Astrophysical Journal Letters 2012 vol.751 N1

Dynamics of magnetized vortex tubes in the solar chromosphere

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Abstract

We use three-dimensional radiative MHD simulations to investigate the formation and dynamics of small-scale (less than 0.5 Mm in diameter) vortex tubes spontaneously generated by turbulent convection in quiet-Sun regions with an initially weak (10 G) mean magnetic field. The results show that the vortex tubes penetrate into the chromosphere and substantially affect the structure and dynamics of the solar atmosphere. The vortex tubes are mostly concentrated in intergranular lanes and are characterized by strong (near sonic) downflows and swirling motions that capture and twist magnetic field lines, forming magnetic flux tubes that expand with height and attain magnetic field strengths ranging from 200 G in the chromosphere to more than 1 kG in the photosphere. We investigate in detail the physical properties of these vortex tubes, including thermodynamic properties, flow dynamics, and kinetic and current helicities, and conclude that magnetized vortex tubes provide an important path for energy and momentum transfer from the convection zone into the chromosphere.

http://dx.doi.org/10.1088/2041-8205/751/1/L21

Keywords

Sun: chromosphere, Sun: magnetic topology, Sun: photosphere, Sun: surface magnetism