Statistical Study of Flux Emergences on the Sun

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Since *Hinode* has been launched in 2006, it has revealed new aspects of the sun. We carried out the statistical study of flux emergences on the solar surface observed with *Hinode* Solar Optical Telescope (SOT), which clarified that the total flux of one emerging flux region controls its spatial size and the timescale of emergence [1].

The solar activities such as flares occur according to the release of magnetic energy transported from the convective zone. Emerging flux regions are where the flux tubes from the convective zone emerge onto the solar surface, and take important role in the studies on the solar activities like flares, coronal mass ejections and their effects on the earth.

The result of this study showed the power-law relation between the total flux and the mean flux growth rate of emerging flux regions. This implies that one can estimate the final emerged flux amount of a region from its mean flux growth rate of the initial phase, which can be used for the space weather forecasting.

Hinode SOT observed 101 flux emergence events in between November 2006 and August 2010 with magnetogram. Figure 1 shows the example of a flux emergence event observed on December 30, 2009. From the observed data, physical parameters of emerging flux regions were measured with respect to the spatial size ($d_{\max}$), emerged total flux amount ($\Phi_{\max}$) and the mean flux growth rate ($\langle d\Phi/dt \rangle$). As the result, we obtained the power-law relations as shown in Figure 2.

$$d_{\max} \propto \Phi_{\max}^{0.27} \tag{1}$$

$$\left\langle \frac{d\Phi}{dt} \right\rangle \propto \Phi_{\max}^{0.57} \tag{2}$$

These results give the observational support to the flux tube evolution and emergence model at the convective zone. Further investigation with comparing to the simulation for revealing more realistic picture of the solar interior is required.

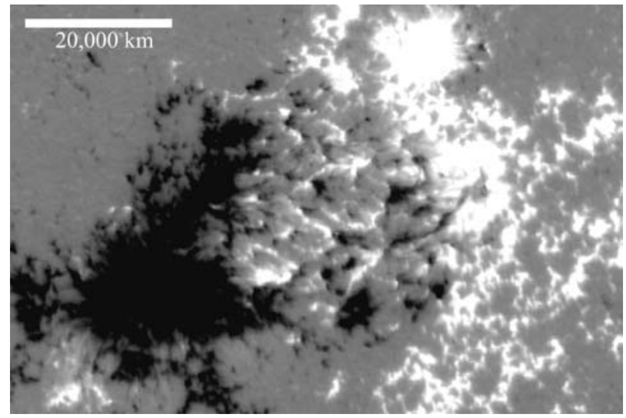

Figure 1: Magnetic field of the emerging flux region observed on December 30, 2009 by *Hinode* SOT. Between the large black and white area corresponding to sunspots, the flux emergence occurs.

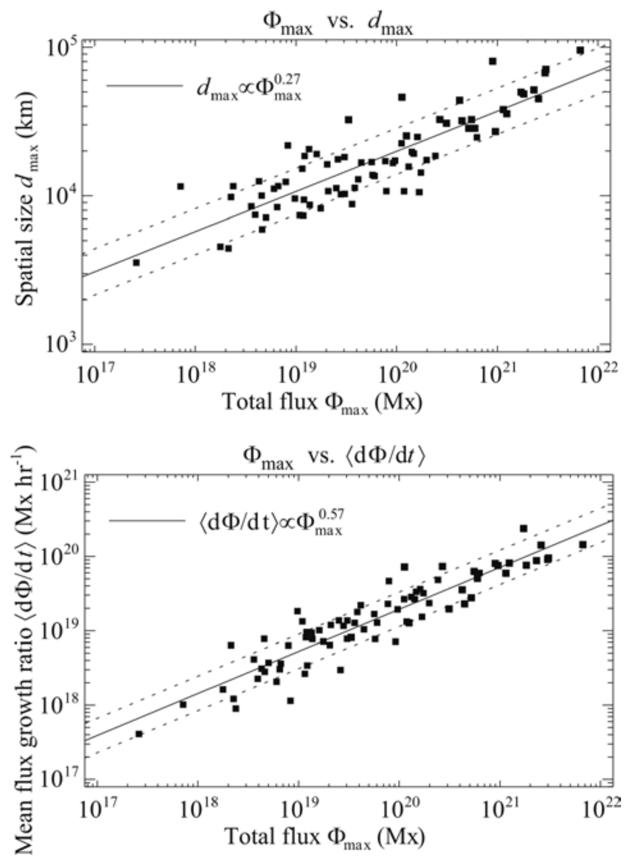

Figure 2: The scatterplots of the total flux ($\Phi_{\max}$), spatial size (d) and mean flux growth rate ($\langle d\Phi/dt \rangle$) of the emerging flux regions.

Reference

[1] Otsuji, K., Kitai, R., Ichimoto, K., Shibata, K.: 2011, *PASJ*, **63**, 1047.