The Structure of the warped Io Plasma Torus constrained by the Io Footprint

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The location of the Io Plasma Torus is routinely assumed to be the centrifugal equator of Jupiter’s magnetosphere, i.e. the position along the magnetic field lines farthest away from Jupiter’s rotational axis. In many models, the centrifugal equator is assumed to lay on a plane, calculated from a (shifted) dipole magnetic field, rather than on a warped surface which incorporates Jupiter’s higher magnetic field moments. In this work, we use Hubble Space Telescope observations of the Io Main Footprint to constrain density, scale height and lateral position of the Io Plasma Torus. We show that the leading angle of the footprints can be used to calculate expected travel times of Alfvén waves along the magnetic field lines. For the magnetic field we use the JRM33 magnetic field model. The inversion results show peak densities between 1830 / cm$^3$ and 2032 / cm$^3$ and scale heights between 0.92 R$_J$ and 0.97 R$_J$ consistent with current literature values. Using a warped multipole centrifugal equator instead of a planar dipole the quality of the fit increases by about 25 %. To evaluate these findings quantitatively, a Monte-Carlo-Test was conducted confirming that the multipole centrifugal equator explains the data much better. Furthermore, in a second set of inversion the latitudinal displacement of the torus due to quadropole moments has been fitted using a half synodic periodicity. The best fit locations are comparable to the predicted multipole centrifugal equator location, calculated from the JRM33 model. The additional half synodic periodicity of Io’s orbital position inside the torus due to the incorporated quadropole moments alters Io’s relative position to the torus center by about 0.15 R$_J$ , which changes the plasma density in Io’s vicinity by up to 20 %. 