NASA scientists on the trail of mystery molecules

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(PhysOrg.com) -- Space scientists working to solve one cosmic mystery at NASA's Ames Research Center, Moffett Field, Calif., now have the capability to better understand unidentified matter in deep space. Using a new facility so sensitive that it can recognize the molecular structure of particles in space, researchers now are able to track unidentified matter seen for the last century absorbing certain wavelengths of light from distant stars.

Astronomers suspect that one family of carbon-containing compounds, called polycyclic aromatic hydrocarbons (PAHs), are the long-sought matter that produces holes in astronomical observations from multiple wavelengths. Researchers compared laboratory data of PAHs, measured in this unique facility that simulates space-like conditions, with an extensive set of high-resolution optical astronomical data. With this approach, they were able to survey the mysterious spectral signatures seen in both light absorption and emission that are common throughout interstellar space and determine the abundance of PAHs.

"It is important to understand how PAHs absorb stellar radiation, and how they emit it back, because it contributes to the global energy balance in space," said Farid Salama, a space science researcher in the Astrophysics Branch at Ames. "Now, we can offer a clear and unambiguous explanation for the presence (or the absence) of specific PAH molecules in the interstellar medium." This research will be presented today at the American Astronomical Society meeting in Boston, Mass.

The research helps solve a problem scientists have struggled with for most of the century. They have detected more than 500 interstellar absorption lines in the spectra (range of frequencies or color) of starlight approaching Earth. Absorption lines are discrete colors of light absorbed by intervening matter; this absorption leaves holes or "lines" in the spectra. The lines are called diffuse interstellar band.

"PAHs are excellent candidates to account for the infrared emission bands seen in the interstellar medium," said Salama. "But their signature also must be seen in the visible and ultraviolet. This evidence was missing until now, because of the lack of relevant laboratory data."

PAHs are very stable and thought to be ubiquitous in the interstellar medium. They are flat molecules of carbon and hydrogen that form hexagons – their skeleton looks like chicken wire. On Earth, they can be found in coal, soot, and automobile exhaust.

By mimicking realistic interstellar conditions in the laboratory, Salama and his colleagues measured the spectra (fingerprints of molecules) of large PAHs and ions in the ultraviolet and visible light bands and compared the data to high-resolution astronomical data from the Ultraviolet and Visual Echelle Spectrograph instrument of the Very Large Telescope at the European Southern Observatory.

To achieve these results, Salama and his team used a unique specialized facility, called the Cosmic Simulation Chamber (COSmIC), which integrates a variety of state-of-the-art instruments to allow scientists to form, process and monitor simulated space conditions for interstellar materials in the laboratory. The chamber recreates the extreme conditions in space, where average temperatures can be as low as 100 Kelvin (less than -170 degree Celsius), densities are quadrillionths of Earth's average atmospheric density at sea level, and interstellar molecules and ions are bathed in stellar ultraviolet and visible radiation.

Interstellar molecules and ions must be stable enough to survive in this harsh environment.

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