Helen Sawyer Hogg and the Globular Cluster Period-Luminosity Relation

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The Back Story

Helen Sawyer Hogg (HSH) was a well known astronomer whose research focussed on globular clusters and their variable stars. Her astronomical career began in 1926 at the Harvard College Observatory where she worked with Harlow Shapley.

Shapley was famous for his seminal research on the size and structure of the Milky Way galaxy which he had estimated by deriving the distances of its globular clusters. The period-luminosity relation was an important tool for his investigation (1918, ApJ, Vol. 48, p.89). His modus operandi was to match the P-L relation of the long period Cepheids in globular clusters to the relation that Leavitt derived for Cepheids in the SMC (1912, Harv. Circ. No. 173).

However, at the time, some astronomers were concerned that Shapley's P-L relation was based on so few clusters and so few variables that it had little meaning. When HSH heard about this at a meeting of the American Astronomical Society in 1927, it came as quite a shock because Shapley was her mentor. Nevertheless, it motivated her to investigate the literature on the subject and she soon realized there was too little material to warrant the significance being given to it.

HSH related this story when she gave her Presidential address to the Canadian Astronomical Society in 1972 (1973, JRASC, Vol. 67, p.8).

It turned out that, in Shapley's investigation, only one cluster had long period Cepheids with a range of periods suitable for testing the slope of the P-L relation. This was Omega Centauri which had 5 variables with periods of 1.3, 2.3, 4.6, 14.8 and 29.5 days, respectively. Three other clusters, M3, M5 and M15 were also included, but M3 had only one long period Cepheid, with a period of 15.8 days, M15 had one, with a period of 1.4 days, and even though M5 had two, both had periods of approximately 26 days.

In 1931, after HSH completed her PhD, she moved to Canada with her husband, Frank Hogg, also an astronomer. They spent a few years working at the Dominion Astrophysical Observatory in Victoria, BC and then relocated to Richmond Hill, Ontario in 1935, when the David Dunlap Observatory opened. At both observatories, HSH set up her own program to photograph globular clusters.

Helen Sawyer Hogg standing beside the 74-inch telescope at the David Dunlap Observatory in Richmond Hill, Ontario, Canada. She used this telescope to photograph globular clusters for 35 years, beginning in 1935. Prior to that, she observed for 4 years with the 72-inch telescope at the Dominion Astrophysical Observatory in Victoria, British Columbia.
Credit: University of Toronto Archives.

Helen Sawyer Hogg's Globular Cluster Observing Program

The motivation for the program was to study the variable stars because, during the course of her research with Shapley, HSH had recognized their importance as distance indicators. Also she was well aware that there was much work to be done. In the ensuing years she identified and characterized the variable star population in numerous globular clusters.

Most of the variables were of the RR Lyrae type, then known as cluster variables, because this was the most frequently occurring variability type among globular cluster stars. However, she also discovered a significant number of type II Cepheids, then known as long period Cepheids. This enabled her to increase the data sample for the globular cluster P-L relation. Three of the clusters that she observed contained type II Cepheids with a range in periods.

- M2 (4 with periods of 15.5, 17.6, 19.3 and 33.6 days)
- M13 (3 with periods of 1.5, 2.1 and 5.1 days).
- M14 (3 with periods of 2.8, 13.6 and 18.8 days)

In all three clusters, the slope she derived for the P-L relation was in good agreement with the one that Shapley derived for Omega Centauri. In addition, she identified type II Cepheids in six other clusters: M10, M12, M22, M28, M56 and M80. The elements she derived for these variables are listed in the second edition of her globular cluster variable star catalogue (Sawyer, 1955, DDO Pub. Vol. 2, p.33)

These type II Cepheids, along with the ones previously known in Omega Centauri, M3, M5 and M15, proved to be a valuable resource for Joy (1949, ApJ, Vol. 110, p105) in his study of the high-luminosity variable stars in globular clusters.

One striking characteristic was their period distribution. They fell into different period groups: a short period group with periods ranging from 1 to 5 days and a longer period group with periods great than 13 days. None had periods between 5 and 13 days, a period range in which there are numerous classical Cepheids.

Another striking difference materialized when Joy made spectroscopic observations of the variables that could be reached from Mount Wilson. When compared with classical (population I) Cepheids of like period, the globular cluster (population II) Cepheids had spectral types that were earlier. Thus, based on period distribution and spectral properties, it was apparent that the two populations might follow different P-L relations. This had important implications for the cosmic distance scale.

It was later confirmed by Baade (1956, PASP, Vol. 68, p.5) that there were indeed different period-luminosity relations for the two stellar populations. The most convincing evidence came when he began observing the Andromeda galaxy (M31) with the 200-inch telescope after it went into operation in 1949. According to the accepted P-L relation, the RR Lyrae variables in M31 should have been been detectable at the limiting magnitude of the plates. Instead, the stars that appeared at that magnitude were the brightest population II stars which were about 1.5 magnitudes brighter. This indicated that the P-L relations were different and that, on average, a classical Cepheid is about 1.5 magnitudes brighter than a type II Cepheid of the same period.

As a result, the cosmic distance scale had to be revised because the calibration for the P-L relation in use at the time was based on the statistical parallax of RR Lyrae variables which were population II stars. This meant that the distances of classical Cepheids had been underestimated by a factor of two. Since extraglactic distances had been derived from classical Cepheids, their distances had to be multiplied by two. The size of the Universe was doubled!