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Cold chemistry: Icy dust specks could provide interstellar staging ground for complex organic chemical reactions

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The creation of the Universe was a messy business, and billions of years after the Big Bang, material still litters the dark space between stars. In these cold interstellar regions, gas and dust specks swirl together, sometimes coalescing to form new stars, sometimes expanding as dying stars spew forth new material into the void. Much of the chemistry that happens in interstellar clouds remains a mystery, but recent work by astrochemists from Heriot-Watt University in Edinburgh sheds new light on this dark part of the Universe, demonstrating the key role that icy dust specks can play in facilitating the formation of a type of organic molecule that could be a precursor to the building blocks of life. The researchers will present their work at the AVS Symposium, held Oct. 30 – Nov. 4, in Nashville, Tenn.

By some estimates molecules make up less than 1 percent of the matter of the Universe, but they can still significantly influence the evolution of stars and planetary systems. Scientists suspect, based on infrared observations, that many of the dust specks within interstellar clouds are covered in a frosty coating of ice. The ice acts as a coolant during star formation, leading to smaller, longer-lived stars such as our own Sun.

"Small stars give evolution on planets time to work," says Martin McCoustra, an astrochemist who studies interstellar ice grains. "Basically we wouldn't be here if the Universe was clean and dust free." In addition to slowing down star evolution, icy dust specks may also influence interstellar organic chemistry, speeding up chemical reactions or shielding molecules from the full energy of incoming cosmic rays.

It is this chemical catalyst behavior of interstellar dust that McCoustra and his colleagues are currently investigating. Using silica and water ice surfaces, the scientists created models of both bare and icy dust grains in the laboratory, and then bombarded the grains with low-energy electrons to mimic an influx of cosmic rays. The researchers were specifically looking for the effect that the rays would have on acetonitrile (CH_3CN), a simple organic compound that has been observed in the interstellar medium. They found that for films of bulk CH_3CN, the incoming electrons rapidly dislodged the molecules, but for CH_3CN molecules isolated on icy surfaces, a chemical reaction took place. CH_3CN is believed to be a precursor to amino acids, McCoustra says, and the product of the reaction, which the scientists are still working to precisely identify, is probably part of an intermediate step in the process that makes large organic molecules. "The key point is that the water is crucial for this chemistry," McCoustra notes, since the chemical reaction did not take place in bulk CH_3CN.

The Scottish research team, part of a large European network studying solid state and surface astrochemistry (LASSIE), is now working with computational chemists to further investigate, from an energy point of view, how water might promote chemistry on icy grains. "Astronomers and astrochemists are working to try and understand the origin of chemical complexity," says McCoustra. "If that chemistry is the same wherever we look in our galaxy, and if we can reproduce it in the laboratory, then that chemistry can seed our galaxy and others with the chemical potential for life."

More information: The AVS 58th International Symposium & Exhibition will be held Oct. 30 – Nov. 4 at the Nashville Convention Center.

Presentation SS1-MoM1, "Surface Science of Acetonitrile on Model Interstellar Ices and Grains," is at 8:20 a.m. on Monday, Oct. 31.

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