Summary of Involvement for the SPD Metcalf Travel Award

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NSO Workshop #30 – SacPeak, Sunspot, NM – August 7-11, 2017

As a PostDoc scientist at the Kiepenheuer Institute for Solar Physics in Freiburg, I am working as an instrument scientist with the Laser Absolute Reference Spectrograph (LARS) at the German Vacuum Tower Telescope (VTT) on Tenerife. Enabled by a laser frequency comb as wavelength calibration source, I study absolute Doppler velocities in the solar atmosphere. I finished my PhD thesis in 2016, supervised by Prof. Dr. Wolfgang Schmidt and Dr. Nazaret Bello González. In my work "Wave phenomena in sunspots", I investigated magneto-acoustic wave properties in the sunspot atmosphere. The observations were taken with the Dunn Solar Telescope (DST) at SacPeak and with the VTT on Tenerife. The *NSO Workshop #30* at the SacPeak observatory was a great opportunity to present my scientific results in a contributed talk to the international solar community. I am grateful to the AAS/SPD for the Thomas Metcalf Travel Award. In the following section, I will present an overview of my findings.

Talk: In my conference talk "Sunspot waves observed with IBIS/DST", I presented the results of my PhD thesis about wave phenomena in sunspots. Since sunspot waves like "umbral flashes" and "running penumbral waves" have been extensively studied in the last decades, it has become common knowledge that these wave phenomena are magneto-acoustic slow-mode waves. Affected by the sunspot's strong magnetic field, these quasi-acoustic waves are guided along the magnetic field to higher atmospheric layers. In my work, I confirmed this scenario by observations with two of the world's leading high-resolution solar telescope, the DST and the VTT. In my talk, I first gave an introduction into the topic and later on focused my presentation on the results obtained with the Interferometric Bidimensional Spectro-polarimeter (IBIS) at the DST. The isolated, circular sunspot (NOAA11823) shown in the figure below was observed on August 21st 2013 in a purely spectroscopic multi-wavelength mode based on two-dimensional imaging of the sunspot region at various wavelength position of photospheric (Fe I 630.15nm) and chromospheric (Na I 589.6nm, Ca II 854.2nm) spectral lines. Thus, I was able to yield the three-dimensional evolution of waves in the sunspot atmosphere. By means of a wave power analysis on the 1h-time series, I extracted the dominating (peak) wave period for each position of the sunspot region. While umbral waves and flashes have periods of predominantly 3min, running penumbral waves increase in period to about 8min at the sunspot boundary. This characteristic is most pronounced in the chromosphere, but already present in the upper photosphere. I found evidence that the wave propagation essentially depends on the atmospheric acoustic cut-off frequency. With increasing inclination of the magnetic field, waves with longer periods can propagate. By implication, I posed the question if it is possible to infer the magnetic field inclination directly from the observed wave periods. Finally, I presented the successful reconstruction of the sunspot's magnetic field inclinations. This novel technique based on purely spectroscopic observations and can open an alternative to polarimetric inversions of chromospheric fields.

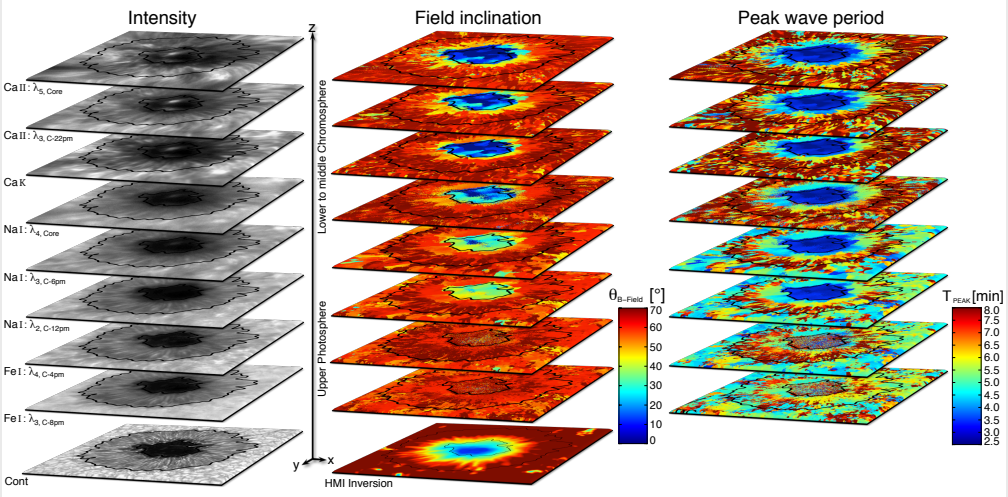

Figure: Three-dimensional distribution of spectroscopic intensity (left), magnetic field inclination (middle), and dominating wave period (right) in the sunspot atmosphere. From bottom to top, the sampled height (not to scale) covers the middle photosphere to middle chromosphere. Zero inclination means vertical magnetic fields. The umbral and penumbral contours are drawn in black.

Poster: I presented my new work with the poster "LARS: The Laser Absolute Reference Spectrograph at the VTT". Enabled by a laser frequency comb as a source of wavelength calibration, I perform spectroscopic measurements at an absolute wavelength scale and determine Doppler velocities in the solar atmosphere at an accuracy of 1 m s^{-1}.