Measurements of Magnetic Helicity Injected through the Photosphere and Magnetic Helicity Content in the Corona

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Magnetic helicity is a useful quantity in characterizing the magnetic connection of the solar interior, surface, corona, and the interplanetary space. It is a common wisdom that magnetic helicity is transferred from the interior to the corona and then is expelled out of the Sun in the form of coronal mass ejections. From observations, it is possible to independently measure the accumulated amount of magnetic helicity transferred through the photopshere, the content of magnetic helicity in the corona, and the amount magnetic helicity carried away by coronal mass ejections. Chae (2001) fisrt proposed that the magnetic helicity injected into the corona through the photopshere is determined from the local correlation tracking of of magnetic fieldline footpoints. The magnetic helicity content of the corona is inferred from the three dimensional structure of coronal magnetic field, which is usually constructed using the extrapolation of magnetic field. The simplest extrapolation model that can be used to determine magnetic helicity is a linear force-free field. We have applied the two indepdent approaches to the active region 10696 to indepently determine the accumulated magnetic helicity injected through the photosphere, and the coronal magnetic helicity content as functions of time. Our results are as follows: 1) most magnetic helicity was supplied intensively during the period of flux emergence, especially during the growth of active regions. The helicity injected in the early five days was about 2×10^{43} Mx^2. 2) The linear force-free assumption is not perfect in that the force-free α depends on the coronal loops chosen to determine it. Nevertheless it is possible to the probable range of the coronal helicity of an active region within an uncetaintly of about 30%. 3) With the loss of magnetic helicity by coronal mass ejections taken into account, the measured value of coronal helicity was close to the accumulated amount of injected helicity with a discrepancy of $10 \sim 30\%$. From these results, we propose that the two independent methods — the linear force-free method and Chae's (2001) method — are consistent with each other, and may be reliable with a probable uncertainty of a few tens of per cent.