磁気嵐中の内部磁気圏プラズマ圧に対するエネルギー帯および粒子種ごとの寄与について：あらせ衛星搭載MEP-i粒子検出器の観測

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Energy and mass dependence of the contribution to storm-time plasma pressure in the inner magnetosphere: Arase/MEP-i observations

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The ring current is mainly controlled by the ion pressure and its spatial gradient. The ion pressure is dominated by ions with energies of a few to a few 100s keV. Oxygen ions of ionospheric origin can be energized in the plasma sheet and/or the inner magnetosphere up to a few tens to a few hundreds of keV. The ionospheric oxygen ions make a significant contribution to the ion pressure during geomagnetically active periods. This paper examines spatial variations and energy-spectral evolution of energetic (~10 to ~200 keV/q) ions during the main phase of a CIR-driven storm on 17 March 2017 (Storm 1) and a CME-driven storm on 27-28 May 2017 (Storm 2). We use ion data from the MEP-i instrument on board the Arase satellite. The instrument measured energetic ions with energies of 5-120 keV/q during Storm 1 and 9-180 keV/q during Storm 2; ion mass/charge was derived from energy and velocity measurements by an electrostatic analyzer and the time-of-flight system, respectively.

During Storm 1, MEP-i observed sudden flux increases of ~10 keV/q protons on the dawn side (~5h MLT) at the beginning of the main phase. After Arase passed through its perigee into an out-bound path around midnight, MEP-i saw high fluxes of greater-than-10 keV/q protons and oxygen ions (and possibly other minor ions) at Lm ~3.5. MEP-i continued to observe high-flux ions until the end of the main phase. Both proton and oxygen ion pressures increased; the O-to-H ratio increased by about an order of magnitude, from ~0.02 to 0.2-0.3. The high-flux greater-than-10 keV/q ions consisted of clearly different two populations: one dominated by 5-20 keV/q ions, likely originating from pre-existing cold plasma sheet population; and the other with structured dispersion signatures at 30-90 keV/q, likely due to the penetration of ions accelerated in the near-Earth plasma sheet. We found that both populations contributed to the total pressure almost equally. It is noticeable that energy ranges that made the dominant contribution (called contributing energies) were extremely narrow, dE = 10-20 keV/q (corresponding to one or two MEP-i's energy bins), for both populations.

During Storm 2, Arase completed a full orbit during the main phase. MEP-i observed enhanced ion fluxes at Lm ~4 at the storm beginning, when Arase was located around midnight. As Arase moved toward post-midnight in an inbound path, MEP continued to observe proton and oxygen high fluxes in a wide energy range (10-120 keV/q). The pressure increased for both protons and oxygen ions; the O-to-H ratio increased from 0.01 to 0.3 during the early main phase (SYM-H greater than -50 nT), and remained at a level of 0.2-1.0 until the storm minimum (SYM-H ~-140 nT). The pressure was contributed by protons and oxygen ions with energies fully covered by MEP-i. The contributing energies are much wider than during Storm 1 and slightly mass dependent: ~20-~100 keV/q for protons and ~30-~120 keV/q for oxygen ions. We also found energy dependence of the O-to-H pressure ratio. It increased with increasing energies, and was higher than 1.0 for greater-than-100 keV/q. The wide contributing energies and the mass dependence of pressure ratio implies the penetration of high-temperature plasma sheet and more effective acceleration of oxygen ions compared to protons.