Henrietta Leavitt – A Bright Star of Astronomy

Measuring distances is a recurring theme in astrophysics. The interpretation of the light from a luminous object in the sky can be very different depending on the assumed distance of the object. Two stars or galaxies can have very different *actual* brightness, even though they may *appear* to have similar brightness in the sky, if the distances to them are very different.

Distances, however, are notoriously difficult to compute. It is possible to use geometrical methods to determine the distances of objects which are in the vicinity of the solar system, say within a distance of about 150 lightyears from us. Beyond this distance it is impossible to use any straightforward method to find distances. And this was the state of affairs in astronomical research in the beginning of the last century. Many new objects were discovered, but without the knowledge of their distances, it was impossible to place them in any model of the stellar systems, or the universe. In fact, it was not known then that we live in a galaxy called the Milky Way, and that there were other galaxies in the universe like ours.

This big handicap was elegantly removed by a momentous discovery by an American astronomer named Henrietta Leavitt in 1912. She found a way to determine the *actual* brightness of a particular kind of stars. If one knows the *actual* and the *apparent* brightness of an object, its distance is easily calculated, since one knows that brightness falls with the square of distance. This relation still remains a cornerstone among the astronomical tools in the endeavour to map the farthest corners of the universe.

Henrietta Swan Leavitt was born in 1868 in Lancaster, Massachusetts, USA. After graduating from Radcliffe College in 1892, where she discovered her love for astronomy, she joined the Harvard College Observatory as a volunteer. This was the place where hundreds and thousands of photographic plates of the sky were being carefully searched to catalogue the stars. Leavitt's principal task was to standardise the method of calculating the brightness of the star in the sky from the measurement on the photographic plate. Her method was ultimately accepted as the international standard. But the discovery for which she is remembered most has to do with a peculiar class of stars.

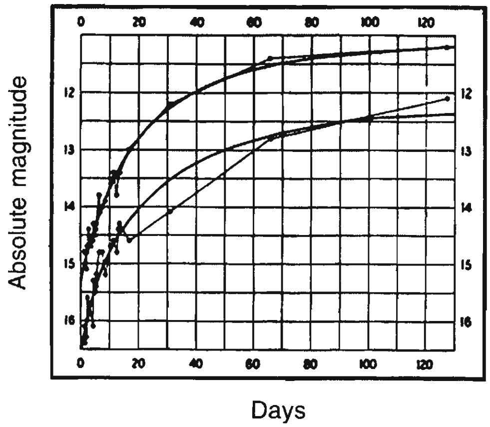
By superposing the plates taken at different times, astronomers could discover a number of stars, which vary their brightness with time (variable stars). Among this set of variable stars lay a particular kind of stars, whose brightness varied with extreme regularity. They were called Cepheid stars – since the first of its kind was found in the constellation of Cepheus. (Astrophysicists now know that these variations owe their existence to the disturbances in the interior of these stars and this is a temporary phase in the life of these stars.)

Henrietta Leavitt spent a great deal of time searching the photographic plates for these variable stars in the small and the large Magellanic clouds. These two 'clouds' (first noted by Magellan in his exploration of the Southern hemisphere) are dense congregates of stars in the sky (which we now know to be small satellite galaxies of our Milky Way). Leavitt discovered around a thousand variable stars in these clouds. Among these, she found 25 Cepheid variables in the small Magellanic cloud and noted that the period of these variable stars were correlated with the peak brightness. The brighter the star was, the longer it took to vary its brightness. In other words, the period was proportional to the brightness. Leavitt argued that since all the stars in the small Magellanic cloud were situated in a small part of the sky, it was reasonable to assume that they were more or less at the same distance from us. In that case, their *apparent* brightness would be proportional to the *actual* brightness, so that the period of the Cepheid stars would be proportional to their *actual* brightness.

The importance of this law was immediately appreciated by the astronomers. Within a year of this discovery, the Danish astronomer Ejnar Hertzsprung determined the distances of a few nearby Cepheids in our Milky Way, using geometrical methods, and calibrated this relation. With this, the relation could be used to find the distance of Cepheids at any distances. (We now know that this calibration depends on a few extra factors which were unknown then. For example, astronomers later realised that this calibration depended somewhat on the amount of heavy elements in the star.)

Within the next 5 years, Harlow Shapley applied this relation to Cepheids in globular clusters, and with the calculated distances he could produce the first map of the Milky Way. He drew a picture of a vast system of stars – around a hundred billion of them – in a disk like structure, whose centre was far removed from our solar system. In a single stroke, Shapley had created a whole new chapter of astronomy, and this was possible only because of the crucial discovery of Leavitt.

Since then, astronomers have devised a number of other relations between the properties of different astronomical objects (supernovae, HII regions, to name a few), which can be used to determine even larger distances, from where Cepheids are hard to detect. The period-luminosity relation of Cepheids, however, remain the least uncertain method of distance determination. One of the key projects of the Hubble space telescope, which was launched about a decade ago, was to detect Cepheid variable stars from galaxies in the Virgo cluster of galaxies (the nearest galaxy cluster from Milky Way, at a distance of approximately 50 million lightyears), and determine its distance as accurately as possible.



The period-magnitude relationship for 25 cepheids in the Small Magellanic Cloud. (From the paper *Discovery of the period-magnitude relation* by Henrietta S Leavitt)

Henrietta Leavitt made the prime discovery of her scientific life at a time when women scientists were often looked down upon by their male colleagues. As if this were not enough, Leavitt had suffered from grave illness during her college days, and was left completely deaf. It was her tenacity and love for science which pushed her into taking up a minor position in the Harvard Observatory. Much of modern astronomy owes its existence to this woman astronomer.

She died young, at the age of 53, of cancer.

Biman Nath, Raman Research Institute,
Bangalore 560 080, India.