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Observational tests of coronal magnetic field models

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Due to the low plasma β the magnetic field is the dominating quantity in the solar corona. Thus, the 3-D magnetic field structure is of basic importance for physical processes in the solar atmosphere, such as flares, coronal mass ejections and X-ray jets. Direct observations of chromospheric and coronal magnetic fields are difficult and usually one has to reconstruct the 3D magnetic field from photospheric measurements. The extrapolation method depends on assumptions regarding the coronal plasma and in particular the electric current flow. The simplest assumption is a current-free potential field. Advanced models include coronal currents with help of linear and non-linear force-free models. Force-free means that the electric current flow is parallel to the magnetic field and consequently perpendicular currents created by, e.g., gradients in the plasma pressure are neglected within this model. This is a good assumption because the magnetic pressure is approximately four orders of magnitude higher than the plasma pressure in the solar corona.

We compare the different magnetic field models (potential, linear force-free, non-linear force-free) with the observationally inferred structure of magnetic loops in a newly developed active region. This is the first time that the reconstructed 3D-topology of the magnetic field is available to test the extrapolations. This comparison reveals that a potential field extrapolation is not suitable for a reconstruction of the magnetic field in this young, developing active region. The inclusion of field-line-parallel electric currents gives much better results. Furthermore, a non-linear force-free computation reproduces the observations better than the linear force-free approximation.