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Comparison of Methodologies to Estimate the Tilt Angle in Solar Active Regions

Active regions (ARs) are the photospheric manifestation of the emergence of magnetic flux ropes (FRs) formed within the solar interior. A key parameter of their evolution is the inclination of the AR polarity axis with respect to the equatorial direction, known as the tilt angle, which is fundamental in semi-empirical flux transport models proposed to explain the transference from toroidal to poloidal solar field components. In this work, we review the estimation of the tilt angle in a selection of around 120 bipolar ARs from Solar Cycle 23 using two methodologies. The first method, which is commonly used, computes the magnetic baricenters of the polarities to define the bipole axis. The second method employs an emerging FR model to fit magnetograms of emerging ARs using Bayesian inference. The Bayesian method uses a twisted toroidal FR model to generate synthetic line-of-sight (LOS) magnetograms, which are then compared with actual observations of the evolution of the photospheric LOS magnetic field of emerging ARs. Model optimization is done by sampling the posterior distribution of the parameters with the Markov Chain Monte Carlo technique provided by the PyMC5 library. In previous works, we found that this method corrects for projection effects, such as magnetic tongues, providing a more accurate estimation of the intrinsic inclination of the FRs during the early stages of AR emergence. In this work, we perform a statistical analysis of the tilt dispersions obtained with each method.

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