# Research on Electronically- and Vibrationally-Excited $O_2$, with Application to Planetary and Terrestrial Atmospheres

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The terrestrial-like planets - Venus, Terra, and Mars - have various characteristics in common, among them the fact that oxygen is present in their upper atmospheres. For Venus and Mars the source is $CO_2$ photodissociation, while in all three atmospheres, excited $O_2$ is produced from O-atom recombination. Almost all optical transitions in $O_2$ are beset by detectability problems; either the transitions are forbidden by selection rules, or (for the Schumann-Runge system) predissociation is very strong. For this reason, progress in investigating the chemistry, reactivity, and branching ratios and pathways of reactions involving excited $O_2$ has been relatively slow.

At SRI we have been active in studying these species for a considerable period of time, and have developed ways of circumventing the usual problems. To a large extent, fluorescence spectroscopy has been replaced as a detection technique by resonance-enhanced multiphoton ionization (REMPI), thereby taking advantage of the fact that processes forbidden in a one-photon transition are often allowed via two photons. In this manner, it has proved possible to make dynamics measurements on individual rotational/vibrational levels of the three Herzberg states, as well as the recently-discovered quintet state [1] lying in the same energy region. For the lower electronic levels, the $O_2(a)$ and $O_2(b)$ states (the former giving intense emission in all three terrestrial planets), we have successfully used REMPI processes to investigate dynamics both in the lower vibrational levels (v = 1-3) and in the very high levels (v = 10- 20) that are generated by collisional relaxation of the Herzberg states. The colliders used in these studies are the ones appropriate to the planetary atmospheres - $O_2$, $N_2$, and $CO_2$.

**References**:

[1] R. A. Copeland, B.-Y. Chang, and D. L. Huestis, Collisional Removal of $O_2(^5)\Pi_g$ at 195 and 150 K, Eos, Trans. AGU 82, S283 (2001).

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