N_2 SELF-SHIELDING IN THE SOLAR NEBULA: AN UPDATE

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Introduction: The N_2 molecule is isoelectronic to CO, and exhibits a similar band system to CO in the VUV. The resolved rovibronic structure and very strong bands make N_2 a plausible candidate for self-shielding, even though it is an order of magnitude less abundant than CO in a gas of solar composition. The discovery of very large ^{15}N enrichment in lithic clasts in carbonaceous chondrites (e.g., [1-5]), in micrometeorites [6], and in comets [7] could be due to either low temperature ion-molecule chemistry that leads to NH_3 formation [8] or to N_2 self-shielding. Nitrogen isotopes in the solar system may also be enriched in ^{15}N as a result of N_2 self-shielding [9].

Previous modeling: A preliminary assessment of N_2 self-shielding in the outer nebula [10],[11] suggests that although self-shielding does occur, it produces substantial ^{15}N enrichment in only a very small fraction of nebular material at 30 AU ($\delta^{15}N$ ~ +800 ‰ in < 1 ppm of total N, [11]). Also, the total enrichment in self-shielding product nitrogen (as HCN) is about +100 ‰ over ~ 10^6 years at 30 AU. This enrichment may not be large enough to distinguish Jupiter, with $\delta^{15}N$ = -380± 80 ‰ [12], from the Sun, which has solar wind with $\delta^{15}N$ ~ -450±100 ‰ [13].

Modeling in progress: The preliminary model ([10],[11]) used a reduced set of nitrogen reactions, and used an N_2 shielding function inferred from a Titan atmosphere photochemical model [14], with mean N_2 cross section representative of the 91-100 nm range applicable to the solar nebula. Present modeling includes 1) a more complete set of nitrogen reactions, and 2) a full integration over 91-100 nm of N_2 dissociation in the presence of H_2 absorption. The $^{28}N_2$ and $^{29}N_2$ cross sections are from a coupled-channel model description of measured N_2 cross sections, and were provided by A. Haeys and B. Lewis at ANU. These calculations are in progress.

Implications: As I pointed at the 2010 LPSC, the preliminary model results on nebular N_2 self-shielding have implications for CO self-shielding in the outer solar system. One criticism of outer solar nebula CO self-shielding has been that Jupiter would become more enriched in ^{15}N due to N_2 self-shielding than is observed [12]. However, with present uncertainties, a ~100 ‰ increase in outer nebular $\delta^{15}N$ is not enough to rule out the occurrence of N_2 (and CO) self-shielding. Reduced uncertainties on solar wind $\delta^{15}N$, as well as a quantitative assessment of fractionation during solar wind acceleration, could influence this conclusion.

References: [1] Sugiura et al. 2000. *MAPS* 35:987-996. [2] Ivanova et al. 2008. *MAPS* 43:915-940. [3] Briani et al. 2009. Abstract #1642. 40th LPSC. [4] Bonal L. et al. 2009. Abstract #2046. 40th LPSC. [5] Ishii et al. 2009. Abstract #2467 40th LPSC [6] Floss C. et al. 2009. Abstract #1082. 40th LPSC. [7] Bockelee-Morvan D. et al. 2008. *ApJ Lett.* 679:L49-L52. [8] Rodgers S. D. and Charnley S. B. 2008. *MNRAS 385*: 48. [9] Clayton R. N. 2002. *Nature* 415:860-861. [10] Lyons et al. 2009. *GCA* 73, 4998-5017. [11] Lyons J. 2009. Abstract #5437, 72nd MetSoc meeting. [12] Owen T. 2001. *ApJ* 553, L77-L79. [13] Kallio A. et al. 2010. Abstract # 2481 41st LPSC. [14] Liang et al. 2007. *ApJ* 664: L115–L118.