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Global Flows Of Energetic Ions In Jupiter's Equatorial Plane During The Galileo Era 1995-2003

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Abstract

The largest entity in our solar system besides the heliosphere itself is the Jovian magnetosphere. Its dimensions with a diameter of about 10 times the diameter of the Sun and its extension of more than 5 AU in the magnetotail as well as their richness of plasma processes makes it a special place. Understanding the global configuration and the dynamics of that magnetosphere is key to all the other magnetospheres in our solar system and beyond. Jupiter and its magnetic environment could serve a template for all the "Hot Jupiters" in other the universe. Brice and Ioannidis (1970) was among the first who described the Jovian system as a fast-rotating magnetosphere, highly stretched due to the centrifugal force due to mass-loading of magnetic field lines fed by the internal source Io and partially Europa.

One of the most important parameters of the Jovian magnetosphere is the understanding of the global flow patterns of plasma and energetic particles in Jupiter's magnetosphere. Early measurements taken by the particle spectrometers onboard the Pioneer 10 (P10) and 11 (P11), Voyager 1 (V1) and 2 (V2), and the Ulysses (ULS) spacecraft confirmed the predicted existence of a rotating magnetodisc of charged particles concentrated in the equatorial plane inside the fast-rotating system. Those early flyby data could only provide a snapshot of the flow patterns along the spacecraft trajectories. (Kane et al. (1992); Sands and McNutt (1988); Carbary et al. (1981), Bagenal et al. (2017); Bodisch et al. (2017); Dougherty et al. (2017)). P10, V1 an V2 left the magnetosphere through the predawn to dawn sector of the magnetosphere while P11 traversed along the high latitude noon magnetosphere. ULS added new data sets from three different instruments in the predawn sector and provided the first hint of flow measurements in the southern high latitude dusk magnetosphere. Kolesnikova and Cowley (2002); Desai and Simnett (2000); Laxton et al. (1997, 1999); Kane et al. (1999); Hawkins III et al. (1998); Hawkins III (1997); Cowley et al. (1996); Staines et al. (1993); Staines et al. (1996); Desai and Simnett (1996); Hawkins III et al. (1995a,b). The global flow pattern, however, could not be derived before the Galileo spacecraft reached the planet and orbited Jupiter for almost 8 years covering a whole range of distances and local times. Krupp et al. (2001) used the directional ion anisotropies of the energetic particle instrument EPD for protons, oxygen and sulfur to derive the first global flow pattern. In their study measurements from the first 10 Galileo orbits were used covering the predawn to midnight sector of the Jovian magnetosphere. The interpretation derived from those measurements revealed that corotation of charged particle is observed throughout the magnetotail at least out to 150 **R**J. The flows show a significant dawn-dusk asymmetry where the flows are much higher at dawn compared to dusk at similar distances. Waldrop et al. (2015) used EPD data again and found essentially the same flow results as Krupp et al. (2001). Krupp et al. (2015) has used the same analysis technique as in Krupp et al. (2001) but for all Galileo orbits. Bagenal et al. (2016) reanalyzed all the low energy ion data of the plasma instrument PLS onboard Galileo.

The purpose of this paper is to combine Galileo PLS and EPD measurements to derive the final global flow pattern in Jupiter's equatorial plane. In addition, the azimuthal flow as a function of distance and local time is used to map the corotation breakdown region in Jupiter's magnetosphere and compare it with a mapping of auroral imaging results of the main oval and a magnetic field model.

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