M15a 3-dimensional simulation of emerging flux tube

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We study the evolution of a magnetic flux tube which rises from the upper convection zone to the solar atmosphere by means of 3-dimensional MHD simulation. A Gold-Hoyle flux tube placed horizontally in the convection zone starts rising by convective motion. As the flux tube emerges through the photosphere, it provides noticeable flow patterns on the surface. First, when the outermost magnetic field lines of flux tube, which are almost transverse to the tube axis, reach the atmosphere, we find that a photospheric plasma flows to the direction perpendicular to the axis. Then, as the inner field lines which have a strong axial component of magnetic field rise across the photosphere, the photospheric flow changes its direction, that is, a plasma moves parallel to the tube axis (neutral line). This result supports the assumption used in a lot of previous studies that shear flow (parallel flow along neutral line) plays an important role in forming energetic magnetic structure in the solar atmosphere.

As to the energetics of magnetic arcade formed in the atmosphere, we compare the magnetic energy of emerging field with the energy of potential field which has the same distribution of vertical magnetic field on the surface as the emerging field. Since the difference between these two energies is related to the energy source of explosive phenomena, we focus on the temporal evolution of those energies as the emergence of flux tube proceeds. We also discuss the configuration of emerging field lines, which has been a hot topic in the solar activity researches since the discovery of 'sigmoid' structures in the corona.

Reference
Canfield, R. C., Hudson, H. S., and McKenzie, D. E. 1999, Geophysical Research Letters, 26, 627