Hinode-3: 3rd Hinode Science Meeting
Hitotsubashi Memorial Hall, Tokyo
1–4 December, 2009

Persistent circulating motion of umbral dots observed with HINODE SOT

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Abstract. The subsurface structure of a sunspot is not well understood although it is important to know how the sunspot structure is maintained during its life time and how its magnetic fields affect convective and radiative energy transfer below a sunspot. The interpretation of helioseismic observations is still controversial because of complex interaction between acoustic waves and strong magnetic fields. In this paper, we propose another clue to know a subphotospheric flow structure using apparent motion of umbral dots (UDs).
The inward motion of UDs is commonly observed in a peripheral region of an umbra associated with inward migration of penumbral grains, whose inward speed is faster than 0.5 km/s. Motion of UDs are observed not only in the peripheral region but in deep insdie an umbra. The migration speed of central UDs is about 0.1 - 0.5 km/s, which is slower than that of the peripheral ones. Their moving direction is not completely random, but circulating motion around an umbral core is noticeable as a global flow pattern in the umbra. In the case of the sunspot in AR10923 observed in Nov 2006, clock-wise persistent motion was observed lasting for at least several days before formation of a light bridge. It is found that faint channels often appear in the umbra, which carry relatively rapid motion of UDs along them. Because a lifetime of each UD is typically shorter than one hour, successive emergence of many UDs along the channels makes the persistent circulating motion. The observations suggest that there should be a magnetic and flow structure below a sunspot responsible for the systematic motion of UDs.