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Field perturbation and ion dynamics in the dayside Mercury's magnetosphere

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We studied field perturbation and ion dynamics at the dayside Mercury's magnetosphere by performing three-dimensional hybrid particle simulations in which the solar wind ions are treated as particles while electrons are massless fluid. Since the intensity of Mercury's intrinsic magnetic field is much smaller than Earth's, the structure of each region of Mercury's magnetosphere is likely to be affected by the ion kinetic effect, such as the finite Larmor radius effect. In the simulations, we observed regular pattern perturbation in the magnetic field and ion density in the dayside magnetosheath. We also found that the magnetic field intensity is inversely correlated with the ion density. Similar to Earth's magnetosheath, this perturbation pattern found in the magnetic field and the density profiles can be due to the Mirror mode instability, which is caused by the temperature anisotropy of ions. For the instability to grow in time, the condition is required that the perpendicular temperature of ions is larger than the parallel one. To examine the ion temperature anisotropy in the simulation, we analyzed the ion dynamics in the magnetosheath in the velocity phase space and the velocity distribution functions. It turned out that the solar wind ions entering the magnetosheath are thermalized perpendicular to IMF. The magnetic field intensity in the sheath becomes larger than in the solar wind because of the IMF compression. Then the ExB drift velocity of ions in the sheath becomes smaller than the solar wind velocity. In this case, ions that originally had solar wind velocity will start gyrating around the new ExB drift velocity which is smaller than the solar wind velocity in the magnetosheath. The ion velocity distribution eventually spreads around the slow-downed ExB velocity perpendicular to the local magnetic fields. This change in the velocity distribution implies that the ion temperature in the direction perpendicular to the magnetic field becomes larger than the parallel temperature. This temperature anisotropy can satisfy the growth condition of the Mirror mode instability in the magnetosheath. We also analyzed the current flow pattern associated with the magnetic field perturbation by the Mirror mode instability.