Two-body vs three-body processes in mutual neutralisation reactions of atmospheric ions at DESIREE

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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], a phenomenon known as mutual neutralisation (MN). The process is straightforward to write out:
$A^+ + B^- \rightarrow A^* + B$,
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, i.e N_2^+, NO^+ and O_2^+. In the MN of such diatomic cations with an atomic anion, two different outcomes need to be considered:
$AB^+ + C^- \rightarrow AB+C$
$AB^+ + C^- \rightarrow A+B+C$
i.e, here 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 [3,4]. We present here the first merged beams results of several atmospheric molecular ions, namely O_2^+, NO^+, and N_2^+ interacting with O^-. The results are interesting, as both processes are observed with very different populations depending on the molecular cation, with no dependence on the bond energy. For the three-body processes, very distinct dynamics are observed, with a clear vibrational dependence on the product yield. These results can be partially be explained from a theoretical approach based on dissociative recombination.

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