Labs Hold the Key to the 21-Micrometer Mystery

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For more than a decade, a strange infrared glow coming from certain red giant stars has perplexed astronomers. Centered on a wavelength of 21 micrometers, the emission forms a wide band in the infrared spectrum, which implies that it comes from a large complex molecule or a solid and not from the atoms or simple molecules normally found around stars. Now an intense email debate is raging over the nature of the source, with researchers proposing substances never before detected in space, including polymers, ball-shaped fullerenes, and even nanodiamonds.

The debate was touched off when the first detailed analysis of the feature, based on observations by the European Space Agency’s Infrared Space Observatory (ISO), was published earlier this year. And this has spurred on astronomers who are working with infrared spectroscopists to try to find a substance that produces a matching spectrum. “It is a mystery,” says Sun Kwok of the University of Calgary in Canada.

Kwok and his colleague Kevin Volk, along with Bruce Hrivnak of Valparaiso University in Indiana, announced the first four stars exhibiting this feature in 1988 using the Infrared Astronomical Satellite (IRAS). But the low resolution of IRAS’s spectrometers made it hard to discern details of the emission feature. After the launch of ISO and its high-resolution spectrometers in 1995, however, the number of stars showing the feature grew to 12, and their nature became clearer.

“The feature can only be observed in a very precise evolutionary stage, in the short transition between the red giant phase and the planetary nebula stage,” says Pedro Garcia-Lario of the ISO Science Operations Centre near Madrid. Stars at that stage of their life smoke like an old lantern, blowing off dust that is rich in carbon compounds.

In March of this year, Garcia-Lario and his colleagues published a detailed study of the infrared spectrum of one of these stars, IRAS 16594-4656, in the Astrophysical Journal. This report, along with another high-resolution study of several similar stars published in this week’s Astrophysical Journal by Kwok and his colleagues, has sparked a host of theories on the identity of this mysterious compound. “The feature is so strong that it has to come from a common element,” says Kwok, and in such stars “carbon and hydrogen are the obvious ingredients.”

The ISO observations have shown that the profile of the emission feature—identical for all 12 stars—is almost 4 micrometers wide, ruling out small molecules as the source because they produce narrow emission lines. “It has to be either a mixture of similar kinds of molecules, like hydrogenated fullerenes, or a very large molecule complex, or a polymer, or even a solid,” says Kwok.

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