New Views of the Magellanic Clouds
IAU Symposium, Vol. 190, 1999
Y.-H. Chu, N.B. Suntzeff, J.E. Hesser, and D.A. Bohlender, eds.

Surface Brightness Scale of Galactic Cepheids

G. P. Di Benedetto

Istituto di Fisica Cosmica, Via Bassini 15, 20133 Milano, Italy

Abstract. An accurate calibration of the surface brightness scale S_V as a function of the near-IR color $(V - K)$ has been recently measured for non-variable Galactic dwarf and giant stars. It can be shown that this correlation can be applied to the S_V scale of Galactic Cepheid variable stars, which are of major cosmological interest.

1. Introduction

Stellar surface brightness methods (Wesselink 1969; Barnes et al. 1978) can provide accurate distances for Galactic and extragalactic investigations, since the apparent brightness of a star may be measured directly by current observational techniques. I have shown the potential of the method of using accurate angular diameters available by Michelson interferometry and the near-IR colors (Di Benedetto (1993). More recently, I have used the same approach using high-precision K magnitudes and Hipparcos parallaxes for dereddening the photometric data to determine effective temperatures as accurate as $\pm$ 1% for a large sample of non-variable galactic A-F-G-K dwarfs and giants selected as standards for the Infrared Space Observatory (Di Benedetto 1998).

However, for the important class of Cepheid variable stars, the empirical S_V scale still remains poorly known due to the lack of accurate diameter measurements available for supergiants and to the uncertainties in the reddening. For the first time, Di Benedetto (1994) applied the near-IR surface brightness approach to yield Cepheid distances (Di Benedetto 1997). Steps for improving the calibration of the S_V scale have been also attempted (Di Benedetto 1995). Using the same precepts and taking advantage of the new accurate observational relationships available for the Galactic field stars, it can be shown that the S_V scale of Galactic Cepheids closely follows that of giants, enabling us to significantly improve the calibration of cosmological Cepheid-based distance indicators.

2. The Method

The surface brightness of a Cepheid variable star can be defined according to Cepheid parameters measured along the pulsation cycle of the light curve as:

$$S_V = < V_0 > + 5 \, log < R > - 0.159 - (m - M)_0 \qquad (1)$$

where $< V_0 >$ is the dereddened visual mean magnitude; $< R >$ is the mean linear radius (solar units); $(m - M)_0$ is the true distance modulus. Individual

https://doi.org/10.1017/S0074180900118832 Published online by Cambridge University Press

values of $< R >$ and $(m - M)_0$ for Galactic Cepheids can be derived either from direct observational data or by relationships using the pulsational period P as the sampling observable. This surface brightness is then compared to a reference sequence of non-variable giants calibrated using high-precision observational data (Di Benedetto 1998). The comparison based on the direct measurements available for Cepheids shows close agreement with the calibration of low-gravity giants. In fact, this calibration is also expected to represent the photosphere of supergiants over the color range of Cepheids according to updated model-atmosphere results (Castelli 1998). Hence, the same comparison is carried out by applying the observational relationships currently adopted as Cepheid-based distance indicators. The systematic deviations of the residuals can be observed as either slope variations or average shifts, or both. These residuals are the most sensitive signature of the type of errors affecting the calibration. In addition, they can be removed in order to improve the accuracy and reliability of the relationship itself as distance indicator.

One of the advantages in plotting the S_V data and assessing the residuals as a function of the near-IR color is that the angular/linear diameters from equation (1) in the $(V-K)$ diagram are largely insensitive to many systematics affecting the magnitude V. In fact, a change of $0^{\rm m}.1$ in V would lead to only $0^{\rm m}.03$ or about 1.4% of shift in the corresponding photometric stellar size. This allows us to estimate accurate Cepheid distances according to the modern Baade-Wesselink method using high-precision K magnitudes.

3. Conclusions

We are still learning how best to exploit the observed surface brightness data for extragalactic Cepheid-based distances, especially in how the results can be affected by metallicity.

References

Barnes, T.G., Evans, D.S., & Moffett, T.J. 1978, MNRAS, 183, 285

Di Benedetto, G.P. 1993, A&A, 270, 315

Di Benedetto, G.P. 1994, A&A, 285, 819

Di Benedetto, G.P. 1995, ApJ, 452, 195

Di Benedetto, G.P. 1997, ApJ, 486, 60

Di Benedetto, G.P. 1998, A&A, 339, 858

Castelli, F. 1998 private communications

Wesselink, A.J. 1969, MNRAS, 144, 297