Magnetic Energy Storage and Current Density Distributions for Different Force-Free Models

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[..] The change in the magnetic configuration due to the increase/decrease of electric current for different force-free models (potential, linear and nonlinear force-free fields) has never been studied in detail before. Here we focus especially on the evolution of the free magnetic energy, the location of the excess of energy, and the distribution of electric currents in the corona. For this purpose, we use an idealised active region characterised by four main polarities and a satellite polarity allowing us to specify a complex topology and sheared arcades to the coronal magnetic field but no twisted flux bundles. We investigate the changes in the geometry and connectivity of field lines, the magnetic energy and current density content as well as the evolution of null points. Increasing the photospheric current density in the magnetic configuration does not dramatically change the energy-storage processes within the active region even if the magnetic topology is slightly modified. We conclude that for reasonable values of the photospheric current density (the force-free parameter alpha < 0.25 Mm-1), the magnetic configurations studied do change but not dramatically: i) the original null point stays nearly at the same location, ii) the field-line geometry and connectivity are slightly modified, iii) even if the free magnetic energy is significantly increased, the energy storage happens at the same location. This extensive study of different force-free models for a simple magnetic configuration shows that some topological elements of an observed active region, such as null points, can be reproduced with confidence only by considering the potential-field approximation. This study is a preliminary work aiming at understanding the effects of electric currents generated by characteristic photospheric motions on the structure and evolution of the coronal magnetic field.

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