

# Henry Norris Russell:

## The Twentieth Bruce Medalist

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**H**enry Norris Russell impressed the physicists and astronomers of his day the way physicists and astronomers sometimes impress the more credulous members of the public: He was a “brain,” not just smart, but supersmart, so quick that he often left his listeners far behind and afraid to ask questions for fear of appearing stupid. He seemed to have every conceivable fact, even tables of logarithms, committed to memory.

Like his friend, George Ellery Hale, Russell was hyperactive, nervous, filled with ideas, and subject to occasional breakdowns. He also shared with Hale a talent for speaking and writing and the goal of understanding the structure and evolution of the stars. But while Hale was a very good scientist and

instrument-builder and a superb fund raiser, organizer, and administrator, Russell was an excellent scientist (and teacher), who depended on others to develop and manage the observatories and laboratories and to provide the data for his research.

He always signed his full name, probably because he identified more with his mother’s family, the Norrises, than with the Russells. He was religious, as befitted the son of a Presbyterian minister, but he felt himself more influenced by his mother’s and maternal grandmother’s mathematical talent, and he lived nearly all of his life in the Norris family home in Princeton.

A “gentleman of the old school,” fully formed in the nineteenth century, he

wore the same style high black shoes and high starched collar throughout his life, and he always carried an umbrella. He was a whiz with a slide rule, which he never abandoned for a mechanical calculator. His family and colleagues were convinced that they should relieve him of every burden possible so that he could carry on his work.

In those days astronomers studied stars, and when he began, around 1900, very little was known about them. Astronomers had painstakingly acquired measurements of distances of a few nearby stars, and—thanks largely to Edward C. Pickering and his staff of mostly female computers at Harvard—apparent magnitudes (brightnesses), colors, and spectral classes of tens of thousands more. Positions of hundreds >

[Henry Norris Russell](#)  
[25 October 1877-](#)  
[18 February 1957](#)  
[1925 Bruce Medalist](#)  
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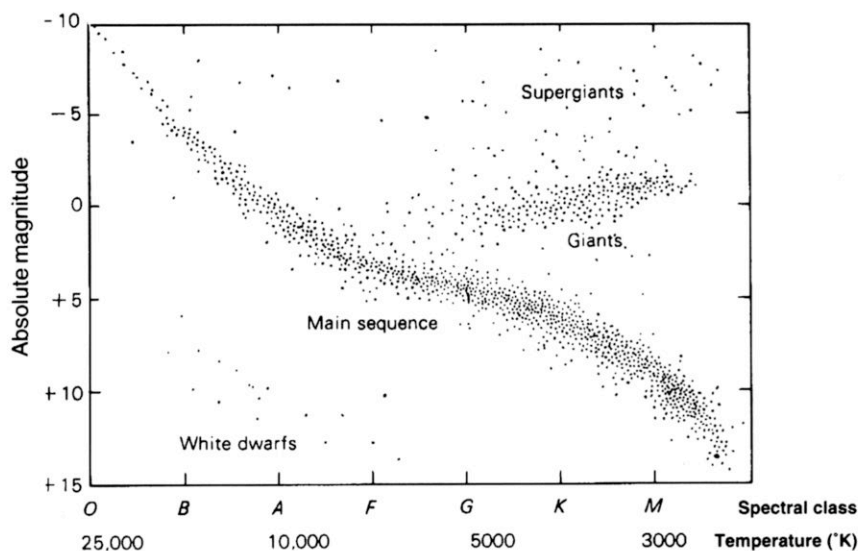
of thousands of stars had been measured. Masses could be determined for a very few stars, the eclipsing binaries. German astrophysicists were determining surface temperatures from stellar colors.

Getting from the stage of measuring properties of stars to an understanding of the physics of stars and a rational

were, on the average, the most distant. He obtained average distances for groups of stars. He published a comparison of color index with absolute magnitude (essentially the logarithm of the luminosity, with the magnitudes smaller for the more luminous stars) in a German photography journal in 1906. He showed that white stars were always very luminous, but that red stars

thanking Hertzsprung for the reprints, "I have noticed independently—though some time later than you did—that the red stars fall naturally into two groups of very different absolute brightness."

In 1913, Russell plotted absolute magnitudes vs. spectral classes for a number of stars, and showed his graphs to the Royal Astronomical Society in June and to the American Astronomical Society in December, the latter occasion being the first time that magnitudes were along the vertical axis and spectral types along the horizontal. The "Russell Diagram," as most American astronomers first called it, was born. In the 1930s astronomers worldwide agreed to call it the Hertzsprung-Russell or H-R diagram. The plot of magnitude versus color index or spectral type became the principal tool of stellar astronomers, one on which theoretical evolutionary tracks can be plotted and compared with observations.



The Hertzsprung-Russell diagram plots the luminosity, given by absolute magnitude, against surface temperature, given by spectral class, of stars. Astronomers use it to track stars as they age.  
(Courtesy ASP Archives)

theory of stellar evolution became a lifelong goal of Henry Norris Russell, as it was for the German astrophysicist, Karl Schwarzschild (who died in World War I; see *Mercury*, Nov/Dec 1992), Danish amateur Ejnar Hertzsprung, who became Schwarzschild's assistant, and Arthur Stanley Eddington.

In 1905 Hertzsprung made an early attempt at finding a relationship between two different properties of stars. Although few individual stellar distances were known, many proper motions (motions across the sky, in arc seconds per year) were, and he knew that the stars of smallest proper motion

could be divided into two groups, the very faint and the very luminous, and that there were no red stars of intermediate luminosity. By 1908 Schwarzschild was referring to Hertzsprung's giants and dwarfs.

Unaware of Hertzsprung's publications, Russell came to the same conclusion in 1910. He presented it at a meeting of what is now called the American Astronomical Society (AAS) at Harvard that year. Schwarzschild was present and informed Russell of Hertzsprung's work, and the two began corresponding and exchanging reprints. On September 27, 1910, Russell wrote,

Meanwhile Hale's team was pointing the world's largest telescopes at the excellent skies of Mt. Wilson. Russell was a professor at Princeton University and director of its observatory when Hale offered Russell a golden opportunity to come to Mt. Wilson regularly as a Carnegie Research Associate to gather data and suggest observing programs. Starting in 1921, Russell spent a month or more at Mt. Wilson almost every spring for thirty years.

Historian David DeVorkin has described Russell as "a fox among the hedgehogs", taking the hard-won data from the observers and using it for his own research, but it was a symbiotic relationship. In return for the observations he needed, Russell brought theory to the observers, lecturing, questioning,

and spouting ideas and suggestions at a great rate throughout his visits. With the small fields of view of the great new telescopes, the time was past for the Pickering program of measuring everything in the sky and just recording data for the use of future generations. Russell suggested the observations that were needed to fill in the gaps in astronomers' understanding of stars. While not a match for Eddington in creativity or mathematics, Russell was closer to the data, and by working with many collaborators, he created a huge body of important work.

A major breakthrough for astrophysics came in 1920. Meg Nad Saha, a 26-year-old physicist from India, applied statistical mechanics and Niels Bohr's quantum mechanics to gases. Saha showed how to relate the degree of ionization of a gas to the temperature and pressure and the energy needed to ionize an atom, a quantity that could be measured in the laboratory. He computed temperatures corresponding to the different spectral classes.

Although he tried for two years in England and Germany, Saha never acquired the solar and stellar spectra needed to apply his theory fully. Russell did. Making use of Saha's work, Russell used the data from Mt. Wilson to determine temperatures and pressures in stellar atmospheres.

Meanwhile, Harlow Shapley, Russell's first and favorite-graduate student, had become director at Harvard (in 1921) and established a graduate school. The first Ph.D. awarded was to Cecelia Payne (later Payne-Gaposchkin). In her 1925 dissertation, *Stellar Atmospheres: A Contribution to the Observational Study of High Temperature in the Reversing Layers of Stars*, she estab-

lished temperatures for stars of each spectral class and determined the compositions of stellar atmospheres. She discovered that stars differ only slightly in elemental makeup; different spectral classes correspond primarily to different temperatures, with smaller distinctions due to pressure differences. Her most astonishing result was that stars are composed overwhelmingly of hydrogen, with helium the second most abundant gas. Shapley had her show her results to Russell, by this time the dominant figure in American astrophysics. The great man said this was impossible, so she wrote that the calculated abundance of hydrogen and helium are "regarded as spurious."

Russell usually had a great number of projects going simultaneously, with different collaborators working on them. They included measurements of the position of the Moon, studies of the albedos and atmospheres of planets, the age of the Earth's crust, and laboratory spectroscopy. In 1920 he hired a new mathematics graduate from Swarthmore to be his assistant. Almost sixty years later, Charlotte Moore said that she might not have taken the job had there been an interview, because she soon found that

...his brain was too active for the average person to follow in some respects. Even scholastic people found him difficult to follow or to cope with, sometimes. And I felt sort of overpowered by him... My first impression was that he was a very brilliant and quick thinker.

Nevertheless, Moore (later Sitterly) stayed with Russell twenty-five years, winning her own Bruce medal in 1991, just before her death at 92. She was his most frequent coauthor, and Russell's son called her a very stabilizing influence" in getting the books and papers out. DeVorkin calls her "Russell's con-

tribution to the data pool that made the partnership palatable" to the Mt. Wilson observers.

In 1940 Russell and Moore published a book on stellar masses, determined by further studies of binary systems. Russell's work on the origin of the solar system became another important book and helped bury the once-prevalent idea that the planets had been pulled out of the Sun by a passing star.

Russell's influence with American astronomers was enormous. Some called him the "Dean of American astronomers," others called him the "Pope." His 1929 paper, "On the Composition of the Sun's Atmosphere," was extremely influential. By now he had reached the conclusion that the Sun is mostly hydrogen, and when Russell said it, astronomers believed it. His advice was sought and followed on appointments and research plans. He visited and lectured and advised at observatories along the way, especially Lowell, on his annual trips to Mt. Wilson. His role at astronomical meetings was called "dominating."

He was also an important writer and an inspiring public speaker. He wrote a monthly column in *Scientific American* for 43 years. With his two Princeton colleagues he wrote an influential textbook. Like Eddington, he produced a book based on a set of lectures on science and religion. When the American Astronomical Society established its highest award in 1946, it was named the Henry Norris Russell Lectureship, and he was its first recipient. ▀

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