

DISCUSSION: SECTION III

Shcheglov (to Dudinov et al.): What is the speckle time here at the 6m telescope and how does it change with weather conditions?

Tsvetkova: The exposure time range is 0.003–0.03s. It certainly varies according to image quality and the object brightness in this range. However, we have not made a special study of the dependence between image quality and exposure time.

Beckers: In the speckle image taken at the 6m telescope which you showed, there were not many speckles. Since the speckle size is only 15 milliseconds of arc, that means that the telescope image quality was very good. Is that correct and how good was it?

Tsvetkova: The image quality was extremely good on that particular night, approximately 1 arcsec. The effective wavelength for the measurements was $\approx 650\text{nm}$.

Shcheglov: What is the phase difference across the telescope aperture during your observations with small telescopes at low altitudes and at mountain sites?

Tsvetkova: For low altitudes the phase difference was of the order of one wavelength, and less than this for higher altitudes.

Angel: The prediction from random turbulence theory is that phase errors should increase as the 5/6 power of separation. Can you tell from your data over 6m if this is so, or is the outer scale of turbulence less than 6m.

Tsvetkova: From our data the Nyquist interval of the function describing optical path difference can be estimated but not the outer scale of turbulence. In turbulence theory the Nyquist interval is absent.

Brown: I think the answer to Dr. Angel's question could be obtained more easily from Dr. Roddier's data than from speckle data.

Beckers: What determines the accuracy of your double star separation measurements? Is it determined by photoelectron noise or by calibration accuracy?

Tsvetkova: Mainly by the scale calibration accuracy.

Brown (to Roddier, F.): What were the exposure times of your interferograms and how does the photometric efficiency of your method compare with speckle interferometry?

Roddier: The exposure time was 1/60th of a second. Compared to speckle interferometry, rotation shear interferometry is a little less efficient

because of absorption by the optics. We believe that for very faint objects the speckle method is certainly better but we think that for bright objects rotation interferometry is superior because of the absence of speckle noise. For example, a double star can be measured with a single exposure whereas the speckle method implies averaging of several hundreds of exposures.

Wlérick: Si vous observez visuellement, combien faut il de temps pour mesurer une étoile double?

Roddier: De l'ordre d'une minute. C'est, je crois, le gros avantage des mesures visuelles. Il est possible de mesurer un très grand nombre d'étoiles par nuit.

Maillard: During the first day of this meeting there was much discussion about ways of estimating atmospheric seeing, which are often only visual estimates. As a by-product of the fringe patterns of the pupil of the CFH telescope a quantitative estimate of the effect of turbulence can be deduced. The fringes were continuous across the pupil and the distortion introduced by turbulence was about one wavelength.

Roddier: Yes, most of the time we had good images. For good sequences the typical fringe distortion was about 1λ over a 1m baseline which means a seeing disc of the order of 0.5 arcsecond.

Richardson (to Maillard): The CFHT coudé was designed to operate with high efficiency in the infrared as well as at UV and visible wavelengths. The coudé focal ratio is f/170 without refractive materials which would absorb in the IR. The "red" mirrors in the optical train have very high reflectance in the infrared and the mountings of these flat mirrors are built to facilitate their cleaning or replacement by mirrors with other coatings such as gold. The lens turret has an empty position to permit lens-less operation or inclusion of an IR transmitting window or weak lens. Are you using the system in the IR in a configuration intended for the visible - near IR region?

Maillard: No, I had to change the configuration by renewing the field lens, using the empty position of the turret to move the intermediate focus and I had to add fore-optics to provide a f/35 beam. This costs a total of 7 mirrors (after the telescope) including the coudé train and after that the maximum unvignetted field was 30 arcsec which is not enough to conjugate the two entrances of the interferometer.

Michel'son (to Boulesteix): What was the focal reducer used at the 6m telescope?

Boulesteix: The system is very simple. After the field lens there is a collimator, a filter, and the objective which forms the image on the photocathode of the detector.

Beckers (to Dravins): Does the transport of the photons in fibers affect

their temporal statistics because of the dispersion of transport times?

Dravins: Presumably not for an instrument resolution worse than 10ms. The temporal dispersion of a light pulse in a moderately long fiber is no more than ≈ 1 ms (30cm path length).

Beckers: Can you use non-linear optical crystals to do two (or more) photon experiments in astronomy?

Dravins: In principle yes, but in practice probably not. The efficiencies of such crystals are steeply dependent on intensity and will be very low for faint (astronomical) light levels.

Tokovinin: We have considered the idea of quantum optics experiments and definitely abandoned it because there are virtually no suitable astronomical sources. If the star is unresolved by the telescope aperture there is a temporal degeneration which reduces the magnitude of quantum effects. If the object is resolved the spatial degeneration adds up which also reduces the effect greatly.

Dravins: For a resolved source the S/N ratio is independent of telescope aperture and spectral resolution; it is defined only by the properties of the source such as brightness temperature. Remember that Hanbury Brown has reached 2.5^m and we believe that we can do a little better. If the source is unresolved the S/N increases as the square of the aperture diameter. The exact magnitude of the quantum effects cannot be estimated with certainty because theory does not yet allow us to do it.

Tokovinin: I agree.

Shvartsman: One of the early publications which pointed out the possibility of laser effects in stars (Be stars) was that by N.N. Lavorinovich and V.S. Letokhov (1974, Zh. Eksp. & Teor. Fiz. 67, pp. 1609-1620). A programme of our MANIA experiment is to search for coherent emission (narrow laser lines) in the radiation of solar-type stars, Be stars, X-ray sources etc., (see V.F. Shvartsman 1977, Soobshch. SAO USSR Acad. Sciences, 19, pp. 5-38). Dr. Dravins mentioned the Crab pulsar as a possible source of coherent emission. According to our observations with the 6m telescope and the MANIA equipment, no photon correlation exists in the optical radiation from the Crab pulsar at time-scales of $3 \cdot 10^{-7}$ s.

Tokovinin: I wish to speak a little about some problems of astronomical high-resolution interferometry. For the past ten years there has been tremendous progress in the development of new methods and instruments. Now the time has come to use these methods for good quantitative measurements. The diameters of bright giants can be measured theoretically to 1%, but up to date an internal precision of 10% is still considered good and discrepancies between various authors are much larger. Even the question of periodic diameter changes of α Ori is still open due to the

lack of systematic work. Only one systematic program of binary star measurements has been performed recently and that was by McAlister. He alone was clearly able to observe only a small fraction of the double stars that require high-resolution observations. Also, I feel there is a lack of good astronomical programs for speckle interferometry. There are many new tasks yet to be done and fortunately some have already been proposed at this colloquium. We in Moscow have built a very simple interferometer for double star measurements. Its main feature is a phase grating which modulates the image. The light is detected by a photomultiplier and the information on fringe visibility is extracted from its signal. The interferometer has been used with 60cm and 1m telescopes and about 150 binary systems have been measured so far. Recently three new binaries were discovered with this device.