Contribution ID: **3** Type: **Poster**

Properties of shock waves in the quiet Sun chromosphere

Short-lived (100s or less), sub-arcsec to a couple of arcsec sized features of enhanced brightenings in the narrowband images at the $\mathrm{H_{2V}}$ and $\mathrm{K_{2V}}$ positions of the Ca II H&K lines in the quiet Sun are known as bright grains. These bright grains are interpreted as manifestations of acoustic shock waves in the chromosphere. Using simulations, earlier studies have shown that upward propagating acoustic waves from the lower atmosphere turn into shocks in the chromosphere due to a drop in the gas density by several orders of magnitude. Earlier observational studies to quantify temperature enhancements and line-of-sight (LOS) velocities had limitations like limited spatial resolution and less optimal assumptions like local thermodynamic equilibrium (LTE). In this study, using the highest known spatial and spectral resolution observations of grains acquired from the CHROMIS and CRISP instruments of the SST, we have inferred the time-varying stratified atmospheric properties using a non-LTE inversion code. The Ca II K profiles of bright grains show enhancement in the $\mathrm{K_{2V}}$ peak intensities with the absence of the $\mathrm{K_{2R}}$ features. We found average enhancements in temperature at lower chromospheric layers (at $\log \tau_{500} \simeq -4.2$) of about 1.1 kK with a maximum enhancement of $\simeq 4.5$ kK. These temperature enhancements are co-located with upflows, as strong as -6 km s^{-1}. The LOS velocities at upper chromospheric layers at $\log \tau_{500} < -4.2$ show consistent downflows greater than $+8$ km s^{-1}. This study provides observational evidence to support the interpretation that the bright grains are manifestations of upward propagating acoustic shocks against a background of downflowing atmospheres.

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Session Classification: Posters

Track Classification: Chromosphere