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Effect of Jovian magnetic field on Io's UV spot emission

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Abstract

A reason for the observed correlation between the UV emissions of equatorial spots and Io's magnetic longitude is considered. It is shown that this correlation is due to the dependence of the UV emission generation on the value of the planetary magnetic field on Io's trajectory.

1. Introduction

Observations of the ultraviolet (UV) emission from Io's atmosphere performed by the Space Telescope Imaging Spectrograph of the Hubble Space Telescope show the brightest sources of UV emission near Io's equator ("equatorial spots") [1,2,3]. Among other features, the images contained sulfur and oxygen multiplet emission lines which originate from the collisional excitation of the neutral gas of Io's atmosphere. One of the interesting features of the equatorial spots, whose origin we consider in this report, was revealed by Retherford et al. [2]. They found that the brightness of the equatorial spot emissions correlates with Io's magnetic longitude (Fig. 1) and therefore with Io's distance from the centrifugal equator of the plasma torus as well. The authors of [2, 4] proposed the variation of the local electron density with the change of Io's location within the torus as a source of the brightness variation of the equatorial spots.

In the present report, we propose the variation of the planetary magnetic field near Io as a source of the brightness variation of the equatorial spots.

2. Model

According to the model of the UV equatorial spots proposed in [5], the UV emission from the equatorial spots is generated due to electrons which are formed as a result of an additional ionization of the atmosphere in the front part of the satellite. These secondary electrons in the crossed electric and magnetic fields are shifted downstream into Io's flanks (Fig. 2) and generate UV emission due to collisions with sulfur and oxygen atoms of Io's atmosphere.

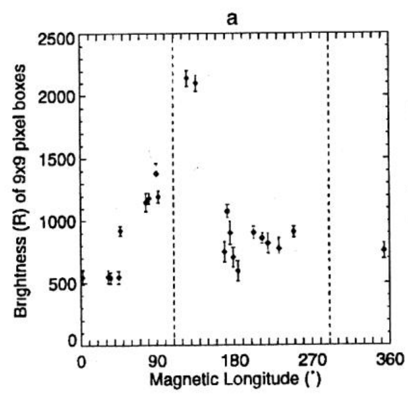

Figure 1: Brightness (R) of OI] 1356Å versus Io's magnetic latitude [2].

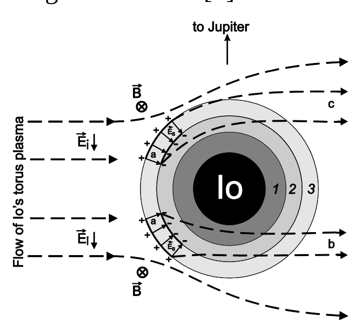

Figure 2. A sketch of electron flows in Io's atmosphere [5].

The density of the secondary electrons, n_e, depends on a number of parameters which include the value of the planetary magnetic field near Io [5]

$$n_e \propto T_e^{-3} n_n^2 B^4 \qquad (1)$$

where T_e is the electron temperature, n_n is the density of and neutrals in the heating region, and B is the planetary magnetic field. For the forbidden UV lines OI] 1356 Å and SI] 1900Å the source can be assumed as an optically thin one. In this case, the brightness of the source varies directly as the electron density n_e, or, with allowance for expression (1), as

$$F_{UV} \propto T_e^{-3} n_n^2 N_a B^4 \qquad (2)$$

From expression (2) it is seen that the brightness of the equatorial spots is strongly dependent on the value of the planetary magnetic field near Io. Figure 3 shows the normalized value of the planetary magnetic field along the orbit of Io (model O4) and the observed brightness of equatorial spots (Sub-Jovian and Anti-Jovian) in the UV lines OI] 1356 Å and SI] 1900Å versus Io's magnetic longitude.

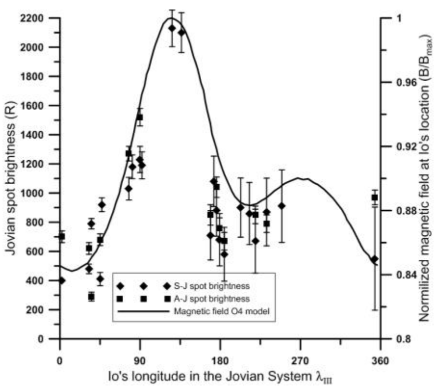

Figure 3. Normalized value of the planetary magnetic field on the orbit of Io (adapted from Fig.1.8 in [6]) and the observed brightness of equatorial spots in the UV lines OI] 1356 Å and SI] 1900Å versus Io's magnetic longitude [2].

It is seen in Fig. 3 that the brightness of the equatorial spots correlates with the value of the planetary magnetic field near Io, which is in good agreement with the prediction of the model of equatorial spots proposed in [5]. Thus, the dependence of the brightness on the planetary magnetic field near Io is a reason for the observed correlation between the brightness of the equatorial spots and Io' magnetic longitude.

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