FAGS - A FAST ASTRONOMICAL GRATING SPECTROMETER

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ABSTRACT. A fast astronomical spectrometer is described using commercially available photographic lenses and a CCD detector. The size and weight of the instrument have been kept to a minimum to allow it to be used on telescopes as small as 0.6m.

1. INTRODUCTION

Despite the wide range of photometric facilities in the Australasian region for studying stellar objects of magnitudes less than about V = 14 using small ($\sim$1m) telescopes there are essentially no spectrometers available for carrying out low or intermediate spectral resolution studies of the same objects using the same telescopes. Only the AAT and the MSSSO 74" have versatile spectrometers which can provide resolutions appropriate for spectral classification. Apart from the obvious problems of oversubscription on these telescopes many of the objects in this brightness range would be embarrassingly bright for these spectrometers. At the other extreme, the MSSSO echelle system has a faint object limit of $V \cong 8$ on the 1m telescope at Siding Spring. In consequence objects in the range $8 < V < 14$ are inadequately provided for in spectral studies.

This is unfortunate, since in many fields observations of stars in this brightness range can provide valuable data for an understanding of the phenomena involved. From our own interests we can cite the need for spectral observations in studies of T- and R- association regions, but equally, the need exists in studies of variable stars, HII regions, emission line stars and so on.

2. DESIGN CONSIDERATIONS

To optimise its usefulness, the instrument was designed to be within the engineering and size limitations of a 0.6m telescope. This meant restricting both the mass and the maximum dimensions. Observationally we attempted to gain maximum spectral resolution while reaching limiting

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magnitude stars in reasonable exposures of the order of 1000 secs.

The need for maximum possible speed dictated the use of a CCD array detector. The resulting optics, restricted by the field scales and focal ratios of 0.6 and 1.0m telescopes, and the need to match the stellar image and CCD pixel sizes were best satisfied by the use of high quality photographic lenses.

To obtain spectra adequate for classification purposes and at the same time have available sufficient resolution to observe the line profiles of objects such as Be stars, a dispersion of 4Å/pixel was set as a target. Using a Thomson -CSF 7802 linear array, with 1024 13 μm pixels implies a dispersion of approximately 300 Å/mm and an available spectral range of 4000Å. With a short wavelength CCD cut-off of slightly less than 4000Å two centre wavelengths can be used to cover the range to the long wavelength cut-off at 1.05 μm. A Jobyn Yvon 300g/mm grating provide this dispersion in conjunction with a Nikon graphic arts 485 mm F/9 collimator lens and a Canon 85 mm F/1.2 camera lens.

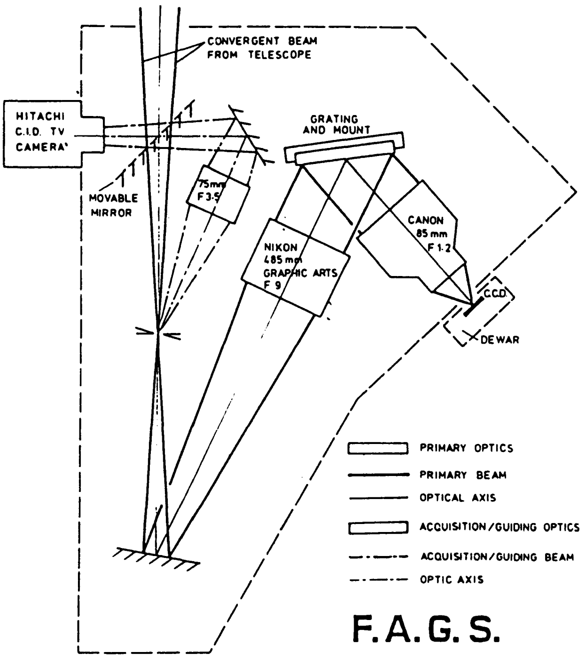

Figure 1. Ray Diagram of the Spectrometer

The final optical assembly is shown in Fig. 1. The maximum dimension (length) is only 68cm, the remaining dimensions lie within a circle of radius 30cm and hence within the lateral dimensions of a 0.6m telescope tube. Object acquisition is achieved using a solid state C.I.D. T.V. camera and diagonal mirror, while guiding is carried out by off-axis refocussing onto the stellar image on the front of the slits.

The data collection system uses dedicated peripheral hardware with its own memory and bus system. It is organised as a 24-bit, 1K (1024) memory block with its own parallel arithmetic processor. The memory block is arranged however, such that it can be accessed from the host microcomputer in single 8 bit words; this shared access to the memory is totally transparent for the computer and the data collection system. The system can be controlled with simple software, to add or subtract the data stream and to control the spectrometer choppers and shutters. All aspects of control and process monitoring are achieved via conventional I/O ports in the computer's address space.

The final cost, including the VVD and its signal processing hardware, but excluding the Apple computer and C.I.D. T.V. camera was approximately $3000.

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