Power Spectral Analysis of the Magneto-Convection on the Solar Surface with HINODE SOT

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Interaction between the thermal convection and magnetic fields creates structures over various spatial scales, such as sunspots (10^4–10^5 km) and fine magnetic flux tubes (~100 km). It is quite important to investigate the transfer of kinetic and magnetic energies among the convection and magnetic fields at various spatial scales for understanding how the magnetic structures are created on the solar surface. In order to quantify it, we performed power spectral analysis of surface temperatures, velocities, and magnetic fields, using spectro-polarimetric data taken with the HINODE Solar Optical Telescope (SOT). Because of the stable image quality as well as accurate polarimetric measurements, we could successfully obtain power spectra of the surface convection at the spatial scale smaller than granules with enough reliability for the first time by characterizing influence of the telescope's angular resolution and noises.

The kinetic (temperatures' and velocities') power spectra have a prominent peak at the granular scale (~1000 km, Fig. 1 top), which indicates injection of the kinetic energy occurs at that scale. At the spatial scale smaller than granules, the power spectra show power-law like spectra whose power-law indices are −4 – −3. The spectra are significantly steeper than the Kolmogorov's −5/3 for isotropic turbulences. It has not been understood why the slope is so steep on the solar surface.

The magnetic power spectra are created in low magnetic flux regions (Fig. 1 top) and high flux regions (Fig. 1 bottom), separately. In the low flux regions (< 10 gauss), the magnetic spectra exhibit a peak at around the granular scale (~800 km) and power-law like spectra whose indices are about −1.3 at the sub-granular scale. A MHD numerical simulation of the surface magneto-convection suggests that small-scale magnetic fields are created at the scale smaller than the HINODE resolution by local dynamo action, and they have more impacts on the overall magnetic energy budgets than the magnetic fields resolved with HINODE. The power spectra based on the Hinode observation imply, on the other hand, that magnetic energies coming from the granular-scale structures are more important than the structures of the unresolved scale. The magnetic spectra are less steep than the kinetic ones at the sub-granular scale, and the power-law indices differ by about 2, which can be interpreted that magnetic structures are created by velocity shear of the surface convection. In the high flux regions (> 50 gauss), the power-law indices of the kinetic and magnetic power spectra become similar. This is probably due to strong coupling of the convection and magnetic fields at each spatial scale. Comparison with MHD numerical simulations of the surface magneto-convection is expected to provide deeper insights on how the magnetic structures are created as a next step.

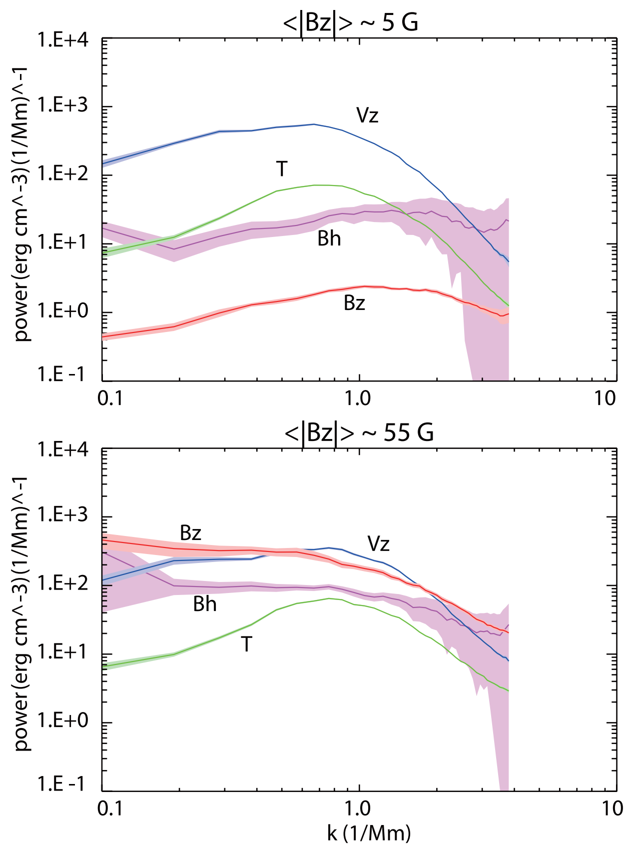

Figure 1: Kinetic and magnetic power spectra of the granular convection on the solar surface derived with HINODE SOT in low and high flux regions (top and bottom, respectively).

Reference

[1] Katsukawa, Y., Orozco Suárez, D.: 2012, *ApJ*, **758**, 139.