Current Helicity in the Solar Cycle, the Properties of Turbulent Magnetic Field from Mosaic SOT/SP Raster Scans and Messages for Dynamo Theory

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The current helicity and twist of solar magnetic fields have been studied observationally by using several ground-based instruments and also the Spectro-Polarimeter (SP) of Hinode Solar Optical Telescope. Current helicity as correlation between the electric current and the magnetic field in an observable measure of breaking of mirror anti-symmetry in solar magneto-convection. Its most important property is the so-called hemispheric sign rule, namely the helicity is mainly negative/positive in the northern/southern hemispheres of the Sun. The previous studies have also identified some specific situations when this rule is reversed. At certain phases of the solar cycle we have been found different patterns of inversion of the hemispheric rule visible in either weak or strong fields, alternately. It turns that the strong and weak magnetic fields mainly show opposite trends regarding this rule.

We present results of analysis of current helicity and twist over more than 20 years period of data from ground observatories Huairou in China, Mitaka in Japan and also obtained by SOT SP. The latter data enabled us to compute average values of current helicity and twist of magnetic fields by exploring various ranges of weak, medium, and strong magnetic fields as well as by combining statistically significant data numbers in terms of latitude, time, and regions. We also performed artificial reduction of SOT resolution in order to mimic the ground-based data which have been obtained for much longer period.

While in most of cases the helicity has been computed locally in active regions, in some cases small-scale events may affect global phenomena. To see these effects we would like to carry out solar magnetic field observations over the full disk (or over a wide-enough field of view) with spatial resolution and accuracy comparable to Hinode/SOT. The large scale and small scale magnetic structures may possess different properties of spatial spectra. While small-scale fields usually reflect the impact of granular convection and background turbulence, large-
scale magnetic fields contribute to the long-term evolution of magnetic activity with the solar cycle. Different physical properties are expected from these two ends of the observable data spectrum.

Having obtained a series of maps of photospheric vector magnetic fields with highest available resolution from Hinode/SOT, we developed a procedure for matching several SOT/SP raster scans taken with relatively little time gap in order to construct a proxy of a large field of view (FOV) magnetogram. First of all, we match two collateral raster scans, and then we are going to apply the same technique to merge two zonal bands of magnetograms. In our work in progress we report some features that indicate a possibility of different mechanisms of energy transfers in turbulent cascades at the large scales compared with the small-scale end of the spectra but still above the spatial resolution limit of Hinode. The energy cascade for magnetic field over a wide range of scales is important to justify numerical modelling, and we hope that this topic can be tackled with Hinode/SOT data.