
D. Coburn, D. Garnier, J.C. Dainty.
Department of Experimental Physics, National University of Ireland, Galway.
Derek.coburn@nuigalway.ie
Denis.Garnier@nuigalway.ie
C.Dainty@nuigalway.ie

Abstract:
We detail a generalised SCIDAR system developed for characterising atmospheric parameters using single star targets. Developments in solving the inverse problem needed to estimate the altitude dependence of refractive index structure constant are also outlined.

© 2005 Optical Society of America
OCIS codes: (280.0280) Remote sensing; (110.0110) Imaging systems.

1. Introduction.
SCIDAR (SCIntillation Detection And Ranging) is a remote-sensing technique used to measure the optical strength of turbulent atmospheric layers, a key factor in the tuning adaptive optics systems. The system developed uses stellar scintillation images produced by a single star in the presence of turbulence to assess the turbulence profile. An ensemble average of the covariance in intensity of the images recorded with an exposure timescale less than the correlation time of the pattern is taken. The resulting signal is related to the height dependence of refractive index structure constant, $C_n^2(h)$, a central parameter in determining the impact of atmospheric turbulence on imaging [1]. Compared with double star SCIDAR [2,3], the system offers the promise of obtaining larger sky coverage. At any one time double star SCIDAR has a limited number of useful targets in the sky.

2. The instrument.
The system employs a Retiga EXi camera to sense the scintillation patterns formed by a conjugate imaging system hooked to a commercial 250mm aperture f 10 telescope. Key in retrieving $C_n^2(h)$ profiles is the fact that the scale size and strength of the scintillation index for a particular turbulent layer grows dependent on the distance between the layer and the viewing plane [4]. We employ a generalised SCIDAR approach in which we sense the scintillation at an image plane several km below the telescope pupil in addition to different pupil heights in the atmosphere. This is a direct aid to solving the inverse problem needed to establish $C_n^2(h)$. In the current system the camera is scanned via a motorised stage laterally in the conjugate image plane to image the desired pupil locations. These images are processed in real time and stored to disk for offline inversion analysis. The system is currently in operation and a proof of principle study is underway at an observing site in Galway, Ireland with the instrument. Results from the instrument will be assessed by comparing them with measurements obtained from simultaneous DIMM measurements on the target star.

3. System modelling and $C_n^2(h)$ calculation
Through the use of multiple conjugated altitudes discussed retrieval of the refractive-index fluctuation profile is realised using a least square method solution with a Tikonov regularization. Methods to enforce non-negativity, reflecting the physical nature of $C_n^2(h)$, are currently being investigated. Validation of the inversion algorithm using simulated single layer turbulence demonstrate the ability of the system to retrieve $C_n^2(h)$ data. This treatment is currently being extended to treat multiple layers in the presence of single noise.

4. Conclusion.
Work is underway in a proof of principle study at an observing site in Galway, Ireland with the single star SCIDAR instrument. Ultimately, with the optimised algorithm in place, a fully automated version of the system is possible with the promise of improved sky coverage for assessing atmospheric parameters needed by adaptive optics systems in astronomy.

5. References

This work is funded by Science Foundation Ireland.