Component of mothballs is present in deep-space clouds

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(PhysOrg.com) -- Interstellar clouds, drifting through the unimaginable vastness of space, may be the stuff dreams are made of. But it turns out there's an unexpectedly strange component in those clouds, and it's not dreams but -- mothballs?

Well, not exactly, but researchers from the University of Georgia have just shown for the first time that one component of clouds emitting unusual infrared light know as the Unidentified Infrared Bands (UIRs) is a gaseous version of naphthalene, the chief component of mothballs back on Earth. The UIRs have been seen by astronomers for more than 30 years, but no one has ever identified what specific molecules cause these patterns.

The discovery that a special kind of naphthalene with a single extra proton is out in space is important to those studying interstellar regions for many reasons. One of the most important is that the UIRs are associated with interstellar dust, and understanding the components of that dust could give clues to the origin of these mysterious voyagers. The new information may also provide insights into stellar lifecycles.

The research, led by Michael Duncan, Regents Professor of Chemistry at UGA, was just published in the Astrophysical Journal. The department of chemistry is part of UGA's Franklin College of Arts and Sciences. Co-authors on the paper were Allen Ricks, a doctoral student in Duncan's lab and Gary Douberly, formerly a postdoctoral associate in Duncan's lab and now an assistant professor in the department of chemistry at UGA.

"This came about because we found a way in our lab to make protonated naphthalene ions," said Duncan, "and that allowed us to examine its infrared spectrum. It turned out to be a near-perfect match for one of the main features in the UIRs."

That naphthalene is part of the UIRs is not totally unexpected, as it is composed of only hydrogen and carbon. Hydrogen composes by far the largest part of interstellar clouds, and carbon is another abundant element there. (This is known because scientists can measure their "light signals" or spectra and compare them to such spectra that can be generated in labs.) Still, it opens an entirely new area of study for astrophysicists and chemists who continue to understand the composition of space and the origins of the Universe.

Most people know naphthalene in its earthly crystalline form as C10H8, meaning it has 10 molecules of carbon and eight of hydrogen. The spectrum of this form of naphthalene does not match the UIRs. Duncan and his colleagues, however, had reason to believe that adding an extra proton to naphthalene (from the abundant hydrogen in space), which latches on in an unlikely space collision to give it the formula C10H9 +, might cause just the kind of change in its spectrum to match the UIR pattern.

To see if the component out there in space is protonated naphthalene, they had to first create it in the lab, under conditions near Absolute Zero and then zap it with a laser, turning it into a gas, whose infrared spectrum could then be analyzed. The bad news is that "infrared" refers to radiation whose wavelength is longer than that of visible light and so can't be seen by the naked eye. The good news is that the sophisticated machines in Duncan's lab can both "see" infrared spectrum, and identify what molecule produced it, allowing the distinctive spectrum of protonated naphthalene to be measure for the first time.

It turned out that when Duncan and his team did all this, the spectrum from their laboratory-created protonated naphthalene was almost identical to the spectrum seen in one part of the UIR.

What does it all mean? First, other scientists had found that interstellar dust is responsible for the production of molecular hydrogen from its atoms, which is the principal component of interstellar clouds. Other chemical processes taking place on the surface of dust grains are believed to form many molecules found on Earth, perhaps including the amino acids and peptides essential as the building blocks of life. And it is in these clouds that new stars form, so understanding how naphthalene fits into the equation (so to speak) of all this could provide insights into how stars and planetary systems form.

The new research also helps confirm earlier predictions that molecules called polycyclic aromatic hydrocarbons (PAHs) are the main source of the UIRs, since protonated naphthalene is a PAH.

"Protonated naphthalene itself does not explain all the UIR spectra," said Duncan, "but the characteristics of its spectrum suggest that a distribution of larger protonated PAHs could do this. The same spectral changes caused by the addition of protons to these larger systems would likely explain all the UIR patterns, thus ending one of the oldest mysteries in astronomy." Duncan and his group are now working to make and study these larger protonated PAHs.

Duncan's success in simulating the conditions of deep space in the lab and capturing that elusive proton could also have a payoff in studying other components of stellar clouds too.

Source: University of Georgia (news : web)