CHAPTER TWO

# A History of Astronomical Spectroscopy

The publication of Kirchhoff's and Bunsen's work brought the awareness of the spectroscope, and what it could reveal, to a wider audience, including astronomers. The obvious question was, how could this new instrument be used to analyze the light from the Sun and stars?

Auguste Comte (1798–1857), a French philosopher stated this in 1835: "We may in time ascertain the mean temperature of the heavenly bodies: but I regard this order of facts as for ever excluded from our recognition. We can never learn their internal constitution, nor, in regard to some of them, how heat is absorbed by their atmosphere." He was about to be proved wrong!

One of the first astronomers to apply the spectroscope to his telescope was William Huggins (1824–1910), an English amateur. To quote from his later book:

> I soon became a little dissatisfied with the routine character of ordinary astronomical work, and in a vague way sought about in my mind for the possibility of research upon the heavens in a new direction or by new methods. It was just at this time ... that the news reached me of Kirchhoff's great discovery of the true nature and the chemical constitution of the sun from his interpretation of the Fraunhofer lines.
>
> This news was to me like the coming upon a spring of water in a dry and thirsty land. Here at last presented itself the very order of work for which in an indefinite way I was looking – namely, to extend his novel methods of research upon the sun to the other heavenly bodies. A feeling as of inspiration seized me: I felt as if I had it now in my power to lift a veil which had never before been lifted; as if a key had been put into my hands which would unlock a door which had been regarded as for ever closed to man – the veil and the door behind which lay the unknown mystery of the true nature of the heavenly bodies.

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For the next 40 years he and his wife Margaret dedicated their time and resources to observing the sky with the spectroscope.

Huggins designed and built all his prism spectroscopes and pioneered new techniques such as providing a reference spectrum from an electric spark and a reflection slit to improve guiding the spectroscope on a star. See Fig. 2.1.

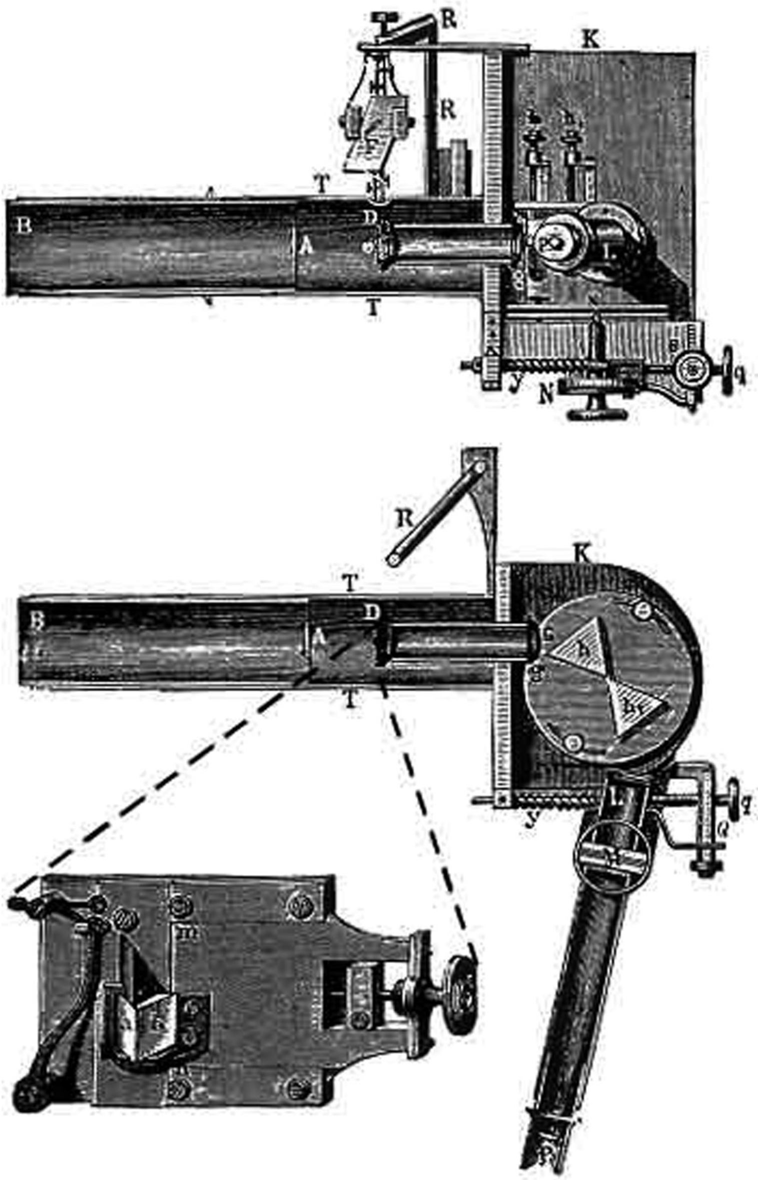



**Figure 2.1.** Huggins spectroscope. (WIKI.)

From his observatory at Tulsa Hill just outside London, Huggins was the first to observe emission lines in the spectra of nebulae; he also correctly applied Doppler's principle to his spectra to determine the radial velocity of a star (Sirius). In 1869, Huggins developed a technique to allow the observation of solar prominences without the need for a solar eclipse. He later also correctly identified the ultraviolet lines of hydrogen on photographic plates.

Another active observer at the time was Father Angelo Secchi (1818–1878) of the Vatican Observatory. Secchi observed the spectra from over 4,000 stars and developed a stellar classification system that was used for almost 50 years.

In 1863 he announced his Class I (strong hydrogen lines) and Class II (weaker hydrogen lines with numerous metallic lines) stars; by 1866 he had added Class III (bands stronger towards the blue, plus metallic lines), and in 1868 Class IV (deep red stars with bands opposite to Class III). He later added Class V (emission spectra). See Fig. 2.2.

The Mertz 12° objective prism 162 mm diameter (made in 1872) used by Secchi for his later research, was displayed at the 2009 ASTRUM exhibition in Rome.

Anders Jonas Angstrom (1814–1874), using an early grating spectroscope, mapped the solar spectrum with greater accuracy than had been done previously. In 1868 he published an atlas of over 1,000 lines, their positions recorded in units of $10^{-10}$ m. This is now known as Angstrom Units (Å) and is still widely used.

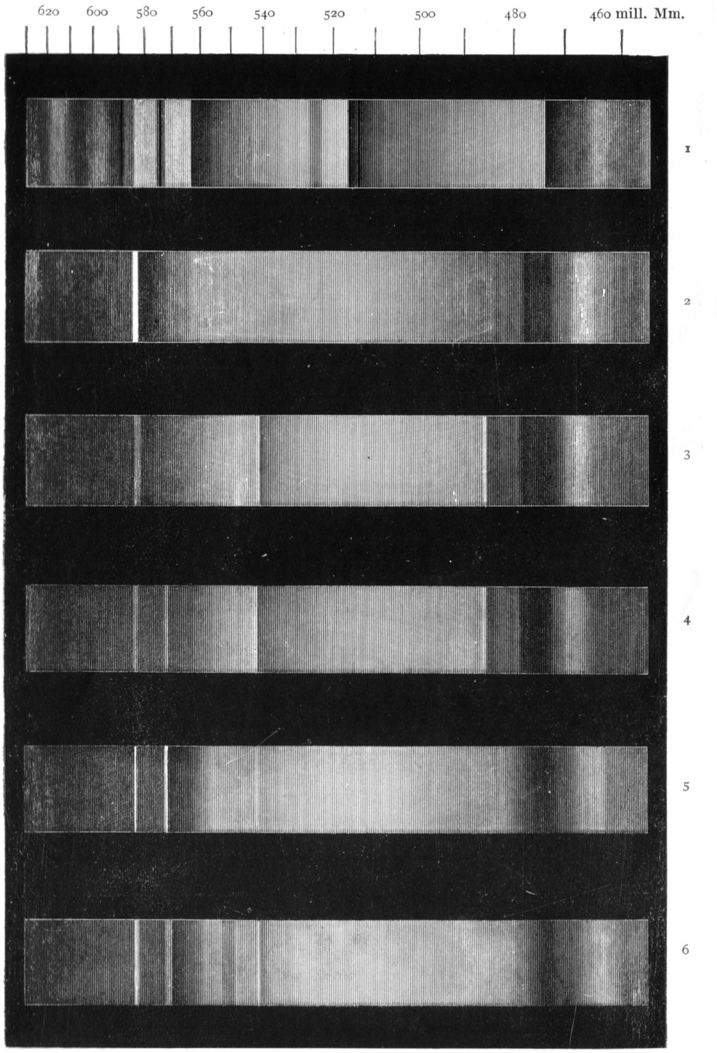
Henry Draper (1837–1882) succeeded in obtaining a photograph of the spectrum of Vega, which clearly showed the hydrogen absorption lines (1872). The advent of the dry photographic plate in the mid-1880s allowed early investigators to carry out the long exposures required to record spectra (Harvard Observatory obtained the first spectrum of a meteor in 1897). The use of these dry plates and later photographic film heralded the beginning of the transfer of spectroscopy from amateurs to professional astronomers.

With monies from the Henry Draper Memorial Fund, Edward Pickering (1846–1919) and his team at Harvard Observatory followed the work of Secchi in recording and cataloging stellar spectra. Using an objective prism mounted in front of the telescope objective he was able to quickly amass large amounts of low resolution spectra (He used objective prisms with angles from 5 to 7° mounted on telescopes up to 13″ aperture to obtain the spectra). The subsequent "Henry Draper Catalogue" of stellar spectra was based on separate classes and sub classes; W O B A F G K M. Updated and enhanced versions of this catalog are still used today.

The work of Henry Rowland (1848–1901) in perfecting his grating ruling engine in 1882 allowed the production of large diffraction gratings that gradually took over from prisms in professional spectroscopes.

By the turn of the century the era of the amateur scientist was drawing to a close; larger and larger spectroscopes and telescopes were producing scientific results that would determine the direction of astrophysics for the next 100 years.

The interested amateur could acquire spectroscopes made by John Browning (1835–1925). These were small direct-vision Amici prism instruments (D-V) for stellar observing, and they established the trend for the next 40 years. Being a dedicated visual instrument, the results were limited to viewing spectra of the Sun, brighter stars, and nebulae.




VISUAL SPECTRA TYPE V COMPARED WITH TYPE IV (VOGEL).
1. Y Can. Ven.; 2. XVIII$^{h}$ 3$^{m}$, S. 21° 16′; 3. VI$^{h}$ 51$^{m}$, S. 23° 49′; 4, 5, 6. Wolf-Rayet, Nos. 1, 2, 3, Cygnus.

**Figure 2.2.** Visual spectra of Secchi Type IV and V by Vogel. (From Preface to Webb's Celestial Objects for Common Telescopes, 1917.)

Commercial D-V instruments continued to be produced by Adam Hilger, Ltd., among others and examples by GOTO (Japan) and LaFeyette (USA) were widely used by amateur astronomers in the 1950's and 1960's (see Fig. 2.3).


**Figure 2.3.** Various D-V spectroscopes. From the top: John Browning. (circa 1880), Adam Hilger (circa 1920), LaFeyette (1960), GOTO (1970), Meiji-Labax (1980), and Surplus Shed (2004).

By the 1970's, transmission gratings became more readily available to amateurs, and these were used to construct spectroscopes capable of much more serious work than the early D-V instruments. This trend has continued, and nowadays instruments are being constructed with reflection gratings that can give spectral resolutions capable of measuring Doppler shifts and spectroscopic binary stars.

Currently (2010) there are at least four manufacturers supplying spectroscopes for the amateur (See later for details).

# Further Reading

Clerke, A. M. *A Popular History of Astronomy*. Adam & Charles Black (1887).
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