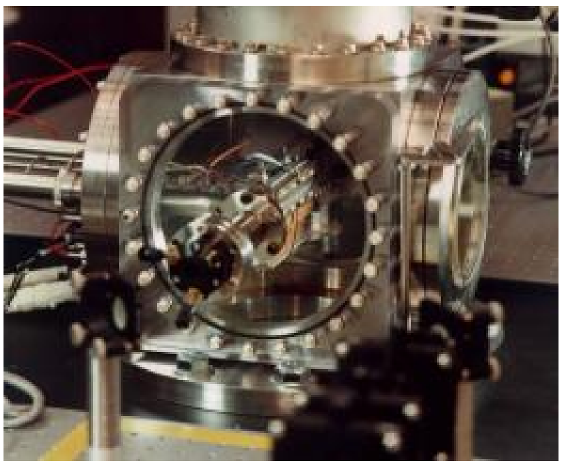
'COSmIC' simulator fingerprints unknown matter in space

February 8 2011, By Ruth Dasso Marlaire



Ames engineers and scientists have equipped COSmIC with a custom-built time-of-flight mass spectrometer (TOFS), an ultra-sensitive device that detects the mass of matter at the molecular level. Credit: Farid Salama

(PhysOrg.com) -- Who are we? Where do we come from? These are questions that scientists hope to find clues to by better understanding the composition and evolution of the universe.

NASA flies sophisticated space missions that can probe vast regions of space to detect spectral signatures, or fingerprints, of unknown materials.

Through the years, scientists have found that these materials are much more complicated than originally anticipated. Because conditions in space are vastly different from conditions on Earth, identifying extraterrestrial materials is extremely difficult. Recently, researchers have achieved a major milestone by adding a new capability to one of the world's unique laboratory facilities.

Located at NASA's Ames Research Center, Moffett Field, Calif., this specialized facility, called the Cosmic Simulation Chamber (COSmIC), integrates a variety of state-of-the-art instruments to allow scientists to form, process and monitor simulated space conditions for planetary and interstellar materials in the laboratory.

The chamber is the heart of the system. It recreates the extreme conditions that reign in space where average temperatures can be as low as 100 Kelvin (less than -170 degree Celsius!), densities are billionths of Earth's (of the order of 10^{-16} - 10^{-17}) and interstellar molecules and ions are bathed in stellar ultraviolet and visible radiation.

"The harsh conditions of space are extremely difficult to reproduce in the laboratory, and have long hindered efforts to interpret and analyze observations from space," said Farid Salama, a space science researcher in the Astrophysics Branch at Ames.

The idea of building the COSmIC facility started as a Director's Discretionary Fund (DDF) project initiated by Salama in 1996, and its realization represents a true success story for Ames' DDF program. The facility resulted from collaboration between Ames space science researchers and Los Gatos research scientists as a Small Business Innovative Research (SBIR) contract awarded by NASA.

Scientists will use the new capability to study the formation of interstellar grains in the outflow of carbon stars. Credit: NASA

The team of space scientists and engineers, lead by Salama, designed and built this unique laboratory facility to gain a deeper understanding of the composition of our universe and of the evolution of galaxies, both major objectives of NASA's space research program.

In 2003, Ames scientists delivered their first major milestone by coupling COSmIC with a cavity ringdown spectrometer, an extremely sensitive device that can detect the spectral fingerprint of matter at the molecular level.

Now, another major milestone has been achieved by coupling COSmIC with a time-of-flight mass spectrometer, an ultra-sensitive device that detects the mass of matter at the molecular level.

In the past, part of the problem that prevented scientists from identifying unknown matter was the inability to simulate space conditions in the gaseous state. Today, researchers can successfully simulate gas-phase environments similar to interstellar clouds, stellar envelopes or planetary atmospheres environments by expanding solids using a free jet spray.

“By doing this, we now can measure large carbon molecules, like polycyclic aromatic hydrocarbons (PAHs) and similar carbon species. This is a major accomplishment,” said Salama. “This type of new research truly pushes the frontiers of science toward new horizons, and illustrates NASA's important contribution to science,” he added.

Scientists will use this “far out” facility to address two key problems: First, they want to identify the nature of big aerosol particles that have been detected by Cassini in the atmosphere of Saturn's moon, Titan. The second problem they will study is the formation of interstellar grains in the outflow of carbon stars.

“We can now truly simulate in the laboratory the formation of carbon grains in the envelope of stars, a major problem in today’s astrophysics,” said Cesar Contreras a NASA Postdoctoral Program (NPP) fellow and a member of the research team.

“We begin with small carbon molecules, expose these molecules to high energy processing in COSmIC, expand them in a cold jet spray and detect them with our highly sensitive detectors,” added Contreras, who studies interstellar grains.

Funded by NASA’s Science Mission Directorate Astronomy and Physics Research and Analysis, Planetary Atmospheres and Cosmochemistry programs, this new facility will also study the very large aerosol particles that were seen by the Cassini spacecraft in the upper atmosphere of Titan.

“In the Cassini data we see evidence for large aerosols in the upper atmosphere of Titan that we plan to explain with COSmIC” said Claire Ricketts, another NASA NPP fellow and member of the team, who studies the composition of the atmosphere of Titan.

“Titan is an important body in our solar system because it helps us understand the conditions that existed on early Earth” added Ricketts. “Organic haze in the atmosphere of Titan is similar to haze in early Earth's air.”

To understand Cassini’s data, scientists need this very powerful, very sensitive new tool. They will begin their analysis by forming molecules and species in the lab, measuring them in situ (inside their environment without disturbing them), and then trying to match their identity to Titan’s unknown aerosol molecules.

“Titan’s upper atmosphere data shows a rich spectrum. We will recreate those data in the lab and compare them to Cassini’s data. If they fit, great. If not, we will try something else. We will know when we are coming close to understanding them. We now have the right tool to do this,” said Salama.

“One day we will talk about the details and the implications of the data, but today we are celebrating the new milestone in the completion of this unique tool,” concluded Salama.

Provided by JPL/NASA