THE AMAS - THE ASTROMETRIC MULTIPLEXING AREA SCANNER

A New Technique for Measuring Stellar Positions and Magnitudes

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Since the introduction of the photographic plate into astronomy over a century ago great improvements have been made in the accuracy of the results from measurements of the plates. With our developing technological and scientific skills came advances in manufacturing, exposing, and measuring photographic plates. However, it now seems that the rate of improvement has slowed and that future developments (barring presently unforseen breakthroughs) will only marginally improve the accuracy of results from photographic plates.

What does the photographic plate really do? In the context considered here, it records the relative positions and magnitudes of the stars in the observed field in a single observation. Let us consider briefly other ways of obtaining this information. Magnitudes can be measured more accurately with the use of the photoelectric photometer, but no positional data are obtained and only one object can be measured in a single observation. Over the past decade a number of techniques have been proposed to give accurate positions as well as photoelectric quality magnitudes. Most of these ideas involve some sort of narrow slit scanning system. While some of these scanner systems have performed well they are somewhat limited in their capabilities in that several observations are generally required to obtain positional information, and that only two stars at a time can be observed, as in a binary system.

At the University of Virginia we are developing an instrument which measures positions and magnitudes of many stars in a single observation. Figure 1 is a schematic concept of the instrument (Villamediana and Frederick 1971) in which a continually rotating Ronchi grating (a series of equally spaced, parallel, opaque lines ruled on a glass plate so that the dark line width is equal to the transparent space between consecutive lines) provides modulation of the light from the stars in the field. The form of the modulation is dependent on the positions of the stars in the field and the amplitude of the signal is related to the stellar magnitudes, so mathematical analysis of the modulated signal allows the reconstruction and measurement of the stars in the field.

A prototype instrument has been built to test the concept. It is the Astrometric Multiplexing Area Scanner or AMAS. Figure 2 shows a schematic diagram of the prototype AMAS. Briefly, the AMAS modulates the intensity of incoming light (from the telescope), which is focused on a Ronchi grating. The grating rotates continuously in the focal plane of the telescope, but its center of rotation is outside of the field of view. The modulated light from the objects being observed passes through a filter and is focused onto a photomultiplier tube, from which the amplified signal is sent to a multichannel analyzer. The multichannel analyzer counts the pulses from the photomultiplier tube and sequentially stores this information in its memory at the rate of several channels per degree of rotation of the grating. After the grating has rotated 360° a trigger pulse reinitializes the multichannel analyzer to ensure the synchronization of the position of the grating and the memory channels of the analyzer. The integrated, digitized signal from the analyzer is read out onto paper tape. This signal is then analyzed to reconstruct the original field of the telescope from which the relative positions and magnitudes of the stars can be determined.

Observations of a variety of double and multiple stellar systems have been made with this prototype AMAS. Figure 3 shows the modulated signals from binary stars of 4", 10", 29", and 46" separation, respectively. These examples illustrate the different forms of the modulated signal as stellar separation changes. (The signals from multiple systems are more complex and it is difficult to see positional effects on casual inspection.) Figure 4 is a contour map constructed from the data given in Figure 3d. From this contour map stellar positions and magnitudes are estimated. A final data reduction procedure produces exact values from these estimates. In Figure 4 the crosses indicate the actual positions of the two stars from the final reduction analysis.

The applications of the AMAS technique are varied. In theory 50 or more stars in a field can be observed at one time and accurate positions and magnitudes recovered. In practice we have observed fields with only a few stars using the prototype AMAS. It is difficult to estimate at this early stage what the capability of a refined instrument will be. One of the main advantages of the AMAS is its ability to provide magnitudes of photoelectric accuracy for stars which are too close for conventional techniques. Variables and other interesting objects in close systems can be observed. We have observed three systems which include variables with the AMAS in a general feasibility study, but we have not followed any of these variables through its period. There are other applications to particular astronomical problems which will not be discussed here.

We have used the present prototype AMAS to carry out an observing program designed to test its feasibility and capabilities. Due to mechanical difficulties with the telescope we were unable to guide on the objects being observed. Therefore we were unable to correct for short time scale image displacements, and even though the telescope drive rate was quite accurate some positional uncertainty was evident. Without going into detail, however, we consider the results obtained to be satisfactory considering the above-mentioned limitations. With a modified AMAS, or a completely redesigned version, we expect positional accuracy at least as good as present photographic plate measurements provide. In addition we should be able to measure stars with separations too small for the photographic plate to resolve (due to the blending together of the stellar images). The magnitudes for these stars should be of photoelectirc accuracy.

The final application of the AMAS is in space. The photographic plate is of limited value in space due to the storage and service requirements and the need of material return to measure the results. The AMAS does not suffer from these limitations since telemetry can be used to recover data from the memory of a multichannel analyzer. In space we will be diffraction-limited rather than seeing-limited when we consider objects to be observed, so the AMAS used with a large space telescope has the potential of providing information of great astrophysical interest for objects we cannot resolve from earth.

REFERENCES

Villamediana, J. F. and Frederick, L. W. 1971, "Automation in Optical Astrophysics", I.A.U. Colloq. No. 11, p. 95.

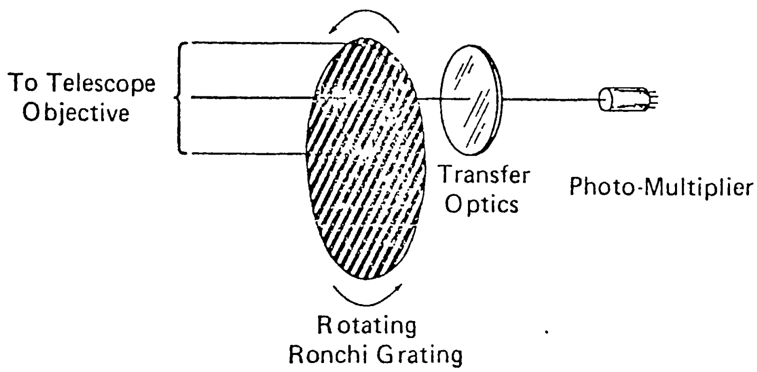

Figure 1. Schematic Concept of Device.

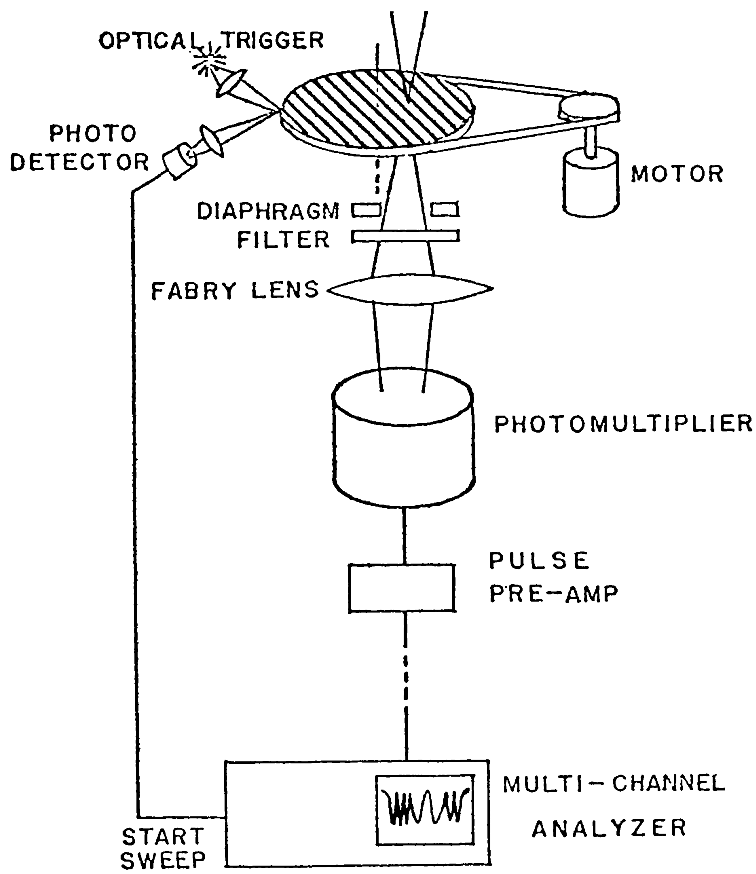

Figure 2. Schematic Diagram of Prototype AMAS.

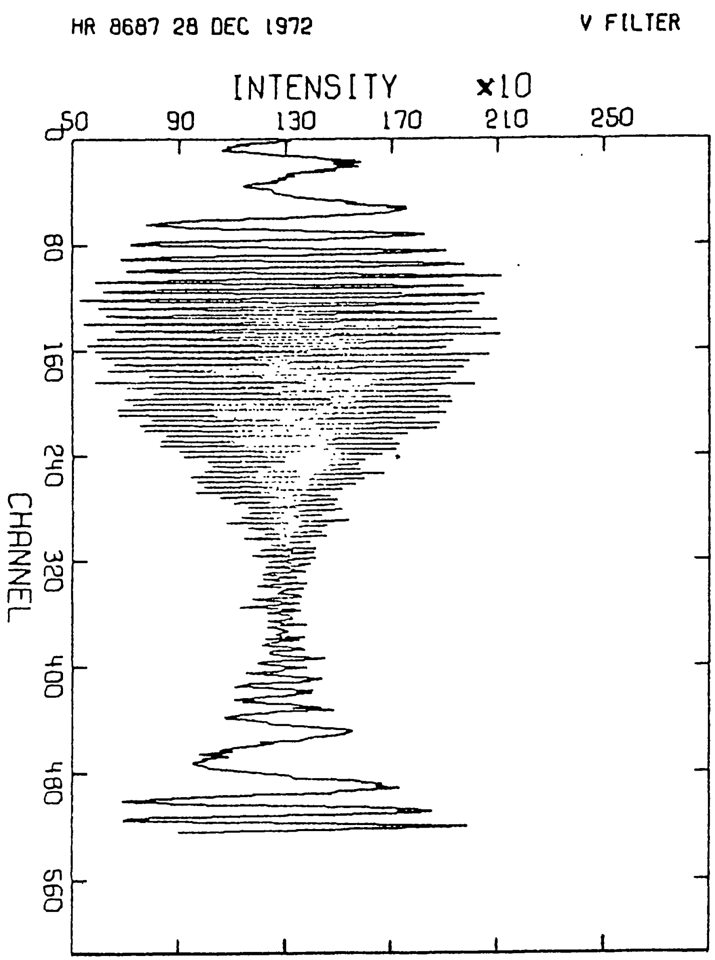

Figure 3a. HR 8687 4" separation.

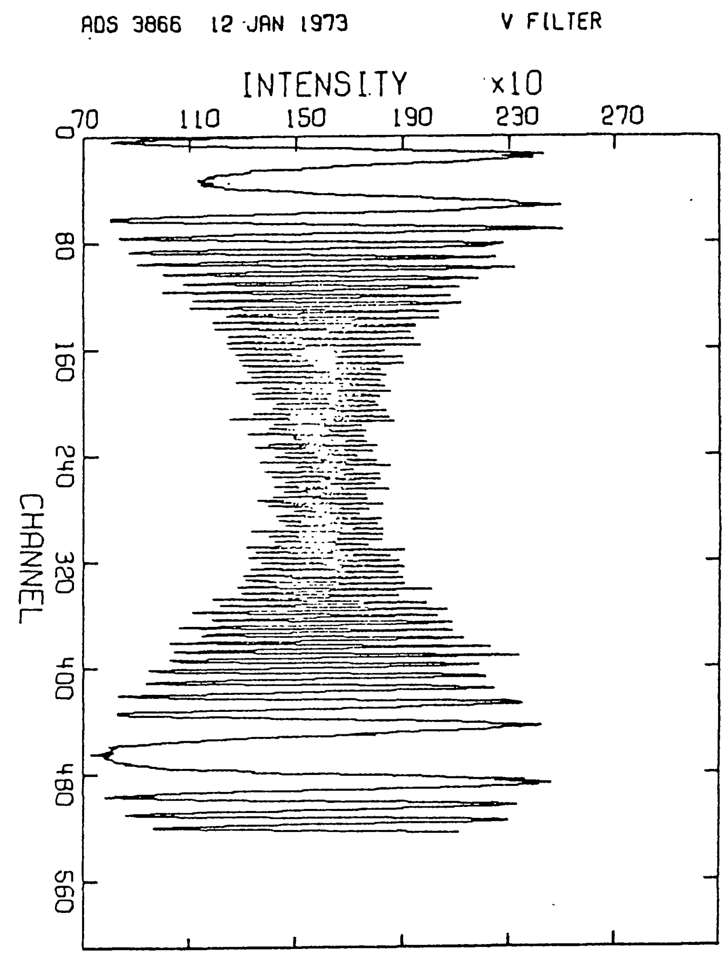

Figure 3b. ADS 3866 10" separation.

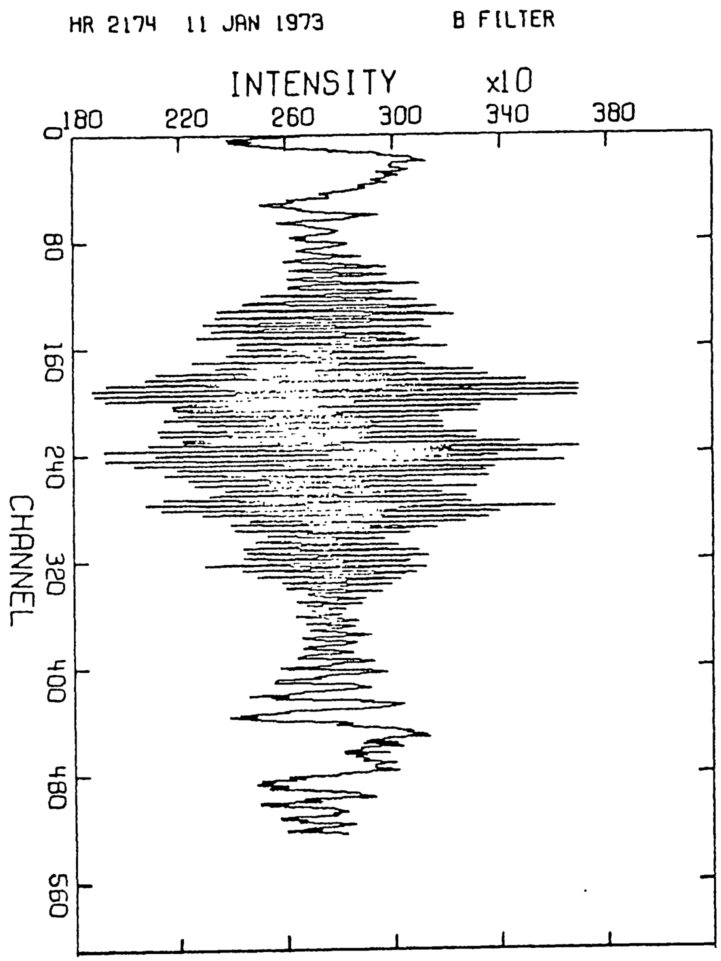

Figure 3c. HR 2174 29" separation.

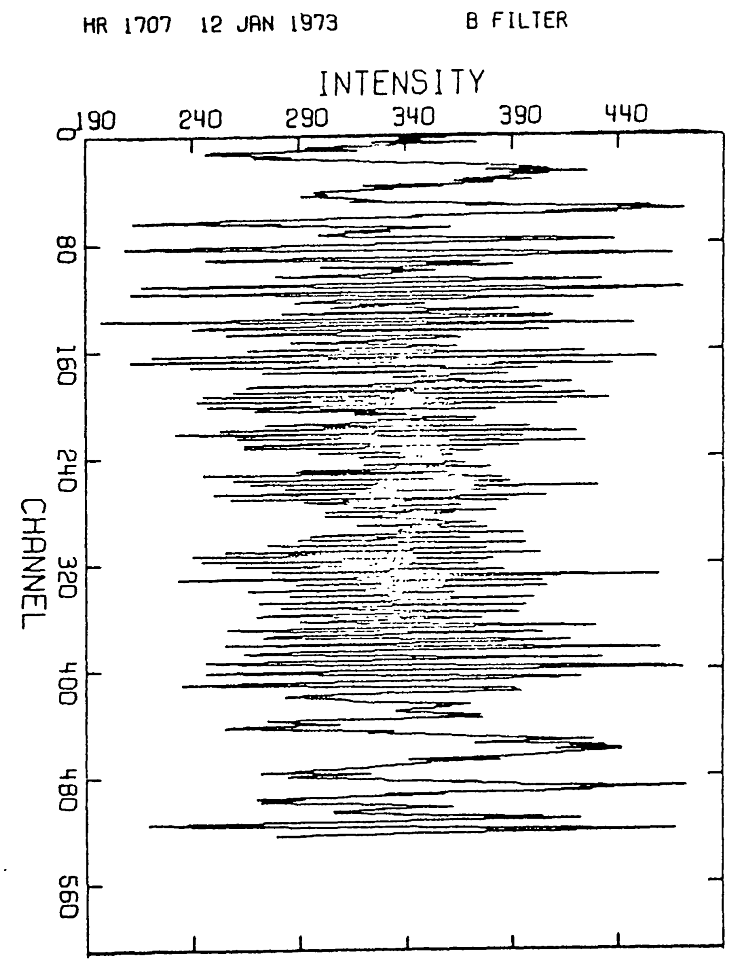

Figure 3d. HR 1707 46" separation.

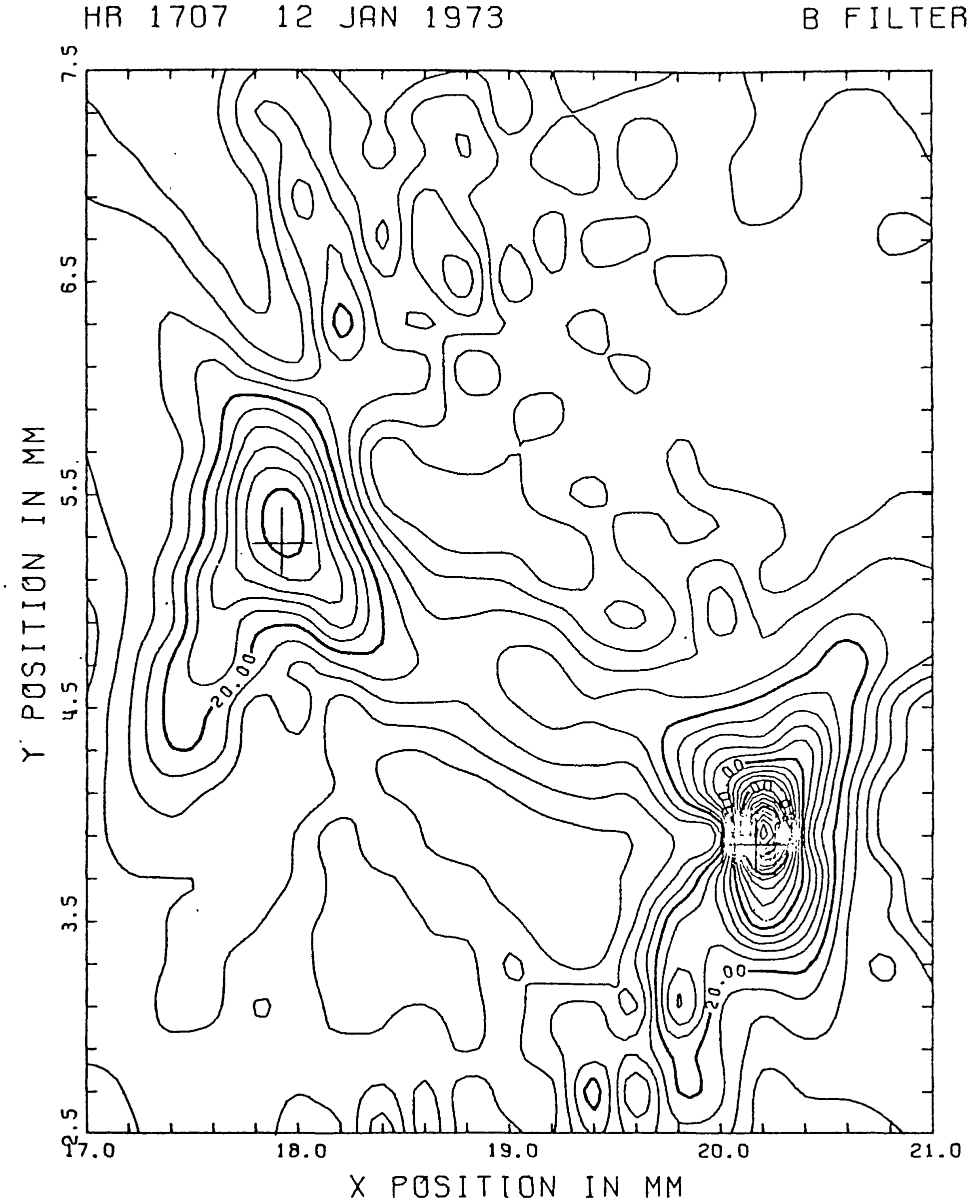

Figure 4. Contour Map of HR 1707 and its 46" secondary.