The $O_2(b^1\Sigma_g^+)$ State - Nightglow Observations and Laboratory Kinetics

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Ground-based observations of the $O_2(b^1\Sigma_g^+)$ state in the terrestrial nightglow have been limited to the 0-1 band of the Atmospheric Band system, at 864 nm. Countless observations of this feature have been made, in order to monitor temperature and gravity waves, and to determine the variability of oxygen atom densities in the 95 km region. Although other O_2 emission systems (cf. the Herzberg transitions) exhibit a range of emitting vibrational levels, vibrational excitation has not been reported in either the $b^1\Sigma_g^+$ or the $a^1\Delta_g$ states. It is generally understood that this is a consequence of the long radiative lifetimes of the two states and the large difference in collisional quenching rates for $\mathrm{v} = 0$ and $\mathrm{v} > 0$ levels. Recent spectra obtained with the Keck telescope and the HIRES echelle spectrometer on Mauna Kea demonstrate that with adequate sensitivity and resolution, vibrational excitation can in fact be observed in the $b^1\Sigma_g^+$ state.[1] We have shown that levels up to at least $\mathrm{v} = 15$ are generated in the nightglow, and that the $\mathrm{v} = 0,1$ levels exhibit high rotational-temperature components. At the same time, we are pursuing a program of laboratory investigations[2] of the temperature-dependent collisional removal of vibrational excitation in the $b^1\Sigma_g^+$ and $a^1\Delta_g$ states of O_2 which will ultimately lead to an understanding of relationships between the observed nightglow band intensities, the production rates of the vibrationally-excited levels, and the ultimate source function - atom recombination in most cases. These measurements will also impact auroral observations, and observations of the Venus and Mars atmospheres.

References:

[1] T. G. Slanger, D. L. Huestis, D. E. Osterbrock, and J. P. Fulbright, Science 277, 1485 (1997).
[2] E. S. Hwang, A. Bergman, R. A. Copeland, and T. G. Slanger, "Temperature Dependence of the Collisional Removal of $O_2(b^1\Sigma_g^+, \mathrm{v} = 1,2)$ at 110-260 K, and Atmospheric Applications", J. Chem. Phys. (submitted, 1998).

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