The Role of Helium Ionization in Supergranular Convection

Abstract: We model the solar photospheric horizontal velocity power spectrum at supergranular scales using a two component approximation to the mass continuity equation, a one dimensional mixing length model of the solar convection zone, and the assumption that large scale motions are driven only in the deepest layers. The model takes four times the local density scale height as the crossover length scale that separates two types of motion: convective modes with wavelengths less than this are taken to be turbulent and isotropic, while modes with scales that exceed the criteria are assumed to decay with height from the depth where their wavelength is equal to the crossover scale. These elements of the model are tested against, and found to hold, in large-scale radiative hydrodynamic simulations. Model results suggest that helium ionization plays a role in the formation of the photospheric velocity spectrum at supergranular scales by reducing the convective velocities in the regions of partial helium I and II ionization. This reduction causes an apparent enhancement in photospheric power for the modes that begin to decay between the depths of helium I and II ionization. The model also predicts increased low wavenumber velocity power than observed in the solar photosphere, adding to other recent evidence that large-scale motions may have lower amplitudes than expected from numerical simulations. The observed low wavenumber spectrum can only be reproduced by a dramatic reduction in the convective flux carried by low wavenumber modes in the deep solar convection zone.