Forming the ion that made the universe

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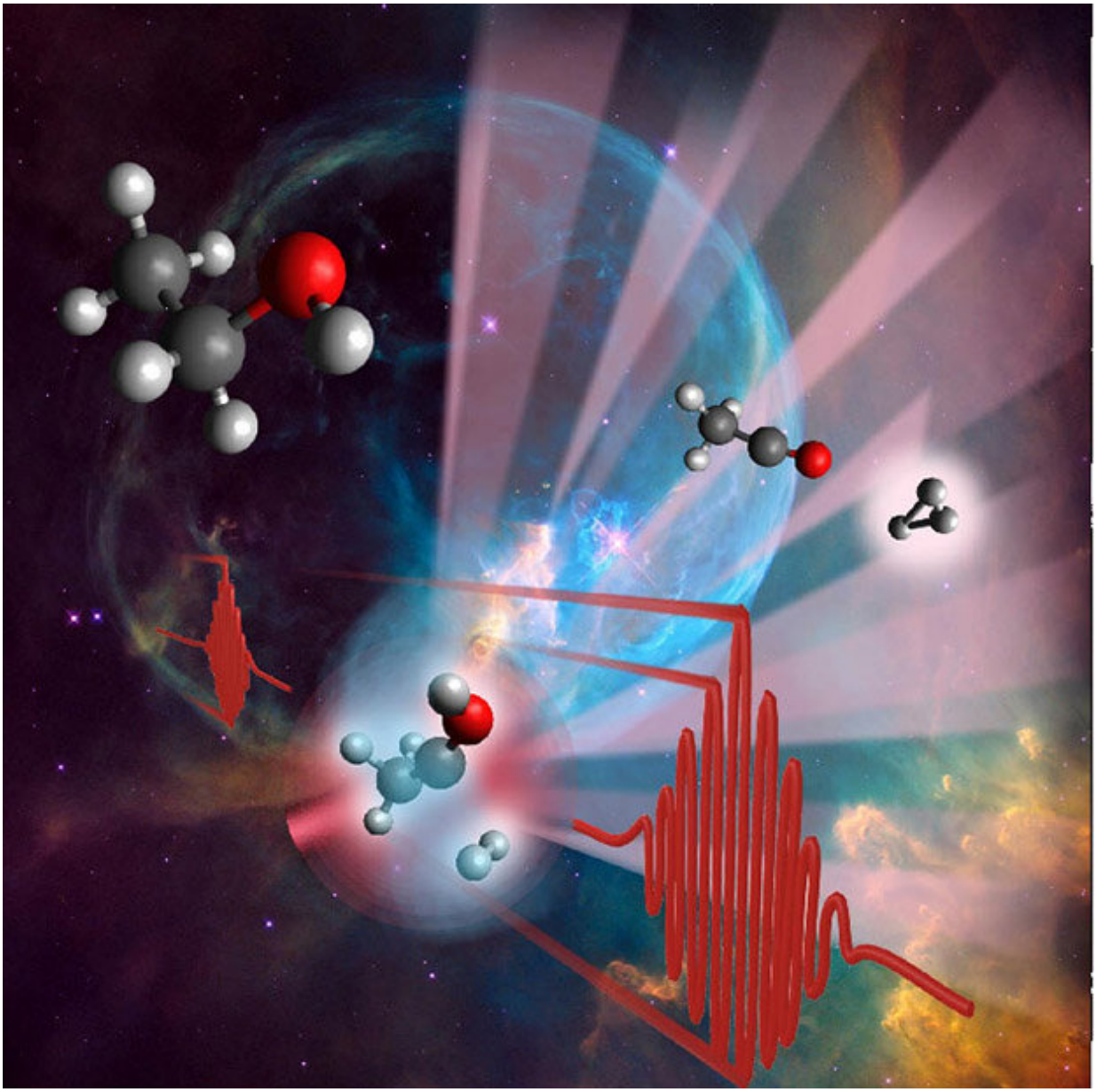

The trihydrogen cation, H^{3+}, plays a major role in interstellar chemistry where it

facilitates the formation of water and organic molecules. Researchers have discovered how the cation forms when organic molecules (particularly alcohols) are excited by an intense laser pulse (artist rendition). Knowing how the cation forms takes us closer to understanding the chemistry that led to life as we know it. Credit: Marcos Dantus, Michigan State University

The trihydrogen cation, H^{3+}, is the starting point for almost all molecules in the universe. Typically, H^{3+} is formed by collisions involving hydrogen gas, but its chemistry at the molecular level is relatively unknown. When organic molecules are hit by a laser pulse, they are ionized and the reaction begins. Then, the molecules break up into different fragments; one of which is H^{3+}. They are able to measure the details of this reaction: the timescales, yield, and how chemical bonds are broken and formed. These experiments also give key details about each step of the reaction which occurs on ultrashort (faster than one millionth of a millionth of a second) timescales.

The findings are important for astrochemistry because organic molecules, including alcohols, are present in space. This is one step further into learning how organic molecules form and behave in the universe. Also, the fact that forming H^{3+} involves a neutral hydrogen molecule that roams and takes away another hydrogen atom is significant. Why? Roaming chemistry is a new and relatively unknown phenomenon; this work offers insight into this type of chemical process.

Scientists have figured out additional ways that the trihydrogen cation, H^{3+}, the most abundant ion in the universe, is produced following high-energy activation of alcohols and other organic molecules. Despite the strong repulsion between charged particles, the team found that a roaming hydrogen molecule was responsible for the chemical reaction producing H^{3+}. The researchers conducted the study using intense

femtosecond laser pulses and instrumentation able to detect the resulting ions from experimental measurements. The reaction happens in either 100 or 340 quadrillionths of a second depending on the starting molecule. They confirmed the mechanisms by using quantum mechanical calculations and by ion-ion coincidence measurements. The research findings are important for astrochemistry and for understanding how organic molecules form and behave in the universe. Furthermore, these findings are relevant when intense lasers are used for surgical procedures.

More information: Nagitha Ekanayake et al. H2 roaming chemistry and the formation of H3+ from organic molecules in strong laser fields, *Nature Communications* (2018). DOI: 10.1038/s41467-018-07577-0

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