# $O_2(^5\Pi_g)$ and Atmospheric Oxygen Atom Recombination

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Understanding oxygen atom three body recombination is crucial for modeling and interpreting the spectral distributions and intensities of the oxygen nightglows of the Earth and the planets [1]. Recent laboratory studies at SRI [2] have provided an unexpected new means of improving this understanding.

Collisions of oxygen or nitrogen molecules with laser-excitated high vibrational levels of $O_2(A^3\Sigma_u^+)$ produce a longer lived excited state, whose resonant multiphoton ionization (REMPI) spectrum cannot be assigned to any known singlet or triplet system. We attribute the lower state of this new transition to the often-invoked but previously unobserved $^5\Pi_g$ state of $O_2$. Although quite weakly bound, at large internuclear distances this state is predicted [3,4] to be the lowest of the states dissociating to ground state atoms, and because of its high degeneracy could be a key intermediate state in O + O recombination, contributing more than 70% according to early estimates [5].

Recent calculations [4] of the potential energy curves gave a shallow well depth (0.16 eV) which Bates [6] concluded made $O_2(^5\Pi_g)$ a relatively insignificant participant, under the assumption that the rate of collisional relaxation is orders of magnitude slower than the rate of collision-induced dissociation. The recent SRI measurements [2] show that the rates of collisional removal (presumably by electronic relaxation to the more strongly bound states) for both oxygen and nitrogen are actually about a factor of 6 *faster* than the dissociation rate estimated by Bates [6]. Thus the first experimental information on $O_2(^5\Pi_g)$ reestablishes its significance in oxygen atom recombination.

The new observations motivate efforts to develop a more detailed and quantitative theoretical model of O + O + M collisions. In addition to the experimental results, we will also present preliminary work on spin-orbit resolved long-range potential curves for $O_2$ and implications for atmospheric recombination and the role of $O_2(^5\Pi_g)$ in predicting nightglow emissions.

**References**:

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