HIPPARCOS AND PRIMARY DISTANCE SCALE INDICATORS

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1. Introduction

The Hipparcos data are providing a dramatic increase, qualitatively and quantitatively, of the basic available distance information. For example, the numbers of stars for which a relative accuracy better than 10 % is available from Hipparcos data and from ground-based data are respectively 22 396 and about 1 000. Moreover, the range of spectral types and luminosity classes for which precise parallaxes are available is considerably enlarged, including many stars in open clusters and a small number of Cepheids and RR Lyrae. The bottom of the main sequence is populated down to absolute *Hp* magnitude 14, including a number of subdwarf stars essential to derive globular clusters distances and ages (Pont *et al.*, 1997a).

Finally, the Hipparcos data show how difficult are the calibration of photometric distances and the transformation of relative trigonometric parallaxes to absolute parallaxes. This is illustrated by the comparison of distances given in the last edition of the Catalogue of Nearby Stars (CNS3, Gliese & Jahreiß 1991), which is the best available compilation of stars said to be closer than 25 pc from ground-based data. About a third of them are found by Hipparcos to be (much) further than this limit (Perryman *et al.*, 1995). A second example is given by the study of (Binney *et al.*, 1997).

2. Open clusters

Open clusters are widely used for distance determination by main sequence fitting. Hipparcos offers for the first time the possibility of thoroughly studying the three-dimensional structure and the kinematics of the closest cluster, the Hyades, giving a mean distance modulus of 3.33 $\pm$0.01 mag for the stars observed by Hipparcos within 10 pc of the cluster center (Perryman *et al.*, 1997a), and to precisely place the main sequences of about 15 open clusters of various ages and chemical compositions in the HR diagram (Mermilliod *et al.*, 1997), (Robichon *etal.*, 1997), (van Leeuwen & Hansen Ruiz, 1997). The surprise is that the positions of the different sequences cannot be explained by differences in metallicities, and that a scatter of Helium abondance of about 0.05 would be necessary to explain these discrepancies. A further use of the main-sequence fitting method requires the understanding of this problem.

3. Pulsating variables

Pulsating variables are some of the more powerful objects for distance determinations, after proper calibration of period-(colour-metallicity)-luminosity relations. The main difficulty is to obtain a representative sampling of the stars considered, covering the whole period, colour, and metallicity ranges for each type of objects. A few trigonometric parallaxes, good proper motions and improved cluster membership for Cepheids are obtained from Hipparcos data. Various authors have presented period-luminosity relations: (Feast & Catchpole, 1997), (Feast & Whitelock, 1997), (Paturel *et al.*, 1997), (Szabados, 1997), (Madore & Freedman, 1997) and (Luri *et al.*, 1997) for Cepheids; (Fernley *et al.*, 1997), (Gratton *et al.*, 1997), (Reid, 1997), (Tsujimoto *etal.*, 1997), (Feast & Whitelock, 1997), (Chaboyer *et al.*, 1997), and (Luri *et al.*, 1997) for RR Lyrae. There is still a scatter in the results, easily explained by the small number of stars used in each study.

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More photometric observations are strongly needed to better evaluate the intrinsic scatter in period-luminosity relations, the interstellar extinction, and the metallicities. However, only a project such as Gaia (Lindegren & Perryman, 1997), (Perryman *et al.*, 1997b) would bring extremely accurate determinations of absolute magnitudes for extensive samples of pulsating variable stars and allow a comprehensive calibration of period-luminosity relations for all galactic (and even the brightest Magellanic) variables of the various stellar populations (both disk and halo).

4. Results and conclusion

The distance of the Large Magellanic Cloud and the age of globular clusters have been derived by various authors, from the Hipparcos data of several types of objects, and using many other ground-based observations. The results are given below. Most results are converging to a LMC distance modulus of 18.5-18.7, but the only paper with no discrepancy between the distance obtained from RR Lyrae and from Cepheids (Luri *et al.*, 1997) gives about 18.3. For the age of globular clusters, there is some spread in the results, but most are converging to 12-14 Gyr. These results go towards solving the previous discrepancy between the age of the Universe, and the age of the oldest objects.

To go further, many more very accurate distances are needed, but also many more accurate photometric and spectroscopic observations, and more detailed theoretical models.

LMC distance modulus		Globular cluster age		
Objects/Authors	$(M\text{-}m)_0$	Objects/Authors	Age (Gyr)	
from Cepheids		**from subdwarfs**		
(Feast & Catchpole, 1997)	18.70 ± 0.10	(Reid, 1997)	$12 - 13$	
(Paturel *et al.*, 1997)	18.7	(Gratton *et al.*, 1997)	11.8	$+2.1$
(Madore & Freedman, 1997)	18.57 ± 0.11			-2.5
(Luri *et al.*, 1997) (1)	18.29 ± 0.17	(Pont *et al.*, 1997b)	14	± 1
(Luri *et al.*, 1997) (2)	18.21 ± 0.20	(Cayrel *et al.*, 1997)	$14 - 15$	
from RR Lyrae		**various methods + RR Lyrae**		
(Fernley *et al.*, 1997)	18.31 ± 0.10	(Chaboyer *et al.*, 1997)	11.78	± 1.4
(Luri *et al.*, 1997)	18.37 ± 0.23			
from RR Lyrae, via subdwarfs		**via RR Lyrae**		
(Reid, 1997)	18.65	(Fernley *et al.*, 1997)	15.8	
(Gratton *et al.*, 1997)	18.60 ± 0.07	using (Chaboyer *et al.*, 1997) Mv for RR Lyrae		
from Mirae		**via Cepheids**		
(van Leeuwen *et al.*, 1997)	18.54 ± 0.18	(Feast & Whitelock, 1997)	11	
(Whitelock *etal.*, 1997)	18.60 ± 0.18			

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