Statistical Analysis of Current Helicity and Twist in Solar Active Regions over the Phases of the Solar Cycle Using the Spectro-Polarimeter Data of Hinode

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Magnetic flux tubes in the solar convection layer emerge to the surface and form sunspots and emerging flux regions. The active regions including sunspots have magnetic fields exceeding 3000 G and produce many active phenomena. The magnetic field in an active region can be twisted by the solar dynamo process when it is generated, or by the interaction with the convection motion during its ascent from the bottom of the convection zone. To measure the twist of the field, the current helicity was introduced. The current helicity is derived from vector magnetic field components at the solar surface, i.e. photosphere. The line-of-sight (z) component of current helicity H_{Cz} is,

$$H_{Cz} = \langle B_z J_z \rangle \,, \qquad J_z = \frac{dB_y}{dx} - \frac{dB_x}{dy}. \qquad (1)$$

where $\langle \cdots \rangle$ represents the spatial averaging, x and y are solar east-west and north-south directions, respectively. From the definition, the right/left-handed helical field lines are characterized by positive/negative current helicity. The preceding studies found a tendency that the negative/positive helicity is dominant in the northern/southern hemisphere. The data used for these studies are, however, obtained from the ground-based observations, which suffered from the atmospheric seeing effect and so on.

We have carried out a statistical study on the current helicity of solar active regions observed with the Spectro-Polarimeter (SP) of Hinode Solar Optical Telescope (SOT). We used SOT-SP data of 558 vector magnetograms of a total of 80 active regions obtained from 2006 to 2012. This period covers from the end of the solar cycle-23 to the middle of cycle-24. To avoid the projection effect, we excluded the data obtained near the solar limb. We divided the area of an active region into weak (<300 G) and strong (300~1000 G) field ranges to compare the contributions from different field strengths. Figure 1 shows the time-latitude diagram of current helicity calculated for individial active regions. The color and size of the circles indicate the sign and magnitude of current helicity.

The result of weak field area shows the same distribution of current helicity as the preceding studies. On the other hand, the strong field area shows the opposite dependency, i.e. positive current helicity in the northern hemisphere and negative in the south. This opposite natures may come from the difference of the origins of strong and weak magnetic fields. To investigate more detailed and long period variations of the current helicity on active regions, a larger statistical analysis using SOT/SP data up to the current date (~2015) is now ongoing.

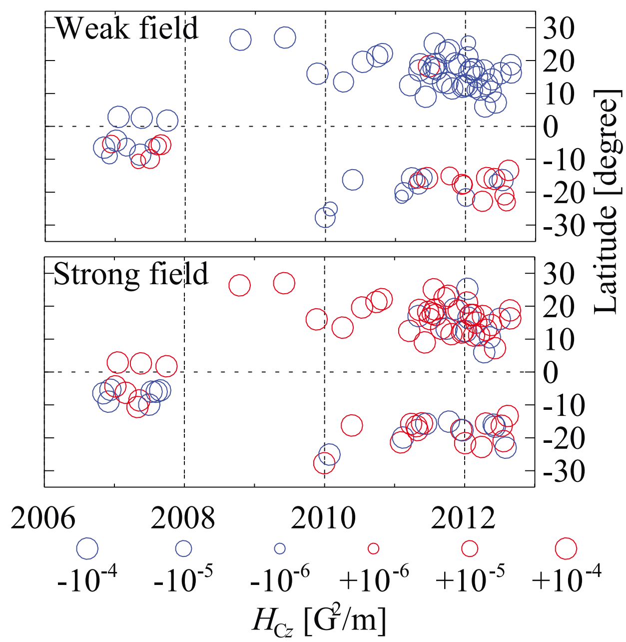

Figure 1: The temporal-latitude diagram of current helicity for every active regions observed by SOT/SP from 2006 to 2012. The upper/lower image represents the result of the area with weak (<300 G)/strong (300~1000 G) field range, respectively.

Reference

[1] Otsuji, K., Sakurai, T., Kuzanyan, K.: 2015, *PASJ*, **67**, 6.