PROPOSED SEARCH FOR FAST VARIABLES

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We propose the examination of trailed photographs as a medium of search for fast variable stars. Diurnal rotation and seeing permit access to the period range from 0.1^s to 10^s for a resolution of 1″, exposures of one minute and a plate field of 30′, while slower or faster periods can be studied by mechanically trailing at the appropriate rate. This permits examination of a wide period band over a field of perhaps 0.1 square degree in a minute's time, while photoelectric devices now available permit only star by star examination. Thus we can contemplate examination of an appreciable fraction of the sky with moderate telescope time required.

Fourier transform processing promises an efficient technique for analogue image processing. As a demonstration, we have prepared an artificial field consisting of uniform trails of some minute's duration (non-variable) upon which we superimposed some twenty exposures of three seconds duration each displaced identically in the diurnal direction by some 12″ (variables). If this plate replaces the transmission grating of a spectrograph, monochromatic illumination of the entrance aperture will produce in the image plane the Fourier transform of the plate (Fourier Image); each set of twenty exposures acts as a narrow grating and produces a grating spectrum, all superimposed, as the image is independent of vertical and horizontal translations of the grating. Dominant in this image is the transform (diffraction pattern) of the plate grain and the aperture. A subsequent Fourier transform, produces an image of the plate (grating) we call the Processed Image which may be modified by inserting spatial filters in the Fourier Image plane to enhance the visibility of the variable stars with respect to the non-variable stars, grains, etc. Essentially, if the spatial filter is the transform of the 'target' signal, then the Processed Image is the cross-correlation of the original image with the target signal; non-cross-correlated signals are strongly suppressed. In particular, a ten slot spatial filter, with period P, matched to our plate, width of slots $P/10$, completely suppressed non-variable images (bars) while the twenty exposure sequences are plainly visible. The random cross-correlations with the background noise provides the limit of detectability for faint strongly modulated variable stars. When the target period is mismatched by 10% both the bars and the variables disappear.

In practice, 11th magnitude stars have been easily detected on our artificial fields prepared on Eastman Kodak 103F emulsion at the 60 cm Cassegrain of the C. E. K. Mees Observatory. We anticipate reaching the same magnitude on trailed exposures in the presence of fog, and perhaps 15th magnitude if the fog background could be reduced by a happier choice of emulsion and processing techniques. This technique is unique in allowing full use of the high detection quantum efficiency of photographic emulsions at low exposure levels.

Ledoux et al. (eds.), Stellar Instability and Evolution, 129–130.

We have been unable to completely analyze the anticipated signal to noise properties of the system in the presence of non-linear photographic effects. Clearly, as in ordinary image recognition we seek to recognize a variation of the plate grain density with respect to the background. Unlike a direct photograph, our image, while containing the same number of grains, is distributed over the length of the trail; the noise background is increased relative to a direct photograph by $(Bs/d)^{1/2}$ where B is the ratio of mean grain densities, s is the trail length and d, the width. For large amplitudes, $B \sim 1$ while for an equatorial one minute exposure, s is 900″ while $d \sim 1''$, hence the noise is some 30 times larger than on guided images for the same exposure time. This implies a loss of 7.0 magnitudes as compared to direct exposure and is the basis for the estimate above. The actual number of grains dominates the noise for fog-free case, and we have assumed above that the number of grains is one-tenth the number of photoelectrons counted with modern equipment for a 15th magnitude star.

The concepts introduced here arose from suggestions by Charman (1968) on the usefulness of the first Fourier transform in searching for variables. Photoelectric searches using tuned recorders by Duthie *et al.* (1968) and fast tape recording by Horowitz *et al.* (1971) could only search a small area (pin-hole) at a time, while the photographic techniques pioneered by Wampler and Miller (1969) and applied by Chiu *et al.* (1971), while more sensitive than ours and panoramic, require sufficient period information to ensure phase coherency over the entire set of exposures. The study of trailed star images with the use of image processing permits efficient search for fast variable stars over large portions of the sky. Although the sensitivity of the search is less than that for direct photography, the opportunity to examine many images efficiently promises a statistical base for discussions of the numbers and duration of fast stellar variability.

References

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