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A BINARY OBSERVING PROJECT ON THE NCUO SPECKLE INTERFEROMETER

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ABSTRACT

Speckle Interferometer equipped with an ITT intensified CCD have been used on the NCUO (National Central University Observatory, Taiwan) 24-inch telescope for studying the orbits of bright binary systems selected from the Yale's Bright Star Catalogue. The high resolution and high sensitivity ITT intensified solid state video camera (F4577) has external gain and gate control functions which will simplify the design of the speckle camera and allow us to do precise speckle photometry. The goal of this project is trying to study the bright binary systems with separations between the average size of seeing disk and the diffraction limit of the 24-inch telescope. Recently some observing data have been reduced and compared with the other teams' results. We are now improving the data reduction technology and trying to use real time observing mode on the monthly routine observation.

Key Words : Speckle Interferometer, Binary, Seeing disk

I. INTRODUCTION

Since the speckle interferometry technique has been studied for about two decades and been improved following by the new solid state detector and computer facility, we have adopted an ITT F4577 intensified CCD video acme to design a speckle interferometer on the NCUO 24-inch telescope for our binary orbit observing project. The NCUO 24-inch telescope with a focal ratio f/13.5, made by Perkin Elmer in 1980, is located on the university campus about 40 kilometer southwest from Taipei city. Under the poor condition of near city , we choose this technique at NCUO to avoid the light pollution problem to study bright binaries' orbits. For binaries with angular separation in the range of 0.03 to 0.3 arc seconds, speckle interferometry currently provides the best method for measuring their orbital motions (McAlister 1990). Such measurements lead to the determination of stellar masses, quantities that are relatively rarely known and yet play a vital role in our theoretical understanding of the origin and evolution of stars. There are thousands of binary systems suited to the speckle interferometry technique. The two stars comprising a binary system are bound in orbit around a common center of mass by their mutual gravity and may be so close together or the system may be so far from the Sun that the angular separation of the components is smaller than the seeing disk or even smaller than the Airy disk. The intrinsic limiting ability of a telescope to resolve fine angular detail is set by the diffraction properties of light. For a telescope such as the 4-m aperture Mayall reflector on Kitt Peak in southern Arizona observing at wavelength 550 nm, the center of the visible region of the spectrum, the Rayleight limit is approximately 0.035 arc seconds. Unfortunately, the atmospheric turbulence degrades this resolution and imposes an effective seeing limiting resolution from 1 to 2 arcseconds. As the speckle interferometry technique has been adopted so many years, most of the measurements are made on large telescopes (two meters or larger). Their are two main reasons why astronomers are used to apply large telescope for speckle interferometry : 1). as large as the aperture is , more speckles can be collected; also fainter and closer binary systems can be observed. 2). as large as the telescope is, the telescope time becomes more expensive so that astronomers use large telescope on fainter and closer binary systems only. Therefore many bright binary systems with a little larger separations are eliminated by some speckle observing projects. We have started to use the homemade speckle camera mounted on our 24-inch telescope (Rayleight limit 0.23 arc seconds) to survey those bright binary systems from the Yale's Bright Star Catalogue. Similar works have been studied such as at the U.S. Naval Observatory (Worley 1996).

II. INSTRUMENT CALIBRATION

The NCUO speckle interferometer, adopting the ITT/F4577 Intensified CCD Camera and Stromgren system filters, has a set of 5 magnification power microscope objective lens for different resolution requirement. The detector is a 488 V x 754 H pixel frame transfer CCD which has 6.6 mm V x 8.7 mm H image format size; thus the corresponding single pixel size is 27 x 11.5 microns square. From the preliminary testing experience, we found that with a plate scale of about 1/10 the telescope diffraction limit should be suitable for small aperture telescope work on speckle binary observation. According to the diffraction limit of 24-inch telescope on the Stromgren y band filter, we choose 1x, 4x, 6.3x, 10x and 16x magnification powers to offer different plate scale range from 0.4 to 0.025 "/pixel on horizontal side and 0.32 to 0.02 "/pixel vertical side. From our experience, the higher resolution mode of this

speckle camera will be able to resolve those closeing binary systems with separations similar to the 24-inch telescope's Daylight limit. Preliminary study on some well known binary systems with separations between 0.25 to 3.0 arc seconds have been conducted during past year. Well calibrated plate scales and detector orientation for different magnification using double slit mask mounted on the front of telescope have been done during each observation. Now we are able to use this system routinely to survey the new binary systems according to the Yale's Bright Star Catalogue.

III. OBSERVATION AND ANALYSIS

In our testing, there are 44 binary systems which were observed monthly with total 127 measurements during August, 1995 through January, 1996. Speckle image frames are recorded on SONY Hi8 video tapes during observation. Later these tapes are digitized and reduced by using both the FFT and DVA (Directed-Vector-Autocorrelation) Algorithms developed by Bagnuolo et al. (1990). An IBM-compatible 486 DX/66 clone equipped with an Imaging Technology's eight bit video rate frame grabber (PCVisionplus-AT) is adopted to digitize the speckle frames and reduce data with the DVA algorithm on line. According to Bagnuolo's DVA, it can offer correct quadrant determination which is ambiguous in the old vector- autocorrelation (VA) algorithm. In this DVA algorithm, the digital intensities as well as the (x, y) locations of all the pixels in a frame above a threshold (or the brightest n pixels) are saved. Suppose two pixels have intensities I1 and I2 and locations (x1, y1) and (x2, y2), respectively. The 2-d histogram of the separation is incremented in location (x2 - x1, y2 - y1) if I1 is greater or equal to I2 and in location (x1 - x2, y1 - y2) if I1 is smaller or equal to I2. That is, a direction is given to the separation, in the sense of from brighter to dimmer pixel, hence the name of the algorithm.

IV. SUMMARY

In our preliminary results, eight binary systems, ADS 1598, 6175, 11479 , 11635, 14296, 14787 and 15971 have been compared with previous data adopted from the WDS catalogue (Worley and Heintz. 1992) and the CHARA speckle data (Hartkopf et al. 1995) . The accuracy of our results show good agreement with the CHARA results. Specifically, ADS 15971 is a well known triple system (angular separation 1.9") while one of the companion is invisible. From our results of three measurements with 0.03" angular resolution accuracy combined with the CHARA's results, we conclude that the NCUO speckle interferometer is accurate enough to study such kind of wide separated multiple system with unseen companion. In the coming future we are planning to adopt high speed Pentinum 586/133 MHz clone with large RAM disk to do real-time on line analysis without recording speckle image frames to video tapes. This will avoid the video tape noise when digitizing image from tape and increase the accuracy of our measurements.

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