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MAVEN observations of complex magnetic field topology in the Martian magnetotail

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MAVEN observations have revealed an unexpectedly complex magnetic field configuration in the magnetotail of Mars. This planetary magnetotail forms as the solar wind interacts with the Martian upper atmosphere and the interplanetary magnetic field (IMF) drapes around the planet. This interaction is classically defined as an induced magnetosphere similar to the plasma environments of Venus and comets. However, unlike at these induced magnetic environments, Mars is complicated by the existence of crustal magnetic fields, which are able to reconnect with the IMF to produce open magnetic fields. Preliminary magnetohydrodynamic simulation results have suggested that this magnetic reconnection may be responsible for creating a hybrid magnetotail configuration between intrinsic and induced magnetospheres. This hybrid tail is composed of the closed planetary fields, draped IMF, and two distinct lobes of open magnetic fields. More importantly, these open lobes appear to be twisted by roughly 45°, either clockwise or counterclockwise, from the ecliptic plane with a strong dependence on the east-west component of the IMF and negligible influence from crustal field orientation. To explore this unexpected twisted-tail configuration, we analyze MAVEN Magnetometer (MAG) and Solar Wind Ion Analyzer (SWIA) data to examine magnetic field topology in the Martian magnetotail. We compare the average magnetic field orientation, directed toward and away from the planet, for a variety of solar wind parameters at various downtail distances. We conclude that the east-west IMF component strongly affects the magnetotail structure, as predicted by simulations. Furthermore, these data reveal that the tail lobes are indeed twisted, which we infer based on model results, to be regions of open magnetic fields that are likely reconnected crustal fields. These MAVEN observations confirm that the Martian magnetotail has a hybrid configuration between an intrinsic and induced magnetosphere, shifting the paradigm of Mars as we have understood it thus far.