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What does Cassini ENA observations tell us about gas around Europa?

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From about December 2000 to January 2001 the Ion and Neutral Camera (INCA) imaged Jupiter in Energetic Neutral Atoms (ENA) from a distance of about 137-250 Jovian planetary radii (R_J) over an energy range from about 10 to 300 keV. A forward model is employed to derive column densities and assumes a neutral gas-plasma model and an energetic ion distribution based on Galileo in-situ measurements. We demonstrate that Jupiter observations by INCA are consistent with a column density peaking around Europa's orbit in the range from 2x10^{12} cm^{-2} to 7x10^{12} cm^{-2}, assuming H_2, and are consistent with the upper limits reported from the Cassini/UVIS observations. Most of the INCA observations are consistent with a roughly azimuthally symmetric gas distribution, but some appear consistent with an asymmetric gas distribution centred on Europa, which would directly imply that Europa is the source of the gas. Although our neutral gas model assumes a Europa source, we explore other explanations of the INCA observations including: (1) ENAs are produced by charge exchange between energetic ions and neutral hydrogen originating from charge-exchanged protons in the Io plasma torus. However, estimated densities by Cheng (1986) are about one order of magnitude too low to explain the INCA observations; (2) ENAs are produced by charge exchange between energetic ions and plasma ions such as O+ and S+ originating from Io. However, that would require O+ plasma densities higher than expected to compensate for the low charge-exchange cross section between protons and O+; (3) We re-examine the INCA Point-Spread Function (PSF) to determine if the ENA emissions in the vicinity of Europa's orbit could be explained by internal scattering of ENAs originating from Jupiter's high-latitude upper atmosphere. However, the PSF was well constrained by using Jupiter from distances where it could be considered a point source.