Helical lengths of magnetic clouds from the magnetic flux conservation

Tetsuya Yamamoto[1]; Satoshi Inoue[2]; Ryuho Kataoka[3]

[1] STEL; [2] ESC/JAMSTEC; [3] RIKEN

We present a clue of spatial structures of magnetic clouds estimated from the helicity conservation law.

Spatial structures of magnetic clouds are an enigma in the interplanetary physics because of a few, at least one, {¥it in-situ} data points.It is difficult to clearly decide spatial structures of magnetic clouds from {¥it in-situ} data fitting, because we can fit {¥it in-situ} data either by using closed structures (e.g., torus model) or by using the magnetic flux model rooting in the solar corona (e.g., Marubashi & Lepping, 2007, Ann. Geophys., 25, 2453). Additional restrictions are needed.

The helicity conservation law is one of promising restrictions for magnetic cloud structures.Magnetic helicity is a quantitative measure of the magnetic field helicalness, and is a conserved quantity in the corona and in the interplanetary space.Recently magnetic helicities in the solar atmosphere have been quantitatively measured by several authors. Field pitch angles or values of force-free parameter $¥alpha$ in magnetic clouds are also obtained from model fitting. Applying the magnetic flux tube model whose spatial scale length is longer than 2 AU, total helicities in magnetic clouds (10.–100.) are much larger than those in solar active regions (0.01-1.0; e.g., Leamon et al., 2004, JGR, 109, A05106). However, by using the helicity conservation law and data of Leamon et al., we can estimate spatial scale lengths of magnetic clouds, 0.01–0.1 AU. From the short scale lengths, we propose two possible candidates of magnetic cloud structures. One is the spheromak, and another is the magnetic flux tube having partial helical structure around the apex. Several sample events supporting our hypothesis are shown to discuss in detail.