Astrobiologists discover 'sweet spots' for the formation of complex organic molecules in the galaxy

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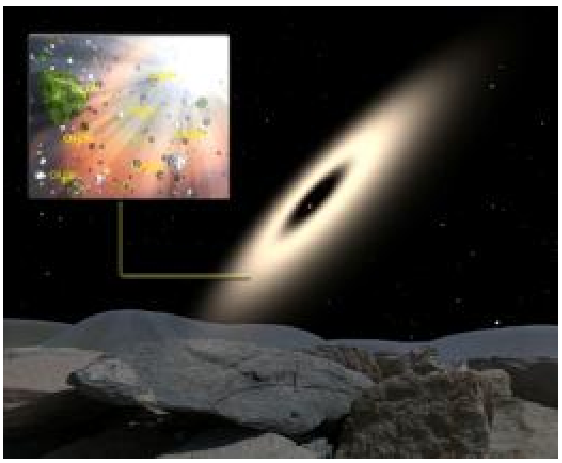

Photo courtesy of NASA

(PhysOrg.com) -- Scientists within the New York Center for Astrobiology at Rensselaer Polytechnic Institute have compiled years of research to help locate areas in outer space that have extreme potential for complex organic molecule formation. The scientists searched for methanol, a key ingredient in the synthesis of organic molecules that could lead to life. Their results have implications for determining the origins of molecules that spark life in the cosmos.

The findings will be published in the Nov. 20 edition of the Astrophysical Journal in a paper titled "Observational constraints on methanol production in interstellar and preplanetary ices." The work is collaboration between researchers at Rensselaer, NASA Ames Research Center, the SETI Institute, and Ohio State University.

"Methanol formation is the major chemical pathway to complex organic molecules in interstellar space," said the lead researcher of the study and director of the NASA-funded center, Douglas Whittet of Rensselaer. If scientists can identify regions where conditions are right for rich methanol production, they will be better able to understand where and how the complex organic molecules needed to create life are formed. In other words, follow the methanol and you may be able to follow the chemistry that leads to life.

Using powerful telescopes on Earth, scientists have observed large concentrations of simple molecules such as carbon monoxide in the clouds that give birth to new stars. In order to make more complex organic molecules, hydrogen needs to enter the chemical process. The best way for this chemistry to occur is on the surfaces of tiny dust grains in space, according to Whittet. In the right conditions, carbon monoxide on the surface of interstellar dust can react at low temperatures with hydrogen to create methanol (CH_3OH). Methanol then serves as an important steppingstone to formation of the much more complex organic molecules that are required to create life. Scientists have known that methanol is out there, but to date there has been limited detail on where it is most readily produced.

What Whittet and his collaborators have discovered is that methanol is most abundant around a very small number of newly formed stars. Not all young stars reach such potential for organic chemistry. In fact, the range in methanol concentration varies from negligible amounts in some regions of the interstellar medium to approximately 30 percent of the ices around a handful of newly formed stars. They also discovered methanol for the first time in low concentrations (1 to 2 percent) in the cold clouds that will eventually give birth to new stars.

The scientists conclude in the paper that there is a "sweet spot" in the physical conditions surrounding some stars that accounts for the large discrepancy in methanol formation in the galaxy. The complexity of the chemistry depends on how fast certain molecules reach the dust grains surrounding new stars, according the Whittet. The rate of molecule accumulation on the particles can result in an organic boom or a literal dead end.

"If the carbon monoxide molecules build up too quickly on the surfaces of the dust grains, they don't get the opportunity to react and form more complex molecules. Instead, the molecules get buried in the ices and add up to a lot of dead weight," Whittet said. "If the buildup is too slow, the opportunities for reaction are also much lower."

This means that under the right conditions, the dust surrounding certain stars could hold greater potential for life than most of its siblings. The presence of high concentrations of methanol could essentially jumpstart the process to create life on the planets formed around certain stars.

The scientists also compared their results with methanol concentrations in comets to determine a baseline of methanol production in our own solar system.

"Comets are time capsules," Whittet said. "Comets can preserve the early history of our solar system because they contain material that hasn't changed since the solar system was formed." As such, the scientists could look at the concentrations of methanol in comets to determine the amount of methanol that was in our solar system at its birth.

What they found was that methanol concentrations at the birth of our solar system were actually closer to the average of what they saw elsewhere in interstellar space. Methanol concentrations in our solar system were fairly low, at only a few percent, compared to some of the other methanol-dense areas in the galaxy observed by Whittet and his colleagues.

"This means that our solar system wasn't particularly lucky and didn't have the large amounts of methanol that we see around some other stars in the galaxy," Whittet said.

"But, it was obviously enough for us to be here."

The results suggest that there could be solar systems out there that were even luckier in the biological game than we were, according to Whittet. As we look deeper into the cosmos, we may eventually be able to determine what a solar system bursting with methanol can do.

Provided by Rensselaer Polytechnic Institute