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Chaos, Cosmic Ray Anisotropy, and the Heliosphere

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After more than a century of discovering cosmic rays, a comprehensive description of their origin, propagation, and composition still eludes us. One of the difficulties is that these particles interact with magnetic fields; therefore, their directional information is distorted as they travel. In addition, as cosmic rays (CRs) propagate in the Galaxy, they can be affected by magnetic structures that temporarily trap them and cause their trajectories to display chaotic behavior, therefore modifying the simple diffusion scenario.

Here, we examine the effects of chaos and trapping on the TeV CR anisotropy. Concretely, we apply this method to study the behavior of CRs in the heliosphere since these heliospheric effects can be remarkably significant for this anisotropy. Specifically, how the distinct heliospheric structures can affect chaos levels. We model the heliosphere as a coherent magnetic structure given by a static magnetic bottle and the presence of temporal magnetic perturbations. This configuration is used to describe the draping of the local interstellar magnetic field lines around the heliosphere and the effects of magnetic field reversals induced by the solar cycles.

In this work, we explore the possibility that particle trajectories may develop chaotic behavior while traversing and being temporarily trapped in this heliospheric-inspired toy model and the potential consequences that it can have on the cosmic ray arrival distribution. It was found that the level of chaos in a trajectory is linked to the time the particles remain trapped in the system. This relation is described by a power-law that could prove to be inherently characteristic of the system. Also, the arrival distribution maps show areas where the different chaotic behaviors are present, which can constitute a source of time-variability in the CR maps and can prove critical in understanding the anisotropy on Earth.

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