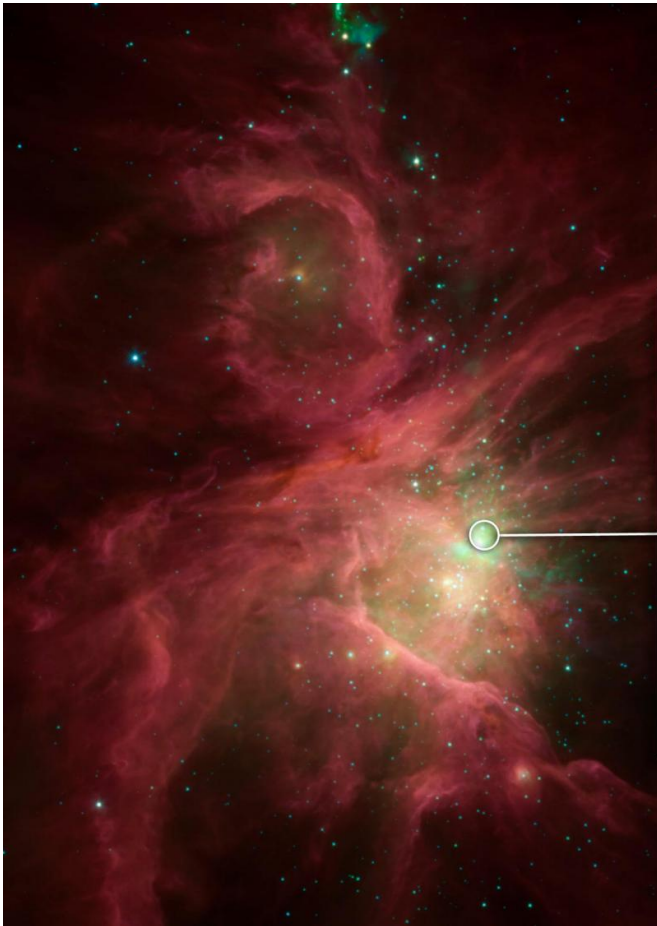


The search for molecular oxygen among cosmic oxygen atoms

27 July 2015



An infrared image of the Orion Nebula; the circled area shows the region where shocks and emission from molecular oxygen are found. Credit: ESA/NASA/JPL-Caltech

Oxygen is the third most abundant element in the universe (after hydrogen and helium) and of course it is important: all known life forms require liquid water and its oxygen content. For over thirty years, astronomers have been searching for molecular oxygen, O₂, as part of an accounting of cosmic oxygen atoms. Despite early predictions that O₂ should be abundant in the molecular clouds that form new stars and planetary systems, it is virtually

absent.

Only two locations have convincing O₂ detections, a region of shocks near the Orion Nebula, and a cloud in the constellation of Ophiuchus. The theory is clearly wrong. What is not clear is whether O₂ is missing (with dramatic implications for its abundance and the chemistry of [molecular clouds](#)), is in some less detectable form (perhaps frozen onto [dust grains](#)), or has been taken up to form water, carbon monoxide, or other oxygen-bearing molecules.

The launch of the Herschel Space Observatory enabled much more sensitive searches for O₂, and prompted updated chemical modeling for molecular clouds and their oxygen. CfA astronomer Gary Melnick and his colleague improved the models to take into account the role of ultraviolet radiation in modifying the chemical and physical conditions in shocks. Their goal was to explain the strength and proportions of the line emission in Orion, and to understand what made the Orion environment so special.

The scientists report that when UV illuminates the region of a shock, the width and temperature of the shocked region changes, and enhances the O₂ in two ways: by knocking oxygen off dust grains and breaking apart some molecules, thus increasing the number of free atoms before the shock, and by breaking apart water in the post-shock gas so that more O₂ can form. The new model also successfully resolves the outstanding puzzle about its limited detection, finding that the detectability is very sensitive to the size and geometry of the emitting region. The paper provides the first self-consistent treatment of preshock, shock, and postshock regions under the influence of UV fields, and explains why O₂ detections are so rare.

More information: "O₂ Emission Toward Orion H₂ Peak 1 and the Role of FUV-Illuminated C-Shocks." arxiv.org/abs/1505.03909

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