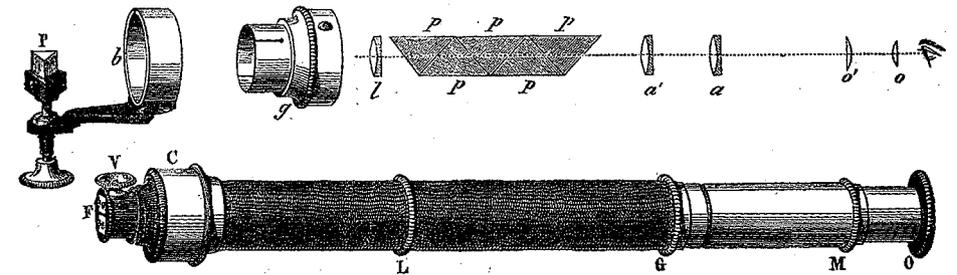


Fig. 2. Hofmann's Direct-Vision Spectroscope. From F. MOIGNO, *Une médaille de bronze!*, «Les Mondes», 2nd ser., XIV, 1867, pp. 717-726, on p. 720.

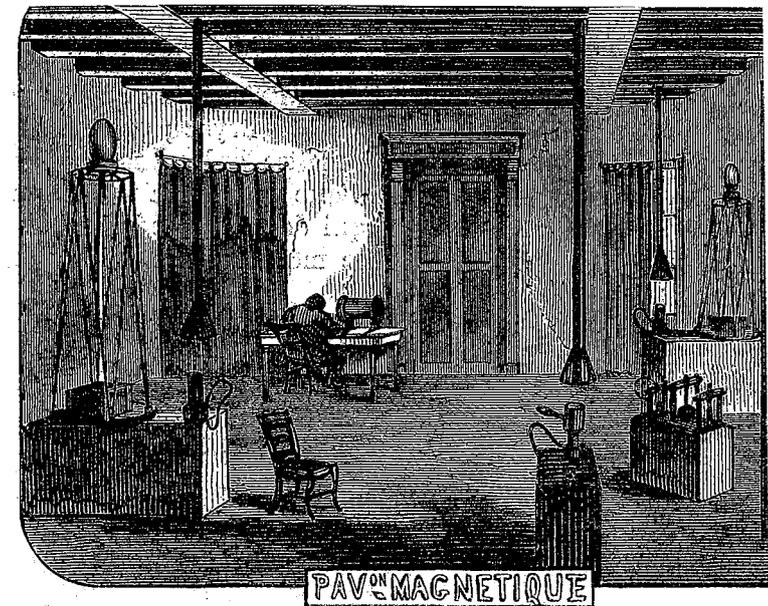


Fig. 3. The Magnetic and Geodetic Laboratory of the Paris Observatory in 1862. From ÉMILE BOURDELIN, *L'Observatoire de Paris*, «Le Monde illustré: journal hebdomadaire», VI, 1862, pp. 69-71, on p. 71.