Investigating the Nature of Running Sunspot Waves with the Interface Region Imaging Spectrograph

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We present simultaneous, high-resolution, NUV and FUV observations of running waves and umbral flashes in sunspots from the Interface Region Imaging Spectrograph (IRIS). We analyze intensity variations in slit-jaw images to investigate the relationship between running waves in the 1400 Å (Si IV, transition region) passband and umbral flashes in the 2796 Å (Mg II, chromosphere) passband. Using global wavelet analysis, we find that the dominant wave periods increase from approximately 180 s in the umbra to about 300 s in the penumbra in both passbands, experiencing a sharp increase near the umbra-penumbra boundary. This coincides extremely well with the radially increasing inclination of magnetic field lines observed with SDO/HMI, suggesting that the oscillations/waves are likely propagating vertically along the inclined field lines. Furthermore, apparent velocities in both passbands decrease from about 12 km s-1 at the sunspot center to about 3.5 km s-1 in the penumbra which is predicted by the same inclined field geometry. Finally, we find that umbral flashes lead running waves in both the spatial and time domains. The former result is attributable to the inclined field geometry; however, the geometry does not predict the radially increasing time lag which is likely due to the opacity disparity between the emission lines that dominate the two passbands. These results suggest that the apparent trans-sunspot propagation of running waves is not real, but is rather a signature of upward-propagating (slow) magneto-acoustic modes triggered by photospheric p-mode oscillations and tied to field lines of radially increasing inclination.