Magnetic Forces in the Solar Photosphere and Its Implication

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In this paper we have estimated the integrated magnetic forces for 33 vector magnetograms of four flare-productive active regions to examine the force-freeness of active region magnetic fields at the photospheric level, The magnetic field vectors are derived from simultaneous Stokes profiles of the Fe I doublet 6301.5 and 6302.5 obtained by the Haleakala Stokes Polarimeter of Mees Solar Observatory, with a non-linear least square method adopted for field calibration. The resulting vertical Lorentz force normalized to the total magnetic pressure force |Fz/Fp| ranges from 0.04 to 0.32 with a most probable value of 0.15, which is much smaller than the values obtained by Metcalf et al. (1995) who applied a weak field derivative method to the Stokes profiles of Na I 5896. Our estimation is also consistent with those from theoretical sunspot models. Our results imply that the photospheric magnetic fields are not so far from force-free as conventionally regarded. As a good example of a linear force-free field, AR 5747 is examined. By applying the three methods (a most probable value, a least square fitting method, and a comparison with linear force-free solution) introduced by Leka and Skumanich (1999), we have derived consistent linear force-free coefficients for AR 5747. Our results also show that the force-freeness of photospheric magnetic fields depends on the evolutionary status of the active region.