Infrared Imaging Spectropolarimeter to Probe the Solar Atmosphere

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Introduction: The study of the dynamic, magnetically connected solar atmosphere requires probing a variety of physical parameters over an extended field of view. Simultaneously sampling an extended region of the solar surface allows us to capture the full lifetimes of small, stochastic events that may play an important role in the thermal and density structuring of the atmosphere. A variety of approaches are being applied in solar physics to address this need, including fiber bundles, image slicers, and microlens arrays. Over the past several decades, instruments based on Fabry-Perot interferometers (FPI) have been workhorses in the field, offering significant flexibility and observational efficiencies. One key aspect of such instruments has been their ability to leverage adaptive optics, short exposures, and post-acquisition image reconstruction to record spectral information at diffraction-limited resolutions.

One wavelength regime that has not been studied with this kind of solar instrumentation is the infrared interval from ~1-2 microns, despite there being several lines of interest in this range. One key target for such an instrument would be the He I 1083 nm multiplet that provides one of the most straightforward measurements of the vector magnetic field at the base of the corona, which is a crucial boundary condition for extrapolating the field's topology and evolution into the corona. Other targets are the magnetically sensitive Fe I 1565 nm doublet, which provides sensitive measurements of the photospheric field; molecular bands useful for sunspot polarimetry; and the Mn I line at 1526 nm with hyperfine structure sensitive to very weak magnetic fields. We also suggest that such an instrument could be used to observe the coronal Fe XIII emission lines at 1074.7 and 1079.8 nm, providing times series of coronal diagnostics that would be invaluable to assess the presence of different wave modes, small-scale heating events, as well as provide insight on the elusive coronal magnetic field.

We propose the development of such an FPI-based instrument to be installed on the NSF-funded Daniel K. Inouye Solar Telescope (DKIST). This would take advantage of its large aperture, broad instrument suite, and advanced adaptive optics system. An imaging instrument like this would have the advantage of higher resolution and higher cadence, therefore complementary to other types of imaging spectrometers. The development of an off-limb adaptive optics system for DKIST would make such an instrument even more powerful, providing high-resolution images of prominences and coronal loops. Based on existing heritage and expertise, this would provide a low-risk, high-reward tool for the solar community to probe new spectral diagnostics in a new way.