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HIPPARCOS MEASUREMENTS OF THE NEAREST BRIGHT ECLIPSING BINARIES

A general idea of stellar parallax measurements from space was born twenty years ago (Dworak, 1973), when "A Catalogue of Photometric Parallaxes of Eclipsing Binaries" was prepared and then published (Dworak, 1975). It follows from this Catalogue that about 80 eclipsing systems with unknown trigonometric parallaxes are probably within 100 pc from the Sun. We need more precise and homogeneous data on the nearest and also bright eclipsing binaries for further investigating their geometrical and physical properties as well as for checking the modified mass-luminosity relation and the method for determining photometric parallaxes (Dworak, 1983; Griffiths et al., 1988). The results obtained for these stars can be extended to distant eclipsing variables and to eclipsing systems observed in other galaxies, so the method for determining photometric parallaxes can serve as an independent source for knowing the distances of extragalactic objects (Dworak, 1974). Unfortunately, at that time we had no possibility of measuring the heliocentric parallaxes from space for these new studies.

Such a possibility arose in Besançon in 1982. We discussed this problem with Prof. de Vaucouleurs. As a result of this discussion, we worked out a program for observing the nearest eclipsing binaries from the HIPPARCOS satellite. Our program has been accepted by the Selection Committee of the HIPPARCOS Project (project number 177). We chose 101 of the nearest eclipsing variables within 100 pc from the Sun) including also 21 eclipsing binaries for which the trigonometric parallaxes were determined earlier. We included them to obtain more accurate and homogeneous data. 95 stars of our list have been approved by the HIPPARCOS Selection Committee (Dworak and Oblak, 1989), including the star HD 3765 which is suspected in having a planet-like companion (Dworak, 1979). In addition to these stars, other 87 eclipsing systems have been included in the standard HIPPARCOS and TYCHO programs (Dworak and Oblak, 1984). We called them "the bright eclipsing binaries" because their magnitude $B<8^m$. Their parallaxes (spectroscopic, dynamic, group or trigonometric are known except for six stars of the b Persei (or Ell) type.

Moreover, we will be able to obtain the necessary data for other eclipsing systems (about 500) which have been included in special programs of several authors.

The first complete data of HIPPARCOS measurements will be available in 1994. Preliminary results of HIPPARCOS observations were published by Froeschlé (1992).

In order to obtain homogeneous results for the geometrical and physical parameters of stellar systems, new or additional observations of eclipsing binaries from the HIPPARCOS program are necessary, especially for 84 stars (Dworak and Oblak, 1987). The solution of light curves from photoelectric observations is also needed for accurately determining the geometrical parameters of each eclipsing system. The determination of spectral type and luminosity class for secondary components of some eclipsing binaries is especially necessary. The best way is to determine the effective temperature T of each component of the eclipsing binary directly from spectral observations.

It is well known that we are able to obtain semi-amplitudes K_1 and K_2 of radial velocity curve from spectral measurements. It is thus possible to determine the mass-ratio α of any given system:

$$\alpha = \mathrm{K_1/K_2 = m_2/m_1} \tag{1}$$

where m_1 and m_2 are the masses (in solar masses) of the components of the system.

We can obtain the value of $\sin i$, where i is the inclination of the orbital plane to the plane of the sky, from photometric observations and rectifications of light curve of any eclipsing binary. Then, by combining both spectroscopic and photometric observations, we determine:

$$a \sin i = 13751\sqrt{1-e^2}(K_1+K_2)P, \tag{2}$$

$$A^3 = 74.5P^2(m_1+m_2), \tag{3}$$

$$R_1 = Ar_1,\ R_2 = Ar_2, \tag{4}$$

where a is the separation in kms, e: the eccentricity of orbit, A: the separation of components in solar radii, P is the period of revolution in days, r_1 and r_2: the relative radii of the components, R_1 and R_2: the absolute radii (in solar radii) of the components of any eclipsing system.

Having R_1 and R_2 as well as, from spectroscopic measurements, the effective temperatures T_1 and T_2 (also in solar units, i.e. $T = T_\star/T_\odot$) it is possible to compute absolute bolometric magnitudes according to Stefan-Boltzmann's law:

$$L_1 = R_1^2 T_1^4, \qquad L_2 = R_2^2 T_2^4, \tag{5}$$

and here $L = L_\star/L_\odot$.

To obtain the absolute magnitudes M_{v1} and M_{v2}, we must know the bolometric corrections $(\mathrm{BC})_1$ and $(\mathrm{BC})_2$ because

$$M_v = M_{b\odot} - 2.5\log L - \mathrm{BC} \tag{6}$$

and $M_{b\odot}$ is the absolute bolometric magnitude of the Sun.

On the other hand, we can find the absolute magnitude M_v of an observed eclipsing binary from direct astrometric and photometric measurements of HIPPARCOS and TYCHO Project.

Finally, we should obtain the whole set of observational data (both spectroscopic and photometric) and calculated values.

1. Directly measured values, common for a whole system: parallax π, P, K_1 and K_2, V (or V_1 and V_2 if we observe total eclipse).
2. Calculated values, common for a system: α, A, e, i, M_v (or M_{v1} and M_{v2} if we observe total eclipse).
3. Parameters of each component:

$$m_1,\ r_1,\ R_1,\ T_1,\ L_1,\ (BC)_1,\ M_{v1};$$

$$m_2,\ r_2,\ R_2,\ T_2,\ L_2,\ (BC)_2,\ M_{v2}.$$

4. Other parameters: radii of Roche-lobes, surface brightness, limb darkening and other effects.

The parameters of 2. and 3. should be homogeneous and fulfil the following conditions (O'Connel, 1972; Dworak, 1974):

- Kepler's Third Law (3), i.e. dynamic condition;
- $M_{v,cal}=M_{v,obs}$ (or if we observe total eclipse $M_{v1,cal}=M_{v1,obs}$ and $M_{v2,cal}=M_{v2,obs}$) with the accuracy of measured values, of course, i.e. photometric condition.

We will be able to obtain the magnitudes V_1 and V_2 also in such a case when the resolution (the angular separation between components) is enough to measure directly the magnitude of each component of a resolved eclipsing system, i.e. a">0.002" (Dworak and Oblak, 1984).

The results obtained generally allow us to verify the method for determining photometric parallaxes for distant eclipsing binaries, the geometrical and physical properties of their components and to find some correlations and differences between visual (together with astrometric) double stars (Oblak and Chareton, 1980) and close binary systems (eclipsing and spectroscopic). We are then also able to give a better interpretation of phenomena observed in close binary systems, as well as to carry out statistical investigations.

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