Mutual Neutralization Studies of O^- and N^+/O^+ ions at Subthermal Collision Energies

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Synopsis Absolute mutual neutralization cross sections and branching ratios have been measured and calculated for O^- colliding with N^+ and O^+ in the 0.005-10 eV collision energy range.

Mutual neutralization (MN) of atomic or molecular anions and cations $A^+ + B^- \rightarrow A + B$ is a key reaction for the ionization balance of various astrophysical environments [1, 2] and is included in models of chemical reaction networks [3, 4]. However, the few experimental MN studies with atomic ions have so far mainly been limited to collision energies down to a few eV, which is higher than the range of energies relevant for cold astrophysical environments. Moreover, these experiments could not resolve the electronic states of the neutral products [5].

We recently upgraded the merged beam setup in Louvain-la-Neuve to reach 5 meV collision energies and measure kinetic energy release (KER) spectra, giving unambiguous identification of LS-terms of the products and branching ratio among them.

We present experimental KER-spectra and absolute cross sections for the mutual neutralization of O^- with N^+ and O^+ in the 0.005-10 eV energy range. We found a very good agreement with the total cross section measured at higher collision energies by Hayton and Peart [6]. Cross sections and branching ratios were calculated down to 1 meV for these two systems using the method of X. Zhou and A. S. Dickinson [7], based on a multi-channel Landau-Zener model and an asymptotic method for the ionic-covalent coupling matrix elements. Good agreement is found for $O^+ + O^-$, but for $N^+ + O^-$ the excitation channel from an *s*- to a *p*-orbital of N is highly underestimated. The same method will be used to calculate the branching ratio of other systems studied with the same apparatus in order to shed new light on these charge transfer processes.

The present study will also serve to benchmark merged ion beams studies at the double electrostatic storage ring DESIREE now in operation at Stockholm University [8]. With DESIREE it will be possible to study MN between molecular ions with very low internal energies (down to 10 K).

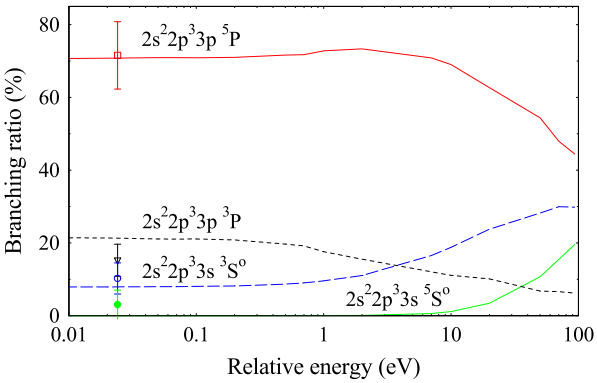

Figure 1. Symbols: our measured branching ratios for the mutual neutralization reaction $O^+ + O^- \rightarrow O(^{2s+1}L) + O(^3P)$ at <E> = 24 meV. Full and dashed curves: our calculations extending the work of Zhou and Dickinson [7] towards lower collision energies.

References

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