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High resolution observations of magnetic fine structures on the solar photosphere with ground based and space observatories

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Magnetic fields on the Sun have various spatial and time scales. Sunspots apparently have the largest scale size (about 10^{4-5} km), long life time (about month). The magnetic elements are the smallest resolved structures (less than 100 km) with intense magnetic fields reaching 1 KG, and are believed to be building blocks for active regions and quiet Sun magnetic networks. The question on how such small structures with strong magnetic flux density and with short lifetime exist is one of the central issues in solar magneto-hydrodynamics. Direct magnetic observations of such magnetic elements are, however, difficult because of its small spatial scales and the short evolution time-scales. One of the indirect methods for tracing the magnetic elements is to use G-band bright points (GBPs).

Small bright structures are often observed in the Fraunhofer G-band (4305A), and are called the GBPs. The GBPs are believed to correspond to magnetic elements. Internal plasma pressure of the flux tubes is lower than the external plasma pressure due to the internal magnetic pressure. The emission, thus, comes from deeper (thus hotter) region in the flux tube. Therefore, the elemental thin magnetic fields are bright due to lateral heat transport from the surrounding region, while for sunspots such lateral heat transport is not effective due to its large size. We investigate relationship between magnetic elements and the GBPs by performing a statistical analysis for the high-resolution ground-based data (Ishikawa, Tsuneta, Kitakoshi, Katsukawa, Bonet, Vargas Dominguez, Rouppe van der Voort, Sakamoto, and Ebisuzaki, A&A submitted).

The G-band filtergrams with magnetograms and dopplergrams were taken with the Swedish 1-m Solar Telescope. We observed a complex active region, and we concentrate on the plage region covered with abnormal granules as well as ubiquitous GBPs with some small pores. Apparently, high magnetic flux density is not necessarily associated to GBPs. We refer to the observed extended areas with high magnetic flux density as magnetic islands to separate them from magnetic elements. We discover that GBPs tend to be located near the boundary of such magnetic islands. The number density of GBPs decreases with inward distance from the boundary of the magnetic islands. Moreover, GBPs are preferentially located where magnetic flux density is higher, given the same distance from the boundary. GBPs have higher minimum magnetic flux density at the larger inward distance from the boundary. Convective velocity is apparently suppressed for such high magnetic field regions regardless whether they are populated by GBPs or not. The magnetic islands are surrounded by downflows.

Magnetic elements are not necessarily associated with GBPs. There would be two conditions to make the magnetic elements bright in G-band. First condition is a high magnetic flux density. The lower density due to higher magnetic allows us to observe deeper and hotter layers inside the magnetic elements. Second condition is concerned with availability of an efficient heat transport path from the surroundings. Deep inside the magnetic islands, there would no lateral heat flux input from the region where we have regular heat flow in a form of convection.

GBPs represent only a subset of magnetic foot points, and the direct observation of high resolution magnetic field is critical for the understanding of the sun. With the launch of Hinode satellite, the situation is drastically changing. Solar optical telescope aboard Hinode can directly observe elemental magnetic elements with spectro-polarimetry and filtergraph in a very stable and continuous manner. Spatial and time resolution is superb. Newly available information includes information on vector magnetic fields and intensity maps for various heights of photosphere and chromosphere. We will also report on the new results from Hinode in addition to the result obtained with the ground-based telescopes.