A COMPARISON OF DIRECT AND INDIRECT METHODS OF DETERMINATION OF STELLAR ANGULAR DIAMETERS

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Several direct and indirect methods for the determination of stellar apparent diameters have been developed in the past; they are summarized in Table 1 by Fracassini, et al. (1981) with a code number and references. So far, no detailed comparison of the methods has been carried out, the main difficulty being the extremely small number of common stars. Nevertheless, from the stars listed in CADARS (Fracassini, et al. 1981), we have obtained some correlations in order to test the reliability of some methods and to define the regions of the HR diagram where they can be applied.

We selected all the stars whose apparent diameter (uniform disk) is determined by two or more methods, of which one is the interferometric method. If many values of $\underline{d}''$ are available for a given method, a weighted average was obtained; for homogeneity, we considered only values measured in the visual region. When possible, the correlation parameters were computed by the weighted least-squares method; otherwise the classical procedure was adopted. Table I reports: the code of the methods, the number $\underline{N}$ of common stars, the correlations and the correlation coefficients $\underline{r}$.

Only three of the direct methods, namely the interferometric (code 1, which includes both the intensity interferometer and Michelson interferometry), lunar occultations (2) and speckle interferometry

TABLE I. Results of the analysis

Code	N	Correlation	r
1,3B	4	d(3B) = (1.16±0.11)d(1) – 0.0068±0.0036	0.99
1,6F	7	d(1) = (1.01±0.02)d(6F)+ 0.000035±0.000056	0.99
1,6H	10	d(1) = (1.11±0.04)d(6H)– 0.000082±0.000038	0.98
1,6G	11	d(6G) = (1.01±0.05)d(1) + 0.0019±0.0009	0.99
1,6I	31	d(6I) = (0.97±0.01)d(1) + 0.00001±0.00001	1.00

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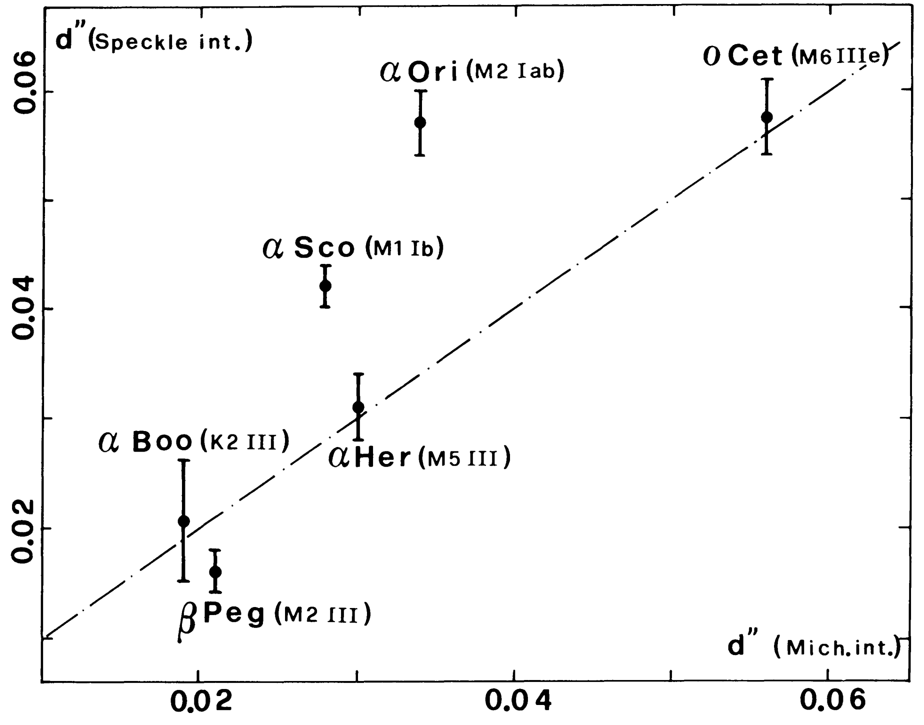

Fig. 1 - Comparison of the apparent diameters d" (arcsec) determined by Michelson interferometry and speckle interferometry.

(3b), have stars in common. Fig. 1 shows the comparison between (1) and (3b); the diameters of all six stars were determined by Michelson interferometry. The values obtained by the two methods are in good agreement, except for those of α Ori and α Sco. The comparison between (1) and (2) is not significant, as it involves only three stars. Again, the diameter of α Sco obtained from (2) differs from the interferometric value, whereas it is in excellent agreement with (3B). Thus Michelson interferometry seems to give understimated diameters for supergiant stars of late spectral types; actually, little can be stated about the reliability of this technique as its diameters may suffer from very large errors (Hanbury Brown, 1968).

Disregarding the methods of purely historical interest, we have made correlations between the interferometric method (mainly the intensity interferometry) and four indirect methods. Methods (1) and (6F) show good agreement for the common stars (up to A7), as already verified by Fracassini et al. (1980). However the applicability field of (6F) is restricted to dwarf stars belonging to the B5-F5 spectral range. Methods (1) and (6H) are interdependent (Wesselink, 1969); the comparison is not quite satisfactory owing to γ Aql (K3II), δ CMa (F8Ia) and κ Ori (B0Ia). As already pointed out by Fracassini et al. (1973) and in more detail by Barnes et al. (1976) and Pastori et al. (1984), surface gravity effects bias the Sv $-(B-V)_0$ relation so that Wesselink's calibration, in its original form, is not suitable for supergiant stars; these stars were not considered in the computations. The comparison between (1) and (6G) shows a disagreement for late supergiants (α Ori, α Her, α Sco and β Peg) whose diameters are measured by the Michelson interferometry technique. These stars are irregular or semi-regular variables. The 6G method is based on the comparison between the observed absolute energy distribution and an energy distribution predicted from a model-atmosphere computation (Gray 1967). Thus, besides the unknown errors of Michelson interferometry, the disagreement is probably due to the difficulty of computing a reliable model atmosphere for variable stars, especially of late spectral type in which metallic absorption lines bias the energy distribution; this conclusion is also strengthened by the late variables β And (MOIII), α Cet (M2III) and α Aur (G8III), which scatter from the straight line. The above-mentioned four supergiants and α Boo (peculiar spectrum) were ignored in the correlation. The angular diameters of the comparison between (1) and (6I) were obtained taking into account the limb-darkening effect; all the spectral types are earlier than F8. The two methods are in good agreement, however. This test is not significant as, like the (1)-(6H) comparison, (1) and (6I) are not independent.

From these comparisons, the following general conclusions may be drawn: a) Michelson interferometry fails when applied to supergiant stars of late spectral type, b) for the spectral range (B0-F8) considered, the intensity interferometer shows its validity whatever the luminosity class is, c) it is not yet possible to obtain correlations for other direct methods as common stars are not available, d) the indirect methods are reliable in the most regions of the HR diagram, however they should be applied with great caution to the supergiants, especially of late spectral type; in particular, the reliability of the 6G method might be poor when applied to variable stars.

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