

Time-variability of the Mesospheric Sodium Profile

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The focus term of the laser guide star measured wavefront is sensitive to variations in height of the Sodium layer. The depth of field of the TMT at 90 km is about 9 meters, therefore Sodium layer variations on the order of 9 meters, about 1/1000 of the layer's nominal thickness, would put an unacceptable amount of wavefront error on the AO correction. To avoid this error, a separate measure of focus using a natural guide star is required. The temporal power spectrum of the variations will determine how often this measurement needs to be made. Lidar measurements (See Herriot, "NFIRAOS Interim Review Status" [TMT.AOS.PRE.05.073.REL03]) show the Sodium height fluctuates by kilometers on 5 minute time scales. The spectrum falls off with a roughly -1.6 power law in height variance (m^2/Hz) in the range from $10^{-4.5}$ to $10^{-2.5}$ Hz (shortest time scales = 5 minutes). Extrapolating this spectrum, by decades, to the 1000 Hz time scale would indicate that the LGS focus component is not at all useful for wavefront reconstruction, and focus sensing of a natural star in real time is required.

Recent measurements performed at the Lick observatory have provided Sodium layer height fluctuation data down to time scales of one second. On 19 November, 2005, we viewed the Laser guide star from another telescope, about 600 meters west of the one projecting the laser, and collected focal plane images of the sodium layer fluorescence. The angle was such that we could resolve the layer into about 100 bins, or about 100 meters. Then, by drift-scanning in a direction perpendicular to the laser track, the CCD could resolve Sodium layer variations on a one second time scale.

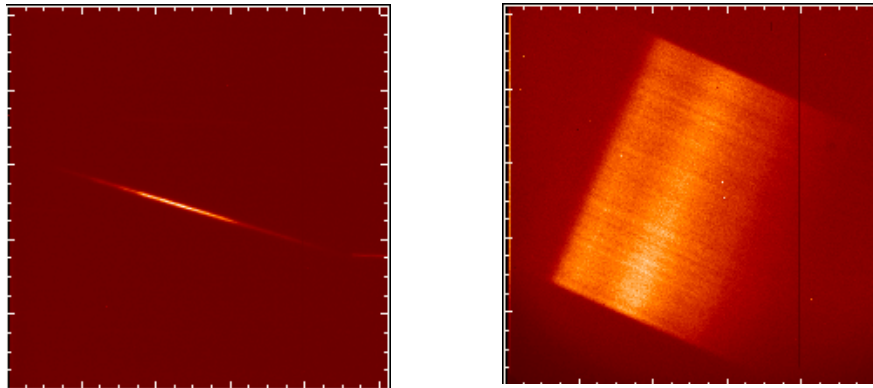


Figure 1. Left: picture of the streak of sodium return from the sodium guide star projected from the 3 meter Shane telescope, as seen from the 1 meter Nickel telescope, about 600 m to the west. Right: drift-scan image; time is resolved in the direction orthogonal to the streak.

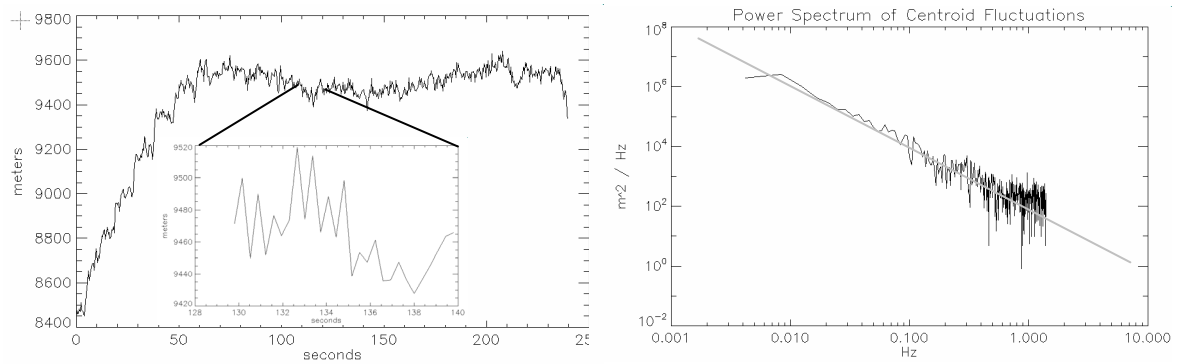


Figure 2. Typical plot of sodium centroid of height fluctuation (left) and power spectrum (right)

The data are consistent with a -2 power law in height variance (m^2/Hz) in the 0.01 to 1.0 Hz range. 20 to 40 meter excursions occur at one second time scales, so, by extrapolation we might conclude that the, say, 1 meter excursions would be occurring on a 0.01 second time scale, and focus updates should occur at about this rate. We should caution that this data set consists of one night's observations and that further data gathering will be necessary before conclusions can be made. Additional observations of the laser from the Nickel telescope will take place during LGS runs later this year.