CD-I14 AAPPS-DPP2018

2nd Asia-Pacific Conference on Plasma Physics, 12-17,11.2018, Kanazawa, Japan

Helicity transport from the solar convection zone to interplanetary space

Mei Zhang
National Astronomical Observatories, Chinese Academy of Sciences
zhangmei@bao.ac.cn

Magnetic helicity is a physical quantity that describes field topology. It is also a conserved quantity as Berger in 1984 demonstrated that the total magnetic helicity is still conserved in the corona even when there is a fast magnetic reconnection. It is generally believed that solar magnetic fields, together with their helicity, are created in the convection zone by various dynamo processes. These fields, together with their helicity, are transported into the corona, through solar photosphere, and finally released into the interplanetary space, via various processes such as coronal mass ejections (CMEs) and solar winds [1]. Here I will give a brief review on the series of our works. First, I will talk about helicity observations on the solar photosphere [2-3] and how to understand these observations via dynamo models [4]. The observed hemispheric helicity sign rule, together with Berger's total magnetic helicity conservation rule, will naturally results in magnetic helicity accumulation in the solar corona. Then, I will talk about what are the possible (by theory) consequences of the magnetic helicity accumulation in the corona, namely, the formation of magnetic flux ropes as a result of Taylor relation [5, fig1], CMEs taking place as an unavoidable product of coronal evolution due to the existence of a magnetic helicity upper bound of force-free fields [6], and how to understand the magnetic flux emergences as a trigger of CMEs [7]. Finally, I will address on in what a form (that is, the Parker-spiral-like structure) the interplanetary space would accommodate the large amount of magnetic helicity that solar dynamo has been continuously producing [8, fig2].

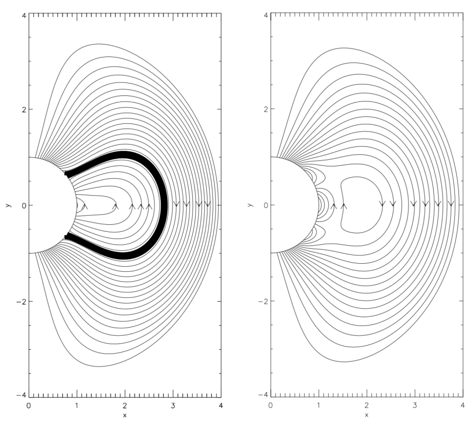

Figure 1. A magnetic flux rope (right panel) will form as a result of Taylor relaxation as long as there is enough total magnetic helicity accumulated in the initial state (left panel).

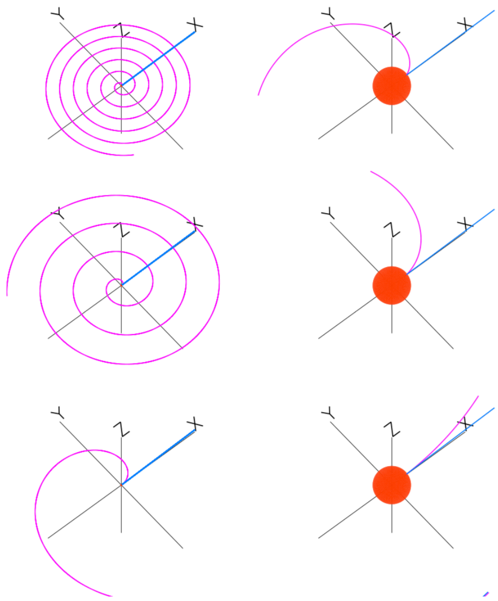

Figure 2: A Parker-spiral-like structure will form when the field of a large amount of total magnetic helicity opens up (purple lines), compared to blue straight lines (when the field of zero magnetic helicity opens up).

References

[1] M. Zhang, B. C. Low, The hydromagnetic nature of solar coronal mass ejections, 2005, Annual Reviews of Astronomy and Astrophysics, 43, 103

[2] M. Zhang, Helicity observation of weak and strong fields, 2006, ApJ, 646, L85

[3] J. Hao, M. Zhang, Hemispheric helicity trend for solar cycle 24, 2011, ApJ Letters, 733, L27

[4] M. S. Miesch, M. Zhang, K. C. Augustson, Magnetic helicity reversals in a cyclic convective dynamo, 2016, ApJ Letters, 824, L15

[5] M. Zhang, B. C. Low, Magnetic-flux emergence into the solar corona. III. The role of total helicity conservation, 2003, ApJ, 584, 479

[6] M. Zhang, N. Flyer, B. C. Low, Magnetic field confinement in the corona: The role of magnetic helicity accumulation, 2006, ApJ, 644, 575

[7] M. Zhang, N. Flyer, The dependence of the helicity bound of force-free magnetic fields on the boundary conditions, 2008, ApJ, 683, 1160

[8] M. Zhang, N. Flyer, B. C. Low, Magnetic helicity of self-similar axisymmetric force-free fields, 2012, ApJ, 755, 78