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Low-altitude energetic neutral atom (ENA) emission from Saturn's exosphere

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The Ion and Neutral Camera (INCA), one three components of the MIMI experiment on the Cassini orbiter, viewed the low-latitude northern hemisphere of Saturn in a sequence of 16-minute images from an altitude of only 0.4-1.4 Rs during two hours (0108-0316 UT on 1 July 2004) following the Saturn Orbit Insertion (SOI) engine burn. A low-altitude band of energetic neutral atom (ENA) emission appeared to be centered N10 deg and extended from post-noon to at past midnight in the TOF energy range $\sim$10-100 keV/nucleon. It appeared to be inside the inner edge of the D-ring (r=1.11 Rs). It was about 1/10 the brightness of the ENA emission from the ring current region (3-8 Rs), also visible in the same images. We interpret this ENA emission to be produced by double charge exchange. ENAs are generated by singly-charged energetic ions from the ring current region. Those that enter Saturn's molecular hydrogen exosphere are stripped and thus become ions temporarily trapped on magnetic field lines several thousand kilometers above the 1-bar level. Subsequently, these ions undergo a second charge exchange collision and are emitted from the exosphere as ENAs once again. A similar double charge-exchange mechanism was identified at Earth in the early 1970s as the source of a low-altitude (L=1.1) radiation belt. The brightness of the exospheric emission, relative to the ring current source region, implies that the ENA emission from Saturn is optically thick. The ENA source in the ring current region is also much brighter, because of the much higher density of neutral gas confined to Saturn's equatorial plane at distances well beyond the rings. Saturn's exosphere thus produces a diffuse mirror image of the ENAs generated in the ring current.