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Equatorial observations of neutral oxygen at Saturn

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Abstract

Observations of neutral oxygen by the Cassini Ultraviolet Imaging Spectrograph (UVIS) from 2007 have been analysed, when the spacecraft was positioned in the equatorial plane. Averaging about two months of data reveals a broad distribution that is centred at ∼3 R_S, inconsistent with neutral sourcing only from Enceladus. In addition, the oxygen is azimuthally offset about 0.1 R_S south of the equatorial plane. Since these observations are averaged over a long period, these features are both persistent and long-lived.

1. Introduction

Within the magnetosphere of Saturn, neutral species outnumber plasma by a factor of at least ten to one. This abundance of neutrals is predominantly a direct result of outgassing, or venting, from the southern pole of Enceladus – Saturn's sixth largest moon, orbiting at a distance of 3.95 R_S. The outflows emanate from large hot fissures on the moon's surface [9, 6], suggestive of large sub-surface water reserves [7]. Once ejected into the magnetosphere, the water/ice plumage is subject to both radiative and collisional dissociation processes producing a range of simpler species such as OH, O_2, H_2, O, H and their respective ions. Over time, the accumulation and redistributions of these species in and about the orbit of Enceladus produces an extensive torus [5, 1]. A number of these species have been detected, both remotely and in-situ; hydroxyl has been observed with the Hubble Space Telescope [HST; 8]; hydrogen and oxygen has been observed with the Cassini Ultraviolet Imaging Spectrograph [UVIS; 3, 5]. In addition, the Cassini Magnetopsheric Imaging Instrument observed a host of water product ions [MIMI; 4].

Here, emission from neutral oxygen (OI 1304 Å; $2p^3\ 3s^3$ S - $2p^4\ {}^3P$) is mapped in the inner magnetosphere.

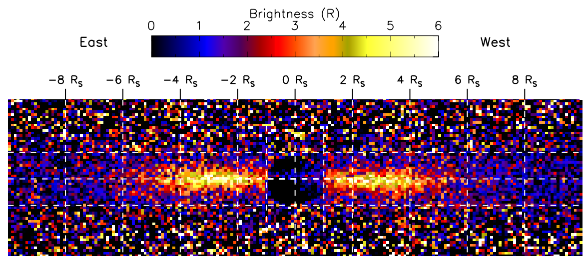

Figure 1: *The average distribution of emission from atomic oxygen (1304 Å) in the Saturn system for the observations of 2007. Indicated in the radial distance from the centre of Saturn. Note that the background subtraction method utilised to derive the brightness does not work on the body of Saturn, rendering the disk dark.*

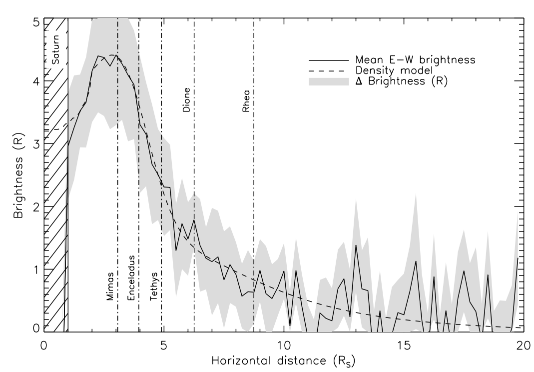

Figure 2: *The radial east-west brightness of oxygen seen in Figure 1. Both the average distribution (solid), and the distribution for each lobe (dotted and dashed) is shown. The major inner moons are also labelled. The width of this swath is 0.5 R_S wide in z.*

2 Observations

The observations analysed here were obtained with the Cassini Ultraviolet Imaging Spectrograph [UVIS; 2], between 2007-185 and 2007-250. Previous analysis [5] have shown that the rings obscure the brightness distribution of neutral oxygen in the inner part of the magnetosphere, restricting our view. Consequently, by analysing these observations from 2007 when Cassini was in the equatorial plane, we can derive the line-of-sight integrated brightness of oxygen up to the limb of Saturn.

3. Results

Figure 1 shows the average distribution of the magnetospheric oxygen for the period covered by the observations considered here. Figure 2 shows the radial distribution along the equatorial plane for both the east and west lobe. The distribution does not peak at 4 R_S, as expected if Enceladus was the dominant neutral source, but is centred at about 3 R_S.

Figure 3 shows the vertical distribution for each lobe between 2 and 4 R_S, showing that the oxygen is offset 0.1 R_S southward of the equatorial plane.

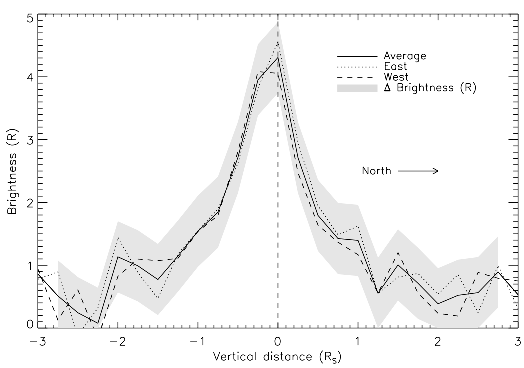

Figure 3: *The average brightness of the vertical distribution of magnetospheric oxygen between 2 and 4 R_S for both the east and west lobe shown in Figure 1. The uncertainty in the mean brightness is shaded grey. The brighness distribution is offset by -0.1 R_S south of the central meridian.*

4. Discussion

The significant offsets, both from 4 R_S and the equatorial plane, indicate a magnetospheric distribution of oxygen that may not be soley sourced from Enceladus. With charge exchange being the dominant loss mechanisms close to 4 R_S any source inward of Enceladus, say Mimas, may be subject to a smaller-loss rate, such that the observed contribution of a weaker source becomes greater than that of Enceladus.

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