Stellar Scintillation

and its Use in

Atmospheric Measurements

by

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A thesis presented for the degree of

Doctor of Philosophy

in the department of

Physics and Mathematical Physics

at the

University of Adelaide

in January 1991

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Abstract

Starlight propagating down through the atmosphere acquires phase variations as it traverses turbulent regions containing fluctuations in refractive index. With further propagation these phase variations produce intensity fluctuations. The turbulence and the associated intensity fluctuations move with the wind, producing the familiar twinkling of the stars. This "stellar scintillation" is a subject of current research due to its application in the remote measurement of atmospheric parameters and in the study of the atmospheric propagation of laser beams.

The work reported in this thesis includes measurements of the characteristics of the stellar scintillation pattern and the development and testing of techniques to use stellar scintillation to measure atmospheric wind profiles and the atmospheric isoplanatic angle. These measurements required the development of analysis techniques for correction for photomultiplier afterpulsing and for correlation between multiple time series.

Observations of scintillation were made with two detectors whose small size and small minimum spacing allowed characteristics of the pattern to be measured at smaller scales than previously reported. Further, two recording modes (time series and frequency distribution) allowed more characteristics to be measured simultaneously. Measurements were made over a wide range of atmospheric conditions.

From these observations the general characteristics of the scintillation pattern are deduced and compared with previous work. Some results are presented which give insight into the nature of the mechanism by which the scintillation is produced.

Atmospheric wind measurements were made using a multiple-beam technique, the development and laboratory testing of which are presented. The tests showed that the position of the turbulence could be deduced with high precision. Application of the technique to stellar scintillation gave measurements of atmospheric wind speeds consistent with weather-station measurements.

A further technique was developed to measure the isoplanatic angle (the angle, looking upwards, over which the distortion produced by atmospheric turbulence is uniform) by a comparison of double and single star scintillation. Application of this technique showed that turbulence associated with the scintillation pattern was different for two paths separated by 21 μrad. Measurements under appropriate conditions confirmed that this technique can measure the isoplanatic angle associated with scintillation scales smaller than the lower limit of other methods.