CO_2 + O Collisions: A Grand Challenge for Upper Atmospheric Science

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Infrared absorption and emission by atmospheric constituents play a crucial role in determining the atmospheric temperature profiles of Earth and the other terrestrial planets, Venus and Mars. Carbon dioxide is a key contributor to the global energy balance of all three planets, mainly through its vibrational bending mode, $CO_2(\nu_2)$, which emits radiation near 15 μm (667 cm^{-1}). This emission is a key cooling mechanism for the middle and upper atmospheres of these three planets. Accurate knowledge of the excitation mechanism for $CO_2(\nu_2)$ and the corresponding rate is crucial for reliable modeling of these atmospheric layers.

The key process controlling the coupling of the 15-μm radiation with the heat reservoir is excitation/quenching in collisions of $CO_2(\nu_2)$ with thermalized atomic oxygen in its ground state, $O(^3P)$. This process is poorly understood despite numerous studies over the past several decades. Unacceptably large discrepancies by factors of 3-4 exist between laboratory rate constant determinations for O-atom excitation/de-excitation of $CO_2(\nu_2)$ and the corresponding values retrieved by analyses of space-based atmospheric observations.

We discuss the relevant background and propose a research program that will bring together diverse expertise relevant to the theme of understanding upper atmospheric cooling and energy balance. A key focus will be to exploit the synergy of space-based observations, modeling and theoretical calculations, as well as laboratory experiments in order to resolve the long-standing problem of CO_2 + O collisions as a source of CO_2 emission at 15 μm.

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