

Mutual neutralisation of atmospheric radical ions at the double electrostatic ion storage ring DESIREE

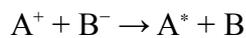
M. Poline¹, M. Larsson¹, N. S. Shuman², S. G. Ard², A. A. Viggiano²,
H. T. Schmidt¹, H. Zettergren¹, R. D. Thomas¹

¹Stockholm University, Department of Physics, Stockholm, Sweden,

²Air Force Research Laboratory, NM 87117, USA

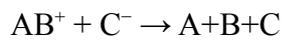
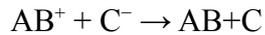
mathias.poline@fysik.su.se

In the highest layer of Earth's atmosphere, situated approximately 150 km above the surface, particles are exposed to high levels of radiation and are mostly composed of atomic ions, dominated by O⁺ and N⁺. During the night, these are neutralised through recombination with free electrons or by interactions with anions [1,2], a phenomenon known as mutual neutralisation (MN). The process is straightforward to write out:



i.e the captured electron ends up in an electronically excited state of the neutralised atom.

In lower layers however, less ionising radiation is present, due to the absorption from the F layer and the higher pressure, and it is believed that the most abundant ions are molecular radicals, namely N₂⁺, NO⁺ and O₂⁺ [3]. These highly reactive species also interact with the anions present, and two different outcomes are then possible:



i.e, the captured electron could also end up on a repulsive potential of the formed molecular neutral, such that it fragments, yielding three products.

At the unique cryogenic electrostatic double storage ring DESIREE, these reactions can effectively be studied [4]. We present here the first merged beams results of several atmospheric molecular radical ions, namely O₂⁺, NO⁺, and N₂⁺ interacting with O⁻. The results are interesting, as both processes are observed with very different populations depending on the molecular cation. For the three-body processes, distinct dynamics are observed, with a clear vibrational dependence on the product yield.

[1] J. Qin *et al.*, *J. Geophys. Res. Space Phys.* **120**, 10116 (2015)

[2] M. Poline *et al.*, *Phys. Chem. Chem. Phys.*, **23**, 24607-24616 (2021)

[3] D. Smith and P. Spanel, *Mass Spectrometry Reviews*, **14**, 255-278 (1995)

[4] R. D. Thomas *et al.*, *Review of Scientific Instruments* **82**, 065112 (2011)