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Vector magnetic field and vector current density in and around the δ-spot NOAA 10808†

Véronique Bommier[1], Egidio Landi Degl'Innocenti[2], Brigitte Schmieder[3], and Bernard Gelly[4]

[1]LERMA, Observatoire de Paris, CNRS, ENS, UPMC, UCP; Place Jules Janssen, F-92190 Meudon, France, V.Bommier@obspm.fr
[2]Dipartimento di Fisica e Astronomia, SASS, Università degli Studi di Firenze, Largo E. Fermi 2, I-50125 Firenze, Italy
[3]LESIA, Observatoire de Paris, CNRS, UPMC, Université Paris-Diderot; Place Jules Janssen, F-92190 Meudon, France
[4]Télescope Héliographique pour l'Étude du Magnétisme et des Instabilités Solaires, CNRS UPS 853 – THEMIS, Vía Láctea s/n, E-38205 La Laguna, Tenerife, Spain

Abstract. The context is that of the so-called "fundamental ambiguity" (also azimuth ambiguity, or 180° ambiguity) in magnetic field vector measurements: two field vectors symmetrical with respect to the line-of-sight have the same polarimetric signature, so that they cannot be discriminated. We propose a method to solve this ambiguity by applying the "simulated annealing" algorithm to the minimization of the field divergence, added to the longitudinal current absolute value, the line-of-sight derivative of the magnetic field being inferred by the interpretation of the Zeeman effect observed by spectropolarimetry in two lines formed at different depths. We find that the line pair Fe I λ 6301.5 and Fe I λ 6302.5 is appropriate for this purpose. We treat the example case of the δ-spot of NOAA 10808 observed on 13 September 2005 between 14:25 and 15:25 UT with the THEMIS telescope. Besides the magnetic field resolved map, the electric current density vector map is also obtained. A strong horizontal current density flow is found surrounding each spot inside its penumbra, associated to a non-zero Lorentz force centripetal with respect to the spot center (*i.e.*, oriented towards the spot center). The current wrapping direction is found to depend on the spot polarity: clockwise for the positive polarity, counterclockwise for the negative one. This analysis is made possible thanks to the UNNOFIT2 Milne-Eddington inversion code, where the usual theory is generalized to the case of a line (Fe I λ 6301.5) that is not a normal Zeeman triplet line (like Fe I λ 6302.5).

Keywords. Magnetic fields, polarization, radiative transfer, sunspots, Sun: magnetic fields, techniques: polarimetric, techniques: spectroscopic

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This paper is now submitted (revision submitted) under the title "Azimuth ambiguity solution in photospheric vector magnetic field measurements from multiline observations" by the same authors in the same order to the Journal *Astronomy and Astrophysics*.

† observed with THEMIS based on observations made with the French-Italian telescope THEMIS operated by the CNRS and CNR on the island of Tenerife in the Spanish Observatorio del Teide of the Instituto de Astrofísica de Canarias.

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