火星探査機 MAVEN によって観測された大密度勾配プラズマ境界層の構造とケルビン・ヘルムホルツ不安定性への影響

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Structure of plasma boundaries with a large density gradient observed by MAVEN and its effects on the Kelvin-Helmholtz instability

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In space plasmas, collisions between constituent particles are usually negligible. Moreover, how to cause plasma mixing across different plasma regimes has been one of the fundamental problems in the plasma universe. At a plasma boundary where different plasma regimes are in contact, there often exists a velocity shear and a density gradient. The Kelvin-Helmholtz instability (KHI) has been studied as a promising mechanism to cause the plasma mixing. Although the importance of the density gradient has previously been pointed out, the structure of large-density gradient boundaries remains unknown due to lack of observations. Based on plasma observations at Mars by MAVEN, we show here that the real structure of velocity-sheared boundaries with a 3-order density gradient has a fundamental difference from the traditional input model used in various simulation studies. We propose a new boundary model adopting entropy considerations to agree with the new observations. Comparison of MHD simulation results with the two different initial conditions shows that the change in the initial condition alters the time evolution of KHI and it can potentially affect the escape rate of cold ionospheric ions. The effects on KHI also depend on the magnitude of the density gradient across the boundary. Particularly in high density gradient case with a density ratio of 5000, KHI cannot develop in the traditional boundary model. On the other hand, KHI can be excited in our realistic new model due to the difference in compressibility effects at the velocity shear layer.