Solar Phys _####################_
DOI 10.1007/s11207-016-1028-5

Plasma Motions and Turbulent Magnetic Diffusivity of Active Region AR 12158 Using a Minimum Energy Functional and Non-Force-Free Reconstructions of Vector Magnetograms

Benoit Tremblay[1] · **Alain Vincent**[1]

Received: 29 February 2016 / Accepted: 16 November 2016

Abstract We present a generalization of the resistive minimum-energy fit (MEF-R: Tremblay and Vincent in *Solar Phys.* **290**, 437, 2015) for non-force-free (NFF) magnetic fields. In MEF-R, an extremum principle is used to infer two-dimensional maps of plasma motions $[\boldsymbol{v}(x, y)]$ and magnetic eddy diffusivity $[\eta_{\rm eddy}(x, y)]$ at the photosphere. These reconstructions could be used as boundary conditions in data-driven simulations or in data assimilation. The algorithm is validated using the analytical model of a resistive expanding spheromak by Rakowski, Laming, and Lyutikov (*Astrophys. J.* **730**, 30, 2011). We study the flaring Active Region AR 12158 using a series of magnetograms and Dopplergrams provided by the *Helioseismic and Magnetic Imager* (HMI) onboard the *Solar Dynamics Observatory* (SDO). The results are discussed for a non-force-free magnetic-field reconstruction $[\boldsymbol{B}_{\rm NFF}]$ (Hu and Dasgupta in *Solar Phys.* **247**, 87, 2008). We found that the vertical plasma velocities $[v_z(x, y)]$ inferred using MEF-R are very similar to the observed Doppler velocities $[v_r(x, y)]$. Finally, we study the potential spatial correlation between microturbulent velocities and significant values of $\eta_{\rm eddy}(x, y)$.

Keywords Magnetic fields, photosphere · Velocity fields, photosphere · Active regions · Granulation

1. Introduction

Observations of plasma proper motions $[\boldsymbol{v}(x, y)]$ are limited to the line-of-sight component, *e.g.* the Doppler velocity $[v_r(x, y)]$. Numerous methods have been devised to reconstruct transverse (or horizontal in approximation) plasma motions $[\boldsymbol{v}_{\rm h}(x, y)]$ at the photosphere from vector magnetograms (*e.g.* Welsch *et al.*, 2007). They are based on simplified

✉ A. Vincent
vincent@astro.umontreal.ca

B. Tremblay
benoit@astro.umontreal.ca

[1] Département de Physique, Université de Montréal, C.P. 6128, Succ. A, Montreal, Québec H3C 3J7, Canada