Plasma Entropy in the Magnetosphere

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In ideal MHD the specific entropy of the plasma is conserved, except at shocks. Thus, entropy should serve as a tracer for plasma throughout the magnetosphere. However, observations show that the specific entropy of the plasma dramatically increases along the typical path of plasma element, from the solar wind, through the magnetosheath, the boundary layers, the tail plasma sheet, and into the inner magnetosphere and the ring current. Ionospheric plasma outflow cannot account for the entropy increase, since its specific entropy is even lower. Surprisingly, MHD based global magnetosphere models by and large replicate the entropy distribution in the magnetosphere, as we will show in this talk. It appears that the non-idealness of the numerical MHD solution, which "miraculously" produces the correct Rankine-Hugoniot jumps at shocks, also seems to accomplish the non-shock entropy production in the magnetosphere. We will present several examples where we trace fluid elements to localize the entropy production sites, and discuss how the magnetospheric plasma is likely much more dissipative than commonly assumed.