NEW OCCULTATION OBSERVATION OF ENCELADUS' PLUME.

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Introduction: 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 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]. 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].

New Occultation Data: On October 24, 2007 an occultation of zeta Orionis by Enceladus' plume took place (Figure 1). 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.

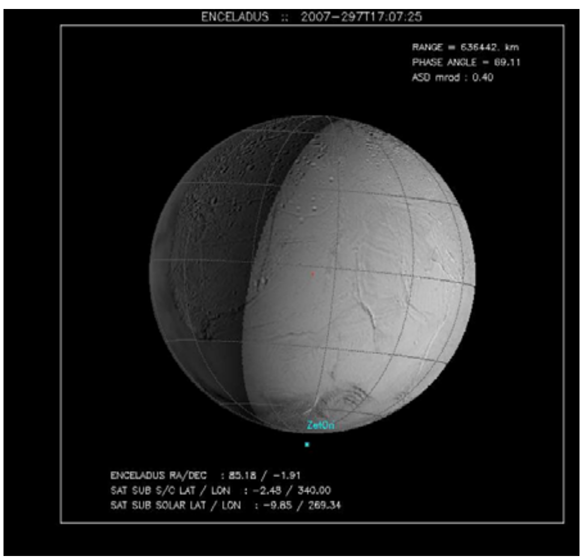

Figure 1. Zeta Orionis passed behind Enceladus' plume on October 24, 2007. The star did not go behind the limb of the moon. The occultation provided a horizontal cut through the plume.

Data was collected in the Far Ultraviolet (FUV) and High Speed Photometer (HSP) channels of UVIS. Both channels cover the wavelength range 1115 to 1912 Å. The FUV integration time was 5 sec. Two FUV records show the stellar signal occulted by the plume. The FUV absorption spectrum was again compared to the spectrum of water (Figure 2) to derive the gas column density. Averaging the two occulted records gives a new derived density, 1.55×10^{16} cm^{-2} , which is almost identical to the value previously determined in 2005: 1.6×10^{16} cm^{-2}. The FUV data is integrated over 5 sec however, approximately half the width of the plume, and comparison to the HSP maximum absorption shows that the highest density in the center of the plume could be higher by a factor of 2.

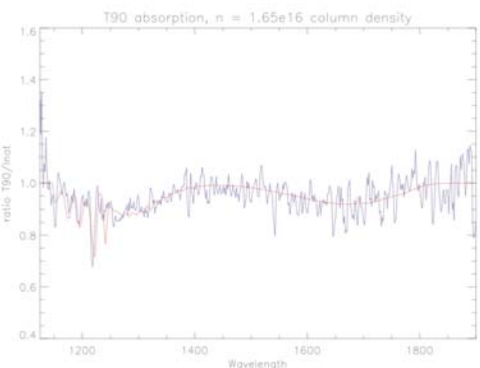

Figure 2. The blue line is the ratio of the occulted to the unocculted signal from zeta Orionis. The red curve shows the fit of water vapor to the spectrum, with a column density of 1.65×10^{16} cm^{-2}.

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 (Figure 3). The next question is then whether or not these features are real or just noise. Statistical tests have been applied and we are working on the criteria to judge which of these features may be declared statistically significant.

As described in [6], the running mean is calculated over the surrounding 1001 integration periods or binned equivalent (e.g for the ith bin of 5 integration periods, the running mean is calculated from bins i-200 to i+200). The mean of these 1001 bins, μ_i, is the baseline for point i. The signal is assumed to be described by a Poisson distribution. C is the binned stellar signal at a particular bin. The probability that the signal would be $\leq$C at that bin is given by the sum of the distribution over values $\leq$C. This step is performed for each bin, i, in the data set to find $P_i = P(\mu_i, \leq C_i)$. P_i is multiplied by the number of bins in the data set, N. This product gives us a value m, where m=NP_i [7], or the number of such events one would expect to occur by chance in the data set. As such, events with m<1 are flagged as statistically significant and then more closely examined.

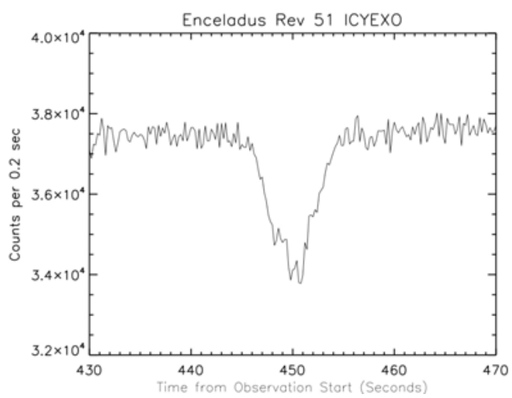

Figure 3. The High Speed Photometer data shows the attenuation of the stellar signal by the gas in the plume.

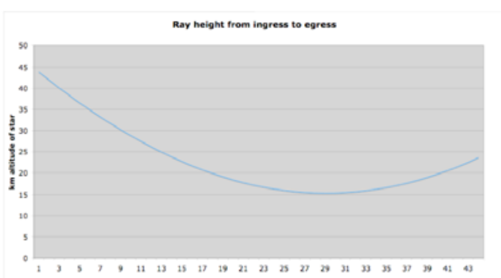

Figure 4. The closest the line of sight got to the star was 15.3 km.

Results: At least two features appear to be real 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. The gas plume is better characterized by a simple $z^{-2.3}$ shape where z is the rayheight (the distance between the line of sight to the star from the limb). This is consistent with the model results reported in [3]. This also bodes well for Cassini spacecraft safety when flying close to Enceladus – a high density gas stream could have caused concern with respect to lofting large particles. Large changes in plume density between the 2005 and 2007 occultations are not observed.

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References:

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