A three-dimensional hybrid simulation of small magnetospheres and its applications

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Small magnetospheres are formed around magnetized small objects and crustal magnetic anomalies of planetary and lunar surfaces and are also artificially formed for magnetosail propulsions and solar storm shelters relevant to spacecraft protection from solar energetic protons. We study ion scale magnetospheres by performing a three-dimensional global hybrid simulation. The dayside stand-off distance of the ion scale magnetosphere are several to a hundred times larger than the ion Larmor radius of the solar wind proton at the stand-off position where the magnetic field pressure equals to the solar wind dynamic pressure. Since the hybrid simulation treats ions as kinetic super particles via a particle-in-cell method and electrons as a massless fluid, it is suitable for the study of the ion scale magnetosphere. The spatial scale and shape of the ion scale magnetosphere are similar to those of a down-sized MHD scale magnetosphere but its local structures are considerably different from the MHD ones due to the finite Larmor radius effects in the interaction between the solar wind and the magnetosphere. The local structures are considerably controlled by the interplanetary magnetic field. These are important for understanding the formation and structure of small magnetospheres for their various applications.