Two-dimensional radiation magnetohydrodynamics simulations on the origin of network magnetic field in the solar quiet region

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The kinetic energy spectrum of the Doppler velocity field observed on the solar surface has two dominant spectral peaks, called granulation and supergranulation. The supergranulation is assumed to advect the magnetic field into the network-like structure. This network magnetic field is considered to have an important role in the heating of the upper atmosphere and the solar wind. However, the origin of supergranulation and the magnetic network is not fully understood until now.

We newly implement radiative magneto-convection simulations for the realistic calculation of the solar surface convection. The results of supergranular-scale two-dimensional convection simulation are presented to investigate the formation process of supergranulation and the magnetic network. When the magnetic field is moderate, no supergranular peak in the kinetic energy spectrum is found. However, the magnetic energy spectrum has an apparent spectral peak at the scale of the magnetic network. The horizontal structure of this magnetic network has a correlation with the horizontal flow at a depth of about 3 Mm. This result is interpreted that the large-scale structure of the magnetic network is formed by the merging of the strong downflows with the smaller scale convection.

When the magnetic field becomes sufficiently strong, the back reaction from the magnetic network to the supergranular convection occurs and the supergranular spectral peak appears in the kinetic energy spectrum. This suggest that the magnetic network is not the result of the supergranulation but the exciter of the supergranular convection in the solar surface.

Based on the results above, we suggest a scenario for the formation process of the magnetic network and supergranulation.