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Cluster observations of sub-proton scale magnetic holes in Earth's plasma sheet

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Spacecraft observations from Earth's plasma sheet have shown that magnetic holes with high electron perpendicular temperature anisotropy can develop when the magnetotail is in a relaxed (dipolarized) state. As these appear in environments that are stable to the mirror-mode instability and they often have cross-field scale-sizes equivalent to or shorter than the local proton gyro radius, these magnetic holes cannot exclusively be explained in terms of a standard mirror-mode growth from an anisotropic proton distribution.

We here investigate a series of such events observed by the Cluster spacecraft and assess whether they may in be explained in terms of electron-vortex magnetic holes (EVHM) – a formation scenario where turbulent depressions in the magnetic field interact with the local electron population, leading to a self-consistent growth of magnetic holes by trapped or quasi-trapped electrons with high energies and large pitch angles. Some of the observable features of EVMH are that they should be close to circularly symmetric with non-gyrotropic electron distributions, and there should be a clear relation between the characteristic electron energy and their cross-field scale-size. In addition to evaluating these criteria, we also attempt to constrain the scale-size of the observed magnetic holes, and we show that they in fact can be highly localized in both the direction parallel and perpendicular to the local magnetic field.