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The structure of the Martian bow shock as seen by the MAVEN spacecraft

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With a mean stand-off distance of typically less than 2 planetary radii, the Martian bow shock is amongst the smallest of the solar system not only in absolute size, but also in terms of solar wind ion gyroradii (of the same order than the curvature radius). In addition, the Martian bow shock displays great complexity as the shock structure (with supercritical features) coexists with ultra-low frequency waves of exospheric origin.

Since 2014 the MAVEN spacecraft has sampled the Martian shock exhaustively providing unique observations of the properties of the plasma and fields across the boundary.

In this work, we analyze the morphology of the Martian shock from MAVEN fluxgate magnetometer (MAG), and of solar wind electrons and ions distribution functions and moments from the Solar Wind Electron Analyzer (SWEA) and the Solar Wind Ion Analyzer (SWIA).

In particular, we carefully analyzed the extent of the shock transition from the changes in plasma and field parameters. Then, we calculated fundamental shock parameters such as the shock normal vector by applying different methods, some of them used for the first time around Mars. In the case of quasi-perpendicular, supercritical crossings, we also identified and characterized the size and amplitude of the shock foot, ramp and overshoot, substructures arising from the reflection of solar wind ions as due to the high Mach numbers, the Martian shock is unable to convert the total excess of solar wind kinetic energy into heat.

We conclude that the Martian bow shock exhibits fast-magnetosonic shock features with well-defined supercritical substructures in quasi-perpendicular crossings. The study of this frontier means an important contribution to understand planetary bow shocks across the heliosphere.