

ASTRONOMY

# Star Velocities in the Line of Sight

## "A Classic of Science"

### Invisible Motions Are Measured in Terrestrial Units Since Huggins Used Doppler-Fizeau Principles in 1868

THE SCIENTIFIC PAPERS OF SIR WILLIAM HUGGINS, Edited by Sir William Huggins and Lady Huggins, London: William Wesley and Son, 1909. HISTORICAL STATEMENT, From the Nineteenth Century Review, June 1897. This is an exact reprint of this publication.

FROM THE BEGINNING of our work upon the spectra of the stars, I saw in vision the application of the new knowledge to the creation of a great method of astronomical observation which could not fail in future to have a powerful influence on the progress of astronomy; indeed, in some respects greater than the more direct one of the investigation of the chemical nature and the relative physical conditions of the stars.

It was the opprobrium of the older astronomy—though indeed one which involved no disgrace, for *à l'impossible nul n'est tenu*—that only that part of the motions of the stars which is across the line of sight could be seen and directly measured. The direct observation of the other component in the line of sight, since it caused no change of place and, from the great distance of the stars, no appreciable change in size or of brightness within an observer's lifetime, seemed to lie hopelessly quite outside the limits of man's powers. Still, it was only too clear that, so long as we were unable to ascertain directly those components of the stars' motions which lie in the line of sight, the speed and direction of the solar motion in space, and many of the great problems of the constitution of the heavens, must remain more or less imperfectly known.

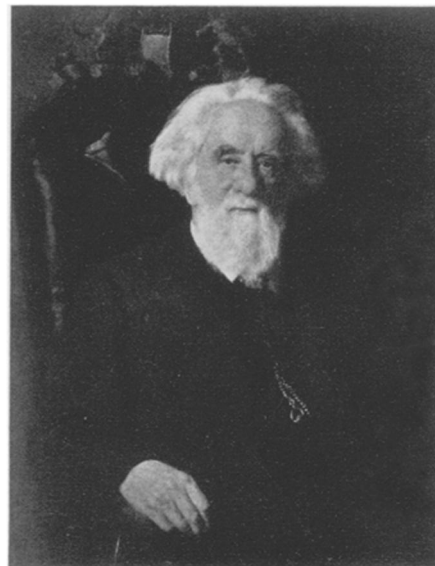
Now as the colour of a given kind of light, and the exact position it would

Sir William Huggins' application of the spectroscope to study of the Great Nebula in Orion, which showed that some nebulae are gaseous like the stars while others have a distinct type of spectrum which may show the presence of solid or liquid matter in the nucleus, appeared as the Classic of Science in the SCIENCE NEWS LETTER for June 20, 1931.

take up in a spectrum, depends directly upon the length of the waves, or, to put it differently, upon the number of waves which would pass into the eye in a second of time, it seemed more than probable that motion between the source of the light and the observer must change the apparent length of the waves to him, and the number reaching his eye in a second. To a swimmer striking out from the shore each wave is shorter, and the number he goes through in a given time is greater than would be the case if he had stood still in the water. Such a change of wavelength would transform any given kind of light, so that it would take a new place in the spectrum, and from the amount of this change to a higher or to a lower place, we could determine the velocity per second of the relative motion between the star and the earth.

The notion that the propagation of light is not instantaneous, though rapid far beyond the appreciation of our senses, is due, not as is sometimes stated to Francis, but to Roger Bacon. "Relinquitur ergo," he says, in his *Opus Majus*, "quod lux multiplicatur in tempore . . . sed tamen non in tempore sensibili et perceptibili a visu, sed insensibili. . . ."

The discovery of its actual velocity was made by Roemer in 1675, from observations of the satellites of Jupiter. Now, though the effect of motion in the line of sight upon the apparent velocity of light underlies Roemer's determinations, the idea of a change of colour in light from motion between the source of light and the observer was announced for the first time by Doppler in 1841. Later, various experiments were made in connection with this view by Ballot, Sestini, Klinkerfues, Clerk Maxwell, and Fizeau. But no attempts had been made, nor were indeed possible, to discover by this principle the motions of the heavenly bodies in the line of sight. For, to learn whether any change in the light had



SIR WILLIAM HUGGINS, 1824-1910

taken place from motion in the line of sight, it was clearly necessary to know the original wave-length of the light before it left the star.

As soon as our observations had shown that certain earthly substances were present in the stars, the original wave-lengths of their lines became known, and any small want to coincidence of the stellar lines with the same lines produced upon the earth might safely be interpreted as revealing the velocity of approach or of recession between the star and the earth.

These considerations were present to my mind from the first, and helped me to bear up under many toilsome disappointments: "Studio fallente laborem." It was not until 1866 that I found time to construct a spectroscope of greater power for this research. It would be scarcely possible, even with greater space, to convey to the reader any true conception of the difficulties which presented themselves in this work, from various instrumental causes, and of the extreme care and caution which were needful to distinguish spurious instrumental shifts of a line from a true shift due to the star's motion.

At last, in 1868, I felt able to an-

nounce, in a paper printed in the *Transactions of the Royal Society* for that year, the foundation of this new method of research, which, transcending the wildest dreams of an earlier time, enables the astronomer to measure off directly in terrestrial units the invisible motions in the line of sight of the heavenly bodies.

To pure astronomers the method came before its time, since they were then unfamiliar with Spectrum Analysis, which lay completely outside the routine work of an observatory. It would be easy to mention the names of men well known, to whom I was "as a very lovely song of one that hath a pleasant voice." They heard my words, but for a time were very slow to avail themselves of this new power of research. My observations were, however, shortly afterwards confirmed by Vogel in Germany; and by others the principle was soon applied to solar phenomena. By making use of improved methods of photography, Vogel has recently determined the motions of approach and of recession of some fifty stars, with an accuracy of about an English mile a second. In the hands of Young, Duner, Keeler, and others, the method has been successfully applied to a determination of the rotation of the sun, of Saturn and his rings, and of Jupiter.

It has become fruitful in another direction, for it puts into our hands the

power of separating double stars which are beyond the resolving power of any telescopes that can ever be constructed. Pickering and Vogel have independently discovered by this method an entirely new class of double stars.

Double stars too close to be separately visible unite in giving a compound spectrum. Now, if the stars are in motion about a common centre of gravity, the lines of one star will shift periodically relatively to similar lines of the other star, in the spectrum common to both; and such lines will consequently, at those times, appear double. Even if one of the stars is too dark to give a spectrum which can be seen upon that of the other star, as is actually the case with Algol and Spica, the whirling of the stars about each other may be discovered from the periodical shifting of the lines of the brighter star relatively to terrestrial lines of the same substance. It is clear that as the stars revolve about their common centre of gravity, the bright star would be sometimes advancing, and at others receding, relatively to an observer on the earth, except it should so happen that the stars' orbit were perpendicular to the line of sight.

It would be scarcely possible, without the appearance of great exaggeration, to attempt to sketch out even in broad outline the many glorious achievements which doubtless lie before this method of research in the future.

*Science News Letter, April 15, 1933*

#### PUBLIC HEALTH

## Electric Refrigerators Credited With Reducing Smallpox

**T**HE LOWEST number of smallpox cases ever reported to the U. S. Public Health Service for the country as a whole has been recorded for the year 1932. The current year is on the way to breaking this record.

During 1932, 11,168 cases were reported. As recently as 1930, there were 48,907 cases.

Electric refrigerators may have been a factor in lowering the number of smallpox cases during recent years, public health officials suggested. Smallpox vaccine for preventive vaccinations keeps best at low temperatures. All vaccine packages are labelled with a warning to keep the vaccine on ice, and

the U. S. Pharmacopoeia requires that they should be kept below freezing. With the old-style, ordinary icebox it was sometimes difficult for druggists to keep the vaccine cold enough to prevent its deterioration.

Public health officials believe that the refrigerated vaccination "takes" more often, and consequently more people are protected.

Other officials state that while refrigerated vaccine may play a part, it may be that the reduction in cases is due to chance or to unknown causes. They point to unexplained fluctuations in influenza and infantile paralysis.

*Science News Letter, April 15, 1933*

#### ENGINEERING

## New Style Mattress On Mississippi River Bed

**A** BRAND NEW mattress with dust in it. A huge black flexible mattress 300 feet long, made and slid neatly into New Orleans harbor. This is the latest experiment of U. S. Army engineers, in their effort to find a really satisfactory mat to keep the Mississippi River's bed in order.

Since 1878, mats of one sort or another have been contrived and laid down in the river at the New Orleans wharves. The problem was, and is, to keep the river from eroding the banks and levees until they cave in.

For a year, Col. J. N. Hodges, district engineer of the U. S. Army Engineer Corps, has been directing work on this new type of mattress which would solve New Orleans' old problem. Walter C. Carey, a civilian engineer, took charge of the task.

After trying many ingredients, the engineers pronounced themselves satisfied with a mixture of about 12 per cent. paving asphalt, 66 per cent. river sand, and 22 per cent. loess—earth so fine that it is light dust. The mixture was poured over a great sheet of chicken wire, completely covering the wire, and producing a mattress that is flexible, does not crack, stands up under heavy water pressure, has no corroding metal exposed. Previous river mats have worn badly for lack of one or more of these qualities.

The new mattress was completed and lowered safely into place during the late-winter rise of the Mississippi, when the strain on the fabric would be greatest. The big black mat withstood the initial hard test and is apparently going to be as satisfactory in real wear as it promised in the laboratory tests.

*Science News Letter, April 15, 1933*

#### METEOROLOGY-ARCHAEOLOGY

## Incas Anticipated Moderns In Frost-Fighting Method

**T**HE modern method of protecting orange and lemon groves from frost damage by orchard firing on cold nights is not so new after all, archaeologists point out.

California groves are protected by thousands of pots burning a heavy crude oil. Long ago, in Cuzco, Peru, where