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Magnetic holes at sub-proton scales - A new type of nonlinear plasma structure?

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We report the results of 2-D full particle, realistic mass ratio simulations of a new type of magnetic hole with properties which are atypical of magnetic holes formed via mirror mode instability, such as scale size between the electron and proton thermal gyroradii and enhancement of electrons at large pitch angle. The simulated structures have many of the properties of magnetic holes observed in the plasma sheet. The simulated magnetic holes have circular cross-section and are maintained by a current carried by an electron vortex which is due to a population of electrons with pitch angles close to 90 degrees in trapped, or quasi-trapped, non-adiabatic orbits. Similar to the plasma sheet events, the simulated magnetic holes are not in pressure equilibrium. We suggest that the simulations and matching observations of plasma sheet magnetic holes may be evidence for a new type of coherent, nonlinear plasma structure at scales less than the proton thermal gyroradius. We present a simplified model for these structures and show simulations indicating their stability. The implications of these coherent structures for space plasmas and how they arise in turbulence will be discussed.