Collisional Removal Rate Constants for N_2 (a, $v = 0$ and 1) with N_2, O_2 and O Colliders at 300, 240 and 150 K

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Accurate modelling of the neutral number density in Earth's middle and upper atmosphere is important for understanding the atmospheric processes, energy deposition and local dynamics of the atmosphere. This knowledge in turn helps to improve measures to counteract drags on satellites.

Spectrally resolved emission in aurora and airglow from atomic and molecular species is used by researchers to obtain a good estimate of the neutral number density of middle and upper atmosphere. A few years ago Budzien et al [1] have shown that the LBH emission intensity from lower vibrational levels of the N_2 a is a factor of 1.6 more in the Earth's airglow than predicted by then existing models. Eastes [2], after incorporating collisionally-induced electronic transitions (CIET) among the three nested singlet electronic states a, a' and w, has improved the agreement between his modelling and observations of Budzien et al [1]. However, it was needed to estimate several rate constants due to the lack of the laboratory experimental data.

Experimentally measured rate constants at temperatures relevant for atmospheric conditions are crucial to improving the accuracy of the models. With this aim we have conducted two-color pump-probe resonance-enhanced multiphoton ionization (REMPI) experiments on the $v = 0$ and 1 levels of $N_2(a^1\Pi_g)$ state at 300, 240 and 150 K. Our experimental results, including first time laboratory measurements for $v = 1$ level at low-temperatures and with O-atom colliders that are generated through photodissociation of O_3, will be presented and discussed.

Briefly, we find that the collisional removal rate constants of the first two vibrational levels are the same within the experimental errors, like for example, $3.5\pm0.5 \times 10^{-11}$ cm^3 sec^{-1} with N_2 colliders at 300 K. The rates are twice as fast at 150 K compared to those at 300 K. The rate constants extracted from our experiments are consistent with the earlier laboratory experiments as well as the estimates of Eastes [2] for N_2 and O_2 colliders at 300 K, but show significant deviation for collisions with O atoms (estimated: 5.1×10^{-9}, observed: 2×10^{-9} cm^3 sec^{-1}). Implications of our results in combination with earlier work on modelling the number density of neutral species in upper atmosphere will be presented in detail.

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[2] Eastes, R. W., *J. Geophys. Res.* **105**, 18557 (2000)