Rotationally Resolved Fluorescence Emissions from the Coupled $c_4'(0)$ and $b'(1)$ States of N_2

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Recently it has been shown theoretically [1] that predissociation and perturbation processes in N_2 involve global interactions among all $^1\Sigma$, $^1\Pi$, $^3\Sigma$, and $^3\Pi$ states. In addition to the global couplings there exists local accidental rotational perturbation [2]. The case in point, the band origins of the $c_4'(0)$ and $b'(1)$ are only separated by 0.0505 nm [2,3]. The absorption oscillator strength of the c_4'-X (0,0) band is a factor of 14.4 times larger than that of the b'-X (1,0) transition. Because of the strong mixing the weaker b'-X (1,0) transition will borrow intensity from the intensely perturbed c_4'-X (0,0) transition. It is thus clear that rotationally resolved J-dependent fluorescence production cross-sections and predissociation yields of N_2 are required at various temperatures in order to provide theoretical constraints and applications in modeling planetary atmospheres.

In this work we have obtained ultrahigh-resolution (0.0014 nm) fluorescence excitation spectra (FES) of N_2 in the EUV region using a synchrotron radiation source. To the best of our knowledge this is the first time that an experiment clearly demonstrates FES spectra with a resolving power of 7×10^4. Specifically, we have carefully investigated the coupled $c_4'(0)$ and $b'(1)$ states. In Fig. 1 the features between absorption (red curve) and FES (blue curve) do not match at all. The absorption features belong to the c_4'-X (0,0) transition while in FES to the b'-X (1,0) transition. The rotational assignments [2] of the latter transition are marked in Fig. 1. The irregularities in line spacing and intensities at P(11), P(12), R(9), and R(10) are evident of accidental rotational perturbation [2,3]. The extremely intense emission rates of those perturbed and adjacent lines in the b'-X (1,0) transition result from intensity borrowing from the much intense c_4'-X (0,0) transition. Spectral perturbation and predissociation effects are clearly observed in the FES. We are currently working on the data analysis to deduce the J-dependent predissociation yields and the absolute fluorescence cross-sections.

We plan to further investigate the high-resolution FES at temperatures as low as 78 K and to determine J-dependent predissociation yields for the $c_4'(0)$, $b'(1)$, and other relevant states of N_2. The results obtained will be particularly useful in our understanding of N_2 airglow emissions of the Earth, Jupiter, Saturn, Titan, Triton, and Pluto. The relevant atmospheric temperature is ~260-1000 K for Earth, ~170-1000 K for Jupiter, ~140-350 K for Saturn, ~97-200 K for Titan, ~50-100 K for Triton, ~44-100 K for Pluto, and even lower for Uranus and Neptune.

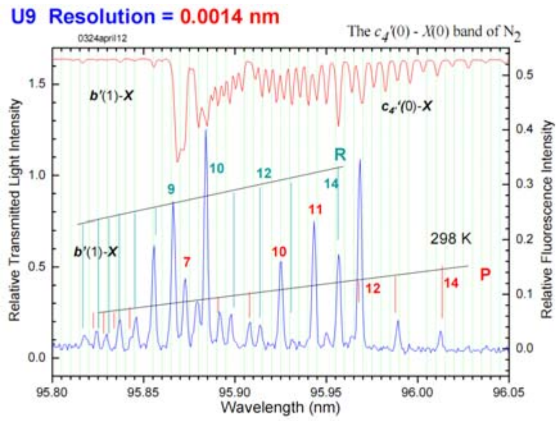

Fig. 1: The FES spectrum produced through photoexcitation of N_2 in the 95.8-96.05 nm region. A N_2 pressure of 0.02 mTorr was used.

References

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