Secular stability of dipolar magnetic binaries

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The existence of robust, extensive, and stable magnetic fields in a substantial fraction of early-type stars (mainly Ap, Bp, and O spectral types), white dwarfs, and neutron stars, has been firmly established. However, the mechanisms that give rise to these fields continue to be actively explored, with proposed explanations ranging from fossil fields to mergers and shear-driven dynamos. It is possible that the interplay between magnetism and binarity could provide insights into the origin of these fields, given the significant impact of magnetic fields on the long-term dynamics of binary systems.

The purpose of this investigation is to analyze the secular spin precession behavior of binary systems under the influence of purely magnetic dipole-dipole interactions, focusing on stars with predominantly dipolar, strong, and stable magnetic fields. We utilize an orbit-averaging technique to develop an effective secular model for the spin precession equations. The spin equilibrium configurations and their associated stabilities are obtained by minimizing the magnetic interaction energy of the system. Additionally, we establish a set of conditions required for the assumptions made in our study to be valid. Our findings demonstrate the existence of a single globally stable secular state among the four possible equilibrium states. This state corresponds to the configuration where the magnetic and spin axes of one star are reversed relative to those of the companion, and are orthogonal to the orbital plane. We compare our results to conventional methods of determining instantaneous equilibrium states, which typically neglect the effects of orbital motion. Finally, we provide analytical solutions in the neighborhood of the stable configuration, that can be used to derive secular orbital evolution that might be useful in the context of gravitational wave astronomy with the LISA mission.