Understanding Molecular Oxygen in Cometary Atmospheres

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The Rosetta spacecraft discovered molecular oxygen during its orbiting of comet 67P Churyumov-Gerasimenko [Bieler et al., Nature 526, 678-681 (2015)]. Based on previous ground-based cometary observations, this was an unexpected finding, as was the significant amount of O_2 detected. The average value of $[O_2]/[H_2O]$ reported by Rosetta was 0.038, with a range of 0.01-0.10. Previous cometary ground-based measurements have relied on optical measurements, whereas the Rosetta study utilized mass spectroscopy.

We have initiated a research program to investigate optical spectra from various comets for evidence of molecular oxygen. Such emission from comets has not been reported previously, but there are compelling reasons for its presence in light of the Rosetta results. In contrast to the situation with molecular oxygen, the presence of atomic oxygen in cometary atmospheres is well established, with both $O(^1D)$ and $O(^1S)$ known emitters that give rise to the green and red emission lines. Nevertheless, it it is generally assumed that their source is photodissociation of CO_2, H_2O, and other oxygen-bearing species. Based on the most recent results by the Rosetta mission, photodissociation of O_2 itself becomes a viable source of $O(^1D)$, which is produced over a large spectral region, 130 to 175 nm.

This type of information has profound consequences for the understanding of cometary formation and the evolution of our solar system. This research also impacts future studies of extrasolar planets. Optical techniques will be the only means for studying *in situ* exoplanet atmospheres, at least in the short term, and thus it is critical to resolve the present conundrum.

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