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Observations of Enceladus' Plume from Cassini's UltraViolet Imaging Spectrograph

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In 2005 Cassini made the startling discovery of an enormous plume of water vapor coming from the south polar region of Enceladus [1]. Cassini's Ultraviolet Imaging Spectrograph (UVIS) observed gamma Orionis being occulted by the plume. Absorption features in the stellar spectrum showed that the primary composition of the plume was water vapor and the column density of the gas along the line of sight was derived from this data [2]. The path of the star as seen from the spacecraft was a vertical cut through the plume so that column density as a function of altitude could be derived and compared to subsequent models [3]. The flux of water vapor coming from the plume was calculated employing simple assumptions, and compared to the quantity of water needed to maintain the E ring, and the quantity of water required to explain the large amount of atomic oxygen detected in the Saturnian system by UVIS. The supply rate of water vapor from Enceladus is calculated to be $\sim$150 kg/sec, adequate to maintain the level of atomic oxygen in the system through dissociation of water molecules against losses due to charge exchange and ionization. Later in 2005 high resolution images revealed numerous individual jets of fine material coming from the "tiger stripe" rifts across Enceladus' south pole [4, 5]. An obvious question was whether high density gas streams might be associated with the dust jets.

On October 24, 2007 an occultation of zeta Orionis by Enceladus' plume took place. This time the path of the star passing behind the plume was an approximately horizontal cut. With this geometry our objective was to look for opacity variations in the gas vapor that could be due to higher density gas streams. Data was collected in the Far Ultraviolet (FUV) and High Speed Photometer (HSP) channels of UVIS. Both channels cover the wavelength range 111.5 to 191.2 nm. The FUV integration time was 5 sec. The FUV absorption spectrum was again compared to the spectrum of water to derive the gas column density. The derived density at $\sim$25 km altitude is almost identical to the value previously determined in 2005. The High Speed Photometer data was collected every 2 msec. For this occultation the data is best viewed binned by 100, thus a temporal resolution of 200 msec. In this view the occultation is clearly visible and several possible features that could be associated with higher density jets can be seen. Two features appear to be statistically significant and can be corellated with the jets observed in the images at the Baghdad VI and Cairo VIII locations [5]. In general however the gas streams do not appear to be as collimated as the dust jets, with an opacity “enhancement” less than 5%.

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References: [1] Dougherty, M. K., *et al.*, Science 311:1406-1409 (2006). [2] Hansen, C. J. *et al.*, Science 311:1422-1425 (2006). [3] Tian, F. et al., Icarus doi:10.1016 (2007). [4] Porco, C. C. *et al.*, Science 311:1393-1401 (2006). [5] Spitale, J. and Porco, C., Nature doi: 10.1038 (2007).