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Detection of N_2 metastable molecules using a solid N_2 matrix detector.

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Synopsis. Excitation of metastable molecular N_2 by electron impact has been studied in the impact energy range from threshold to 300 eV using time-of-flight techniques and a novel solid matrix detector.

Metastable atoms and molecules are important species in a wide variety of applications ranging from low temperature electrical discharges to planetary atmospheres and astrophysical sources. Lifetimes of metastable states can range from tens or hundreds of microsecs to secs to hours or even longer. In our laboratory we have pioneered [1] the use of solid rare gas matrices at low temperatures to allow detection of metastable atomic species with an np^4 electron configuration, such as O (^1S) or (^1D), both prominent species in earth's upper atmosphere. In this technique the metastable particle impinges on the solid surface and forms an excimer which immediately radiates. The resultant photon (visible or near infra-red) is readily detectable. The effect of the excimer formation results in a lifetime reduction of the metastable species sometimes by as much as a factor of 10^7. In the present work we investigate the behaviour of a solid N_2 matrix as a metastable detector and use it to investigate the excitation of hitherto unknown molecular metastable species in N_2.

Metastable N_2 molecules produced in the interaction of electrons of carefully controlled energy with a thermal beam of N_2 in a crossed beam set-up have been studied in the energy range from threshold to 400 eV. The e-beam is pulsed and the metastables produced drift to a solid nitrogen target held at 10 K. Here they form excimers which immediately radiate. The resultant photons are detected using a photomultiplier-filter combination. Time-of-flight techniques are used to separate these photons from prompt photons produced in the initial electron-N_2 collision. The excimer emission is strongest in the green but still significant in the red spectral region. Quench plates in the path of the metastables to the detector allow a check for any Rydberg species which might be present. Excitation functions and threshold measurements help to identify the metastable states being observed and the excitation mechanisms which are responsible.

A sample of the results obtained is shown in Figure 1. Here the excitation probabilities are shown for metastables that produce excimers which decay with the emission of red and green photons respectively. Some significant points should be noted. First, the shapes of the two excitation functions in Figure 1 are clearly different from each other and from the shapes of known N_2 metastable excitation functions [2]. Second, the observed thresholds (~15 eV) are significantly higher than the thresholds of known N_2 metastable states such as a $^1\Pi_g$, $A^3\Sigma_u^+$ or E $^3\Sigma_g^+$. The data strongly suggest the existence of at least two hitherto unrecognised metastable states of N_2.

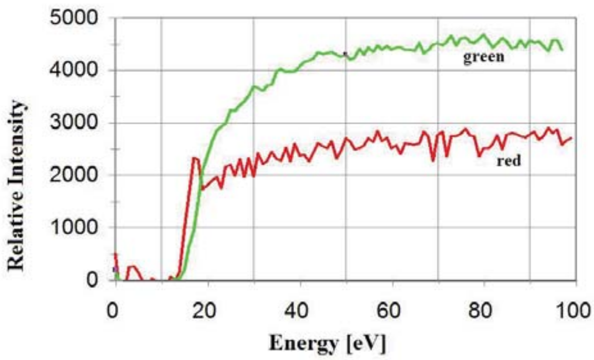

Figure 1. Relative excitation probabilities for production of N_2 metastables as a function of exciting electron energy. Excimer decay in the red and green spectral regions are indicated.

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References.

[1] J W McConkey and W Kedzierski, 2014, Adv At Mol Opt Phys, **63,** 1.

[2] W L Borst and E C Zipf, 1971, Phys Rev A, **3**, 979.