In the second half of the century, there was a major breakthrough in the discipline of astronomy: the application of spectroscopy[1] led to the birth of a new scientific discipline, called "physical astronomy" or astrophysics.[2] The laws of radiation, published in 1859 by Gustav Kirchhoff (1824–87),[3] supplied the theoretical foundation for a correct interpretation of spectral lines, first observed by William Wollaston (1766–1828) in 1802 and classified by Joseph von Fraunhofer (1787–1826) in 1817. Thus it became possible to study the physical constitution of heavenly bodies—a result hitherto considered unattainable.[4] Initially, only a few astronomers—and Secchi was among them—recognized the promise of astrophysics and its advantages in achieving important results with only modest technical equipment. These "innovators," ready to bet on new astronomy, were mainly amateur astronomers with a professional background in other fields, as well as astronomers who had a background in physics, chemistry, engineering—hence free from the weight of a "classical" tradition.

The new astronomy—so called in order to distinguish it from traditional astronomy, which was mainly based on celestial mechanics and positional astronomy—was slow to gain acceptance from the "classical" astronomers, who did not recognize it as a scientific discipline, or at least failed to do so initially. Most of these astronomers viewed astrophysics with suspicion and held to a traditional or "purist" view of astronomy: "What astronomy must do has always been clear—it must lay down the rules for determining the motions of the heavenly bodies as they appear to us from the Earth. Everything else that can be learned about the heavenly bodies [...] is not properly of astronomical interest."[5]

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1 On the history of spectroscopy, its techniques, and applications, see Charlotte Bigg and Klaus Staubermann, eds., "Spectroscope Histories," *Nuncius* 17, no. 2 (2002): 583–689; 18, no. 2 (2003): 735–852.

2 On the early applications of spectroscopy to astronomy, see John B. Hearnshaw, *The Analysis of Starlight* (Cambridge: Cambridge University Press, 1986); and Arthur J. Meadows, *Early Solar Physics* (Oxford: Pergamon Press, 1970). Astrophysics obtained the status of a scientific discipline at an earlier date than spectroscopy; see Klaus Hentschel, *Mapping the Spectrum* (Oxford: Oxford University Press, 2002).

3 See Gustav R. Kirchhoff, "Über den Zusammenhang zwischen Emission und Absorption von Licht und Wärme," *Monatsberichte Berliner Akademie* (1859): 783–787.

4 See, e.g., Auguste Comte, *Cours de philosophie positive*, tome 2 (Paris: Bachelier, 1835), 8–9.

5 Friedrich Wilhelm Bessel (1784–1846) quoted in Karl Hufbauer, *Exploring the Sun* (Baltimore: Johns Hopkins University Press, 1993), 43.

For a long time, this attitude led many astronomers to view astrophysics as a spurious scientific discipline, "a subject both physically and conceptually messy":[6]

> As yet, astrophysical investigations are far from the standard of scientific accuracy possessed by classical astronomy, which [...] rightfully occupies the premier place among the experimental sciences. God forbid that astronomy should be carried away by fascination with novelty and diverge from [its] essential basis, which has been sanctified for centuries [...].[7]

Hence many "classical" astronomers kept their distance from so-called physical astronomy; although they did not openly oppose the new science, they would often admit their unease at its development:

> This new branch of the old astronomy has a completely new and distinctive character. Here, geometry and mechanics are replaced by physics and chemistry. Everything, [...] instruments and staff, had to take a separate path. We find physicists, such as Huggins,[8] [...] or Lockyer,[9] associated with chemists such as Frankland.[10] [...] This new branch has taken root and is developing very quickly. For us, old-fashioned astronomers, it is very difficult to recognize, for its ideas, its methods, its goals, and even the spirit that reigns, are very different from ours. [...]
>
> It is the case of applying an important law [...] that of division of work. [...] The two sciences [physical astronomy and classical astronomy] will develop in parallel, without getting in each other's way, but using different aptitudes.[11]

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6 See Arthur J. Meadows, "The Origin of Astrophysics," in *The General History of Astronomy, 4A: Astrophysics and Twentieth-Century Astronomy to 1950*, ed. Owen Gingerich, part A (Cambridge: Cambridge University Press, 1984), 3–15, here 14. See also the quotation from Admiral William Henry Smyth (1788–1865).

7 Text by Otto Wilhelm Struve (see Chapter 4) quoted in Arthur J. Meadows, "The New Astronomy," in Gingerich, *General History of Astronomy*, 59–72, here 61.

8 William Huggins was a pioneer in the spectroscopic investigations of stars and nebulae (see below); on his life and work, see Barbara J. Becker, *Unravelling Starlight: William and Margaret Huggins and the Rise of the New Astronomy* (Cambridge: Cambridge University Press, 2011).

9 Norman Lockyer discovered helium and was one of the most important contributors to the development of solar physics (see below); on his life and work, see, e.g., Arthur J. Meadows, *Science and Controversy: A Biography of Sir Norman Lockyer* (Cambridge, MA: MIT Press, 1972).

10 Edward Frankland (1825–99) was one of Lockyer's most important collaborators.

11 [*L'on*] *voudra bien considérer le caractère tout nouveau que revêt cette branche nouvelle de la vieille Astronomie. Ce ne sont plus ici la géométrie et le Mécanique qui dominent: c'est*

Consequently, astrophysics mainly developed in new institutions, separate from the traditional observatories. Within a few years, between 1874 and 1880, thanks to astrophysicists such as Jules C. Janssen (1824–1907), Hermann C. Vogel (1841–1907), and J. Norman Lockyer (1836–1920), the astrophysical observatories of Potsdam (Germany), Meudon (France), and South Kensington (England) had been established as standalone scientific institutions with the aim of developing the field of new astronomy without interfering with classical astronomy.[12]

Secchi was a forerunner in this field. Though initially a "traditional" observatory, the Collegio Romano Observatory, which Secchi directed for almost thirty years, soon came to specialize in physical astronomy and, in a few years, was directed toward the new frontiers of astrophysics. Other astronomers later tried to introduce spectroscopic studies into "traditional" observatories, and the establishment of the "Società degli Spettroscopisti Italiani" (see Chapter 8) is the remarkable result of this cooperative effort, inspired by Secchi, which played an important role in the gradual recognition of astrophysics as a new scientific discipline.[13]

This is one of the myriad reasons why Secchi stands out among the protagonists of nineteenth-century astronomy. In some of his autobiographical notes, Secchi presented himself as someone who "brought, in a manner of speaking, the flavor of physics into astronomy and can be considered one of the most active and happy founders of this branch of modern astronomy."[14]

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la Physique et la Chimie. Tout, [...] *instruments et personnel, tout a dû prendre un tour spécial. Nous y trouvons des physiciens, comme Huggins* [...] *ou Lockyer, associés à des chimistes, comme Frankland.* [...] *La branche nouvelle a pris racine dans un sol à elle, et s'y développe rapidement. Nous autres, astronomes anciens, nous avons peine à nous y reconnaître, tant les idées, les méthodes, les objets que l'on a en vue, et jusqu'à l'esprit qui y règne, différent des nôtres.* [...] *C'est ici le cas d'invoquer une grande loi* [...] *celle de la division du travail.* [...] *Les deux sciences se développeront ainsi parallèlement sans se gêner, en utilisant des aptitudes différentes*; Hervé A. 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," Académie des Sciences, séance du 2 novembre 1874, Paris Observatory Archives, Meudon Section, Dossier Janssen.

12 On the formation and consolidation of the solar physics community, see, e.g., Hufbauer, *Exploring the Sun*, 59–67.

13 See Ileana Chinnici, "The Società degli Spettroscopisti Italiani: Birth and Evolution," *Annals of Science* 65, no. 3 (2008): 393–438.

14 Archives of the Pontifical Gregorian University, Fonds "Angelo Secchi" (hereinafter APUG, FS) 23.I.7.

2 The Nineteenth Century in the Catholic Church

This century of crucial changes could not but affect the Catholic Church. The key figure of this era was Pius IX (1792–1878, r.1846–78), who initially attempted a renewal of the Papal States, turning them into a "modern" state in line with the movement of reform granted by other sovereigns in the Italian Peninsula in 1848, but who then, worried by the spread of anti-clericalism, locked himself into a defense of the establishment. In 1848, Pius first suggested that the Jesuits leave Italy in order to keep them from the anti-clerical persecutions, and then, because of republican insurrections, left Rome himself and retired into voluntary exile at Gaeta, in the Kingdom of the Two Sicilies. He returned to Rome seventeen months later, after the failure of the Roman Republic (1849), at which time the Jesuits were also able to return from their diaspora. However, in the 1860s, the Papal States lost part of their territories when they were annexed by the Kingdom of Italy, which suppressed the religious orders and confiscated church properties. Pius reacted by excommunicating the Savoy Government and, in the face of the progress of liberalism, atheism, and socialism, issued the Syllabus of Errors (1864) condemning those ideologies. In 1870, when French troops who were defending Rome left the city to fight on the front lines of Prussia, the Kingdom of Italy launched its final attack and conquered Rome. The eternal city became the capital of the new Italian state, and the pope remained confined within the Vatican palaces, declaring himself a political prisoner. Difficult negotiations were opened with the Italian government, which recognized some of the pope's rights, including the inviolability of his person and the extraterritoriality of the Vatican buildings he inhabited (Law of Guarantees [1871]). But in 1873, the confiscation of church properties, undertaken in the territories of the former Papal States, was extended to Rome. In the face of this unilateral act, the pope replied with the *Non expedit* decree of 1874, which declared that it was no longer acceptable for Catholics to participate in Italian politics. The century ended with this conflict not yet healed: the relationship between the church and the Italian state would only be regularized around fifty years later with the Lateran Treaty, signed by both sides in 1929.

Yet this was a period in which there was turmoil not only outside but also *within* the church. Politically, many Catholics favored liberal ideas; the nineteenth century thus saw a flowering of liberal Catholicism, which attempted to combine patriotism and religion, whose exponents supported freedom of conscience, a free press, and free association, as well as the separation of church and state. On the doctrinal level, some texts "demythologizing" religion also circulated in this period, one of the most popular being Ernest Renan's (1823–92) *Vie de Jésus* (Life of Jesus [1863]), which accepted the historical