

IR Spectroscopy and physicochemical effects on astrophysical N₂O ice bombarded by energetic ions

A.L.F.de Barros^{*1}, G.C.Almeida^{†2}, R.C.Pereira¹, C.A.P.da Costa^{†2}, E.F.da Silveira^{†2}

¹Departamento de Física, CEFET/RJ, Av. Maracanã 229, 20271-110 Rio de Janeiro, RJ, Brazil

²Departamento de Física, PUC-Rio, Rua Marquês de São Vicente 225, 22451-900, Rio de Janeiro, Brazil.

Nitrous Oxide, N₂O, was the first N-bearing molecule found in the interstellar medium (ISM). The discovery of N₂ ice on the surfaces of Triton (Neptune's largest moon) and Pluto, the last one recently confirmed by the NASA New Horizons probe, shed light on a new ice phase mechanism for the formation of N₂O based on non-equilibrium chemistry, where an electronically excited oxygen atom adds to a frozen nitrogen molecule in a no-barrier reaction [1]. Regarding to better understand the N₂O ice phase chemistry, the aim of this work is to investigate the effects of cosmic ray impacts on a N₂O astrophysical ice analog.

Understanding the nitrogen and oxygen chemistry in space is an important step to link the formation of interstellar grain mantles, comets, and frozen surfaces of outer solar system bodies to the origin of life. Nitrogen-containing molecules are essential for life on Earth, and nitrogen oxides are considered to be important astrochemical precursors of complex species and prebiotics, one of such a molecule is N₂O, the nitrous oxide [2].

The current laboratory experiments performed at PUC-Rio, simulate the energy transfer processes that occur when protons and helium ions bombarded the nitrous oxide ice, for example at 10 K. The obtained results help to understand the effects of energetic light ion collisions in the radiolysis of ices in ISM. Infrared spectroscopy (FTIR) was performed before and during irradiation of N₂O icy targets with 1.5 MeV H⁺ and He⁺ beams, permitting absorbance analysis of the main bands.

Figure 1 shows to the most intense absorption bands of N₂O, corresponding to the main rotational and vibrational transitions for different ions.

Figure 1 shows to the most intense absorption bands of N₂O, corresponding to the main rotational and vibrational transitions for different ions. It was observed that the destruction of the solid ice N₂O leads to the formation of all known nitrogen oxides: NO, NO₂, N₂O₂, N₂O₃, N₂O₄ and N₂O₅, besides the azide - N₃ and ozone - O₃. The formation and destruction cross sections of each observed molecular species are determined and the atomic nitrogen and oxygen budgets are used to verify the atomic rearrangement in the chemical reactions.

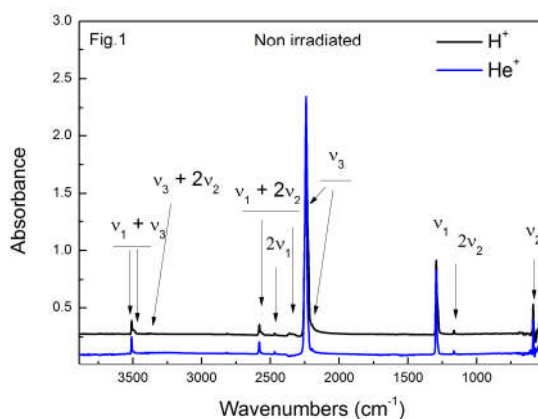


Figure 1. Experimental infrared spectra obtained for the N₂O ice at 10 K before irradiation for H⁺ and He⁺ beams.

As an astrophysical application, the predicted values of the dissociation rate integrated for all cosmic ray energies gives the relative importance of light ions in the astrochemistry induced by ion impact.

Acknowledgments:

The agencies CAPES, CNPq (INEspaço) and FAPERJ (E-110.087/2014) for partial support.

References

- [1] Jamieson, C. S., et al. 2005, *Astrophys. J.* 624, 436-447.
- [2] d'Hendecourt, L. B., Allamandola, L. J., Grim, R. J. A., & Greenberg, J. M. 1986, *A&A*, 158, 119
- [3] de Barros A. L. F., G. C. Almeida, & da Silveira E. F, in preparation.

¹E-mail: ana.barros@cefet-rj.br

²E-mail: g.camelier@gmail.com