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OBSERVATIONS OF *HIPPARCOS* DOUBLE STARS WITH THE WIYN[1] TELESCOPE

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RESUMEN

Se ha iniciado un programa de observaciones de seguimiento para las binarias del *HIPPARCOS* usando el telescopio WIYN de 3.5m en Kitt Peak, Arizona. Las observaciones se realizan mediante RYTSI, la cámara de motas recientemente terminada, que es capaz de determinar diferencias de magnitudes confiables a varias longitudes de ondas, y hasta el límite de difracción del telescopio. Así, además de astrometría relativa de precisión, pueden obtenerse magnitudes y colores de las componentes. Se describen los resultados preliminares y la capacidad del equipo. Las ventajas de un programa de observación para las binarias del *HIPPARCOS* incluyen aumentar el número de puntos en la relación masa-luminosidad (una vez que se conozcan los parámetros orbitales de los pares ligados), obtener pruebas confiables para los cálculos de evolución estelar cuando una de las componentes está fuera de la secuencia principal, así como tener una idea más completa de la población de binarias de campo cercanas.

ABSTRACT

A program of follow-up observations of *HIPPARCOS* Double Stars has been started using the WIYN 3.5-m Telescope at Kitt Peak, Arizona. Observations are made with the recently-completed RYTSI speckle camera, which is capable of determining reliable magnitude differences at various wavelengths down to the diffraction limit of the telescope. Thus in addition to precise relative astrometry, component magnitudes and colors can be obtained in a survey mode for all systems observed. Preliminary results and system capabilities are described. The benefits of a sustained program of observations of the *HIPPARCOS* Double Stars include populating the mass-luminosity relation with many more points (once the orbital status of these stars is known and orbital parameters are determined in sufficient detail for gravitationally bound pairs), robust tests of stellar evolution calculations in cases where at least one component has evolved off the main sequence, and a more complete picture of the nearby field binary population.

Key Words: **ASTROMETRY — BINARIES: VISUAL — TECHNIQUES: INTERFEROMETRIC**

1. SPECKLE DIFFERENTIAL PHOTOMETRY AND ITS IMPLICATIONS

The Rochester-Yale Tip-tilt Speckle Imager (RYTSI) is a new speckle camera designed to be used with large-format astronomy CCDs. RYTSI has two galvanometer scanning mirrors which can direct the image to any position on a large CCD chip. By executing a rapid serpentine step-and-expose pattern across the entire active area, a grid of speckle images can be recorded. Then, all images can be read out together, increasing the efficiency. The system is fully described in Meyer et al. (in preparation). One of the main advantages of RYTSI is that CCDs are linear, so that deriving reliable photometry from the speckle data becomes easier than with photon-counting cameras or intensified-CCDs, which are susceptible to detector non-linearities.

Pre-RYTSI CCD-based speckle imaging at WIYN indicates that the photometric precision of the CCD method at WIYN is approximately 0.13 magnitudes or better under normal conditions. Figure 1 shows the standard deviation of the magnitude difference obtained in multiple two-minute observations of the same target. The objects span a wide range in magnitude difference, from near 0 to approximately 3.5. We expect RYTSI data to be comparable. Better results appear to be obtainable when averaging multiple observations. That is, internal consistency of ~ 0.06 magnitudes for an 8-minute (or four two-minute) observation(s) appears possible, as

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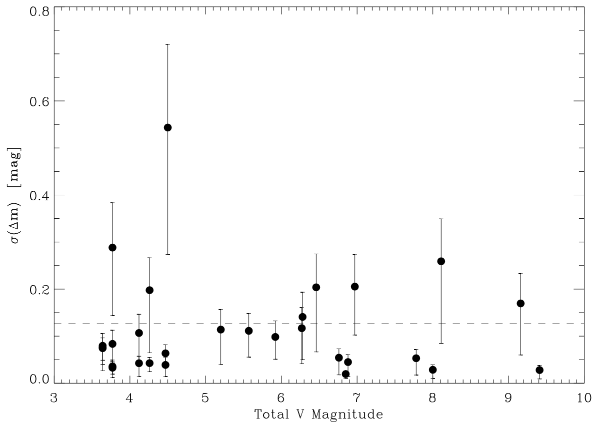

Fig. 1. Standard deviation of the magnitude difference obtained via CCD speckle observations for those objects observed at WIYN on three or more separate occasions. The dashed line shows the average value of the ordinate for all data points plotted, 0.126 magnitudes.

expected from $\sqrt{N}$ statistics.

As discussed in Horch, Ninkov & Franz (2001), a systematic error in speckle-based photometry is obtained if the speckle patterns of the primary and secondary stars are not identical. This occurs when the secondary star falls outside the isoplanatic angle of the primary star. An indication of the degree of isoplanicity is given by a parameter those authors called q, which equals the seeing of the observation times the system separation. The q-values for WIYN data are currently being studied. By observing binary stars listed in the *HIPPARCOS* Catalogue and comparing the speckle magnitude differences obtained with those listed in the Catalogue, it is possible to determine the maximum q-value such that *HIPPARCOS* results and the WIYN results on average agree. It appears that, under typical seeing conditions at WIYN, most binaries of interest to our program have q-values small enough so that the systematic error is not significant.

2. *HIPPARCOS* DOUBLE STARS

In Figure 2, the double stars discovered by *HIPPARCOS* that are within 250 pc of the Sun are shown. These of course have distances already determined by the satellite, and total magnitudes and magnitude differences that place them in a perfect range for follow-up observations using speckle imaging at ground-based telescopes. Many of these systems could well have orbital periods that are short enough for high-quality masses to be determined in the coming years. Some such systems have already been identified in Horch et al. (2002).

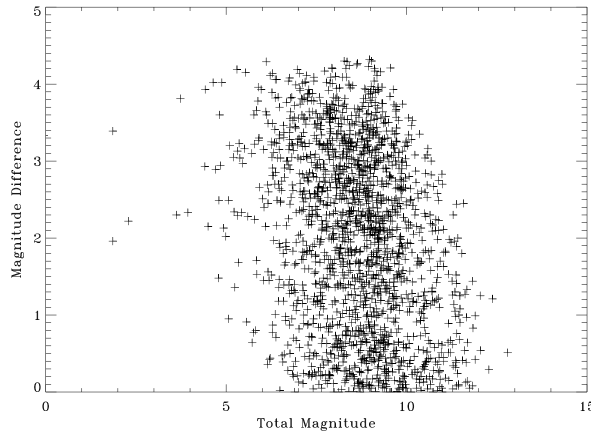

Fig. 2. Magnitude difference plotted as a function of total (system) magnitude for the binary stars discovered by *HIPPARCOS* within 250 parsecs of the Sun.

As soon as orbital information becomes available for these stars, more objects could be added to the current mass-luminosity relation, which is in need of improvement especially in the range of 1.0 to 0.2 solar masses (Henry et al. 1999). With RYTSI, well-determined luminosities and colors of the *components* can also be made available. This permits direct comparision with isochrones such as those of Yi et al. (2001), assuming the stars are coeval. If radial velocity and metallicity measurements are made in addition to RYTSI observations, it may be possible in many cases to over-constrain the standard astrophysical parameters and learn about, *e.g.*, helium abundance in these stars.

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