Bruce Medalist Profiles

Hermann Carl Vogel: The Sixth Bruce Medalist

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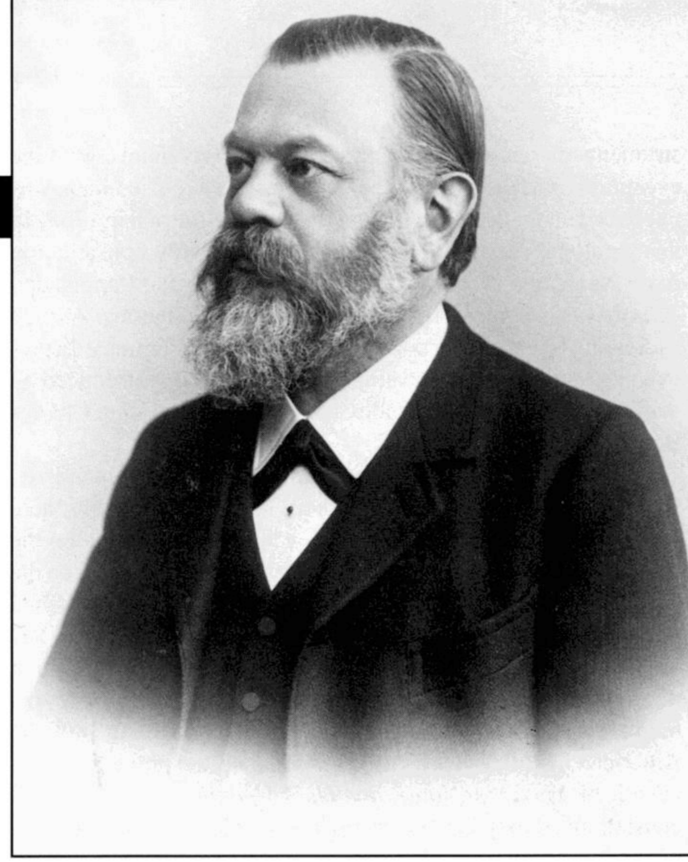

Hermann Carl Vogel
3 April 1841 - 13 August 1907
1906 Bruce Medalist

(Photograph 1895, courtesy of Mary Lea Shane Archives of Lick Observatory, University of California, Santa Cruz)

The determination of the speeds with which the stars are moving toward us or away from us (their *radial velocities)* began with an error. To explain why stars had different colors, Christian Doppler at the University of Prague proposed in 1842 that stars have different colors because of shifts of wavelength due to radial motion. Doppler had correctly shown that the colors of light experience a shift due to the radial motion of the source, and that this shift is proportional to the speed with which the source is moving. The shift is toward longer wavelengths (a redshift) if the source is receding, toward shorter wavelengths (a blueshift) if it is approaching. Thus a star approaching at half the speed of light[1] would have its red light shifted to violet and its blue light shifted beyond the visible range to ultraviolet, and that is why, Doppler said, some stars are blue.

Six years later, apparently unaware of Doppler's proposal, French physicist Hippolyte Fizeau also developed the theory of wavelength shifts due to radial motion. Fizeau, however, correctly pointed out that if the red light is shifted towards the blue, the infrared is shifted into the red, and no noticeable change in color of a star results. Much more important is the shift of the dark, narrow Fraunhofer lines; their measurement could lead to direct determination of a star's radial velocity. Before the long-delayed publication of Fizeau's paper, Austrian physicist Ernst Mach made a similar proposal.

Soon after astronomers started observing stellar spectra, following Gustav Kirchhoff's 1860 discovery that each gas emits and absorbs its own characteristic set of lines, the search began for evidence of what the French aptly call the Doppler-Fizeau effect. Pioneer spectroscopists P. Angelo Secchi in Italy and William Huggins in England argued over the reality of an observable velocity shift in the light of Sirius, the brightest star. Huggins claimed to see it in 1868 (he had both the magnitude and the sign wrong), while Secchi correctly stated that it was smaller than the smallest shift he could reliably detect.

The man who would make the determination of radial velocities a precise science was then in his twenties. Hermann Carl Vogel was the sixth child of a school principal in the German city of Leipzig. Financial difficulties following the deaths of his parents forced him to leave Dresden Polytechnical School, where he had planned to become a locomotive engineer, and to return home and begin studies in natural science at the University of Leipzig. There he supported himself as an assistant at the observatory, and came under the influence of the young professor Johann K. F. Zöllner, a strong advocate of the new astrophysical techniques of spectroscopy, photometry, and photography. (It was Zöllner who coined the term "astrophysics.")

Vogel took his doctorate at the University of Jena in 1868 with a thesis on micrometrical determinations of positions of nebulae and star clusters. Two years later he was appointed to direct a well-equipped private observatory established at Bothkamp by F. G. von Bülow. Like David Gill at about the same time, he built his

1. In 1905 Albert Einstein showed that Doppler's relation is only valid for shifts much smaller than unity, which correspond to velocities small compared to the speed of light. For larger velocities, such as those found in the late twentieth century for quasars and distant galaxies, a slightly more complicated relativistic formula is required.

reputation in four years as a private astronomer. Using an 11-inch refractor, he examined the spectra of stars, planets, nebulae, a comet, the aurora, and the Sun. He introduced a revision of Secchi's classification scheme for stellar spectra, and, with W. O. Lohse, began a survey of the spectra of bright stars. He also began a detailed study of the solar spectrum. The tables he produced were a considerable improvement over the earlier ones of Kirchhoff and A. J. Ångström, but they were soon superseded by much more complete and precise solar wavelength tables produced with concave gratings by Henry Rowland at Johns Hopkins University.

Vogel's 1871 measurement of the Doppler shifts at the limb of the Sun was seen as confirmation that the Sun does indeed rotate as sunspot watchers had long maintained. At the time, it was taken as the first clear proof that Doppler shifts in astronomical spectra really do reveal radial velocities. Spectral observations at different solar latitudes showed that the Sun rotates differentially, not like a solid body.

In the early 1870's the government of recently-united imperial Germany decided to establish an astrophysical observatory at Potsdam, near Berlin. Joining the staff in 1874, five years before the observatory was completed, Vogel participated in planning and equipping the new institution. He traveled to Britain and Ireland to consult with Huggins and other British astronomers.

From 1882 until his death in 1907, Vogel was the director of the Potsdam Astrophysical Observatory. He led an outstanding group of astronomers, and made his institution one of the world's leaders in astrophysics. At first he visually determined and classified spectra of some 4000 stars, revising his classification system after the discovery that helium exists on Earth as well as on the Sun, and that some stellar lines match wavelengths of this new gas. Soon, however, the wholesale classification of spectra of hundreds of thousands of stars by objective prism photography at Harvard swamped all other classification schemes.

By far Vogel's most important work was on the radial velocities of stars, much of it in collaboration with Julius Scheiner. While not the first to photograph stellar spectra,[2] "Vogel was the person who perfected the photographic art so that measurements on stellar spectra with hitherto unattainable precision became a standard, even if laborious procedure."[3] By the early 1890's his probable errors in radial velocities of bright stars were less than three kilometers per second, ten times smaller than those of Huggins's early visual measurements.

In 1889 Vogel's spectrograph proved what had long been suspected: Algol is an eclipsing binary system.[4] By analyzing the Algol system, Vogel and Scheiner obtained the first estimates of masses of stars other than the Sun. That same year Vogel discovered what is now called a *spectroscopic binary star:* the light from what appears to be one star (Spica) contains two sets of spectral lines whose varying velocities reveal that two stars are rotating about their common center of mass. (At about the same time Harvard Observatory director Edward C. Pickering discovered that Mizar A and Beta Aurigae are also spectroscopic binaries.)

This work was done with an eleven-inch refractor with a wooden tube. It suffered from considerable flexure, and the compound prism system used was not reliable at low temperatures. While awaiting the funding to build a larger telescope, Vogel saw the lead in radial velocity measurements pass to observers in two other countries: A. A. Belopolsky, at the Russian observatory at Pulkova, who attached a copy of Vogel's spectrograph to a 76 cm (30-inch) refractor; and young J. Edward Keeler in America, who achieved amazing *visual* results in 1890-91 with the 36-inch

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2. The first photograph to show absorption lines in the spectrum of a star was taken in 1872 by Henry Draper in New York. Within a few years Huggins and others were also obtaining spectrograms.

3. Hearnshaw, John B., *The Analysis of Starlight*, p. 87.

4. See the article by Zdeněk Kopal in the May/Jun 1990 issue of *Mercury*.

Lick refractor, the world's largest telescope. Within a few years W.W. Campbell at Lick would begin the photographic radial velocity program that eclipsed all others.

Meanwhile Vogel and his colleagues oversaw construction of a 32-cm (12.8-inch) refractor designed specifically for photography. Besides a new kind of mount, it featured a guiding telescope of 23.5-cm (9-inch) aperture with the same focal length. The larger telescope was used to produce a portion of the international astrographic catalogue, while Vogel designed a succession of spectrographs to use with the smaller one to obtain improved radial velocities of stars.

Much of Vogel's time was now occupied in administration and instrument planning. In 1899 a dream came true with the completion of an 80-cm (31.5-inch) photographic refractor, for which Vogel had designed improvements in the mounting and even researched the absorption of light by different kinds of glass. Unfortunately, his health failed soon after its completion, and it fell to others to make good use of the new instrument.

A quiet and reserved bachelor, often in poor health, Vogel collected insects and played the organ for recreation. He left his considerable savings to the observatory to endow scholarships and to enable students to study abroad. ■