Geophysical Research Abstracts
Vol. 19, EGU2017-3692, 2017
EGU General Assembly 2017

Magnetic helicity estimations in models and observations of the solar magnetic field

Gherardo Valori (1), Etienne Pariat (2), Sergey Anfinogentov (3), Feng Chen (4), Manolis Georgoulis (5), Yang Guo (6), Yang Liu (7), Kostas Moraitis (2), Julia K. Thalmann (8), and Shangbin Yang (9)

(1) University College London - MSSL, Department of Space & Climate Physics, United Kingdom (g.valori@ucl.ac.uk), (2) LESIA, Observatoire de Paris, PSL Research University, CNRS, Sorbonne Université, UPMC Univ. Paris 06, Univ. Paris Diderot, Sorbonne Paris Cité, 92190 Meudon, France, (3) Institute of Solar-Terrestrial Physics SB RAS 664033, Irkutsk, P/O box 291; Lermontov st, 126a, Russia, (4) Max-Plank-Institut für Sonnensystemforschung, 37077 Göttingen, Germany, (5) Research Center for Astronomy and Applied Mathematics of the Academy of Athens, 4 Soranou Efesiou Street, 11527 Athens, Greece, (6) School of Astronomy and Space Science, Nanjing University, Nanjing 210023, China, (7) Stanford University HEPL Annex, B210, Stanford, CA 94305-4085, USA, (8) Institute of Physics/IGAM, University of Graz, Universitätsplatz 5/II, 8010 Graz, Austria, (9) Key Laboratory of Solar Activity, National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100012, China

Magnetic helicity, as one of the few conserved quantities in magneto-hydrodynamics, is often invoked as the principle driving the generation and structuring of magnetic fields in a variety of environments, from dynamo models in stars and planets, to post-disruption reconfigurations of tokamak's plasmas. Most particularly magnetic helicity has raised the interest of solar physicists, since helicity is suspected to represent a key quantity for the understanding of solar flares and the generation of coronal mass ejections. In recent years, several methods of estimation of magnetic helicity have been proposed and already applied to observations and numerical simulations. However, no systematic comparison of accuracy, mutual consistency, and reliability of such methods has ever been performed.

We present the results of the first benchmark of several finite-volume methods in estimating magnetic helicity in 3D test models. In addition to finite volume methods, two additional methods are also included that estimate magnetic helicity based either on the field line's twist, or on the field's values on one boundary and an inferred minimal volume connectivity. The employed model tests range from solutions of the force-free equations to 3D magneto-hydrodynamical numerical simulations. Almost all methods are found to produce the same value of magnetic helicity within few percent in all tests. However, methods show differences in the sensitivity to numerical resolution and to errors in the solenoidal property of input fields.

Our benchmark of finite volume methods allows to determine the reliability and precision of estimations of magnetic helicity in practical cases. As a next step, finite volume methods are used to test estimation methods that are based on the flux of helicity through one boundary, in particular for applications to observation-based models of coronal magnetic fields. The ultimate goal is to assess if and how can helicity be meaningfully used as a diagnostic of the evolution of magnetic fields in the solar atmosphere.