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Magnetic Nulls in Kinetic Simulations of Space Plasmas

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We present the first ever systematic attempt to study magnetic null points and the associated magnetic energy conversion in kinetic Particle-in-Cell simulations of various plasma configurations. We address three-dimensional simulations performed with the semi-implicit kinetic electromagnetic code iPic3D in different setups: variations of Harris current sheet, dipolar and quadrupolar magnetospheres interacting with the solar wind; and a relaxing turbulent configuration with multiple null points. Spiral nulls are more luckily created in space plasmas: in all our simulations except lunar magnetic anomaly and quadrupolar mini-magnetosphere the number of spiral nulls prevails the number of radial nulls by a factor of 3-4. We show that often magnetic nulls do not indicate the regions of intensive energy dissipation. Energy dissipation events caused by topological bifurcations at radial nulls are rather rare and short-living. The so-called X-lines formed by the radial nulls in the Harris current sheet and lunar magnetic anomaly simulations are rather stable and don't exhibit any energy dissipation. Energetic events are more common in the vicinity of spiral nulls enclosed by magnetic flux ropes with strong current at their axes (resembling magnetic islands). These null lines or pinches efficiently dissipate magnetic energy due to secondary instabilities such as the two-stream or kinking instability, accompanied by changes in magnetic topology.

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