A hot start to the origin of life? Researchers map the first chemical bonds that eventually give rise to DNA

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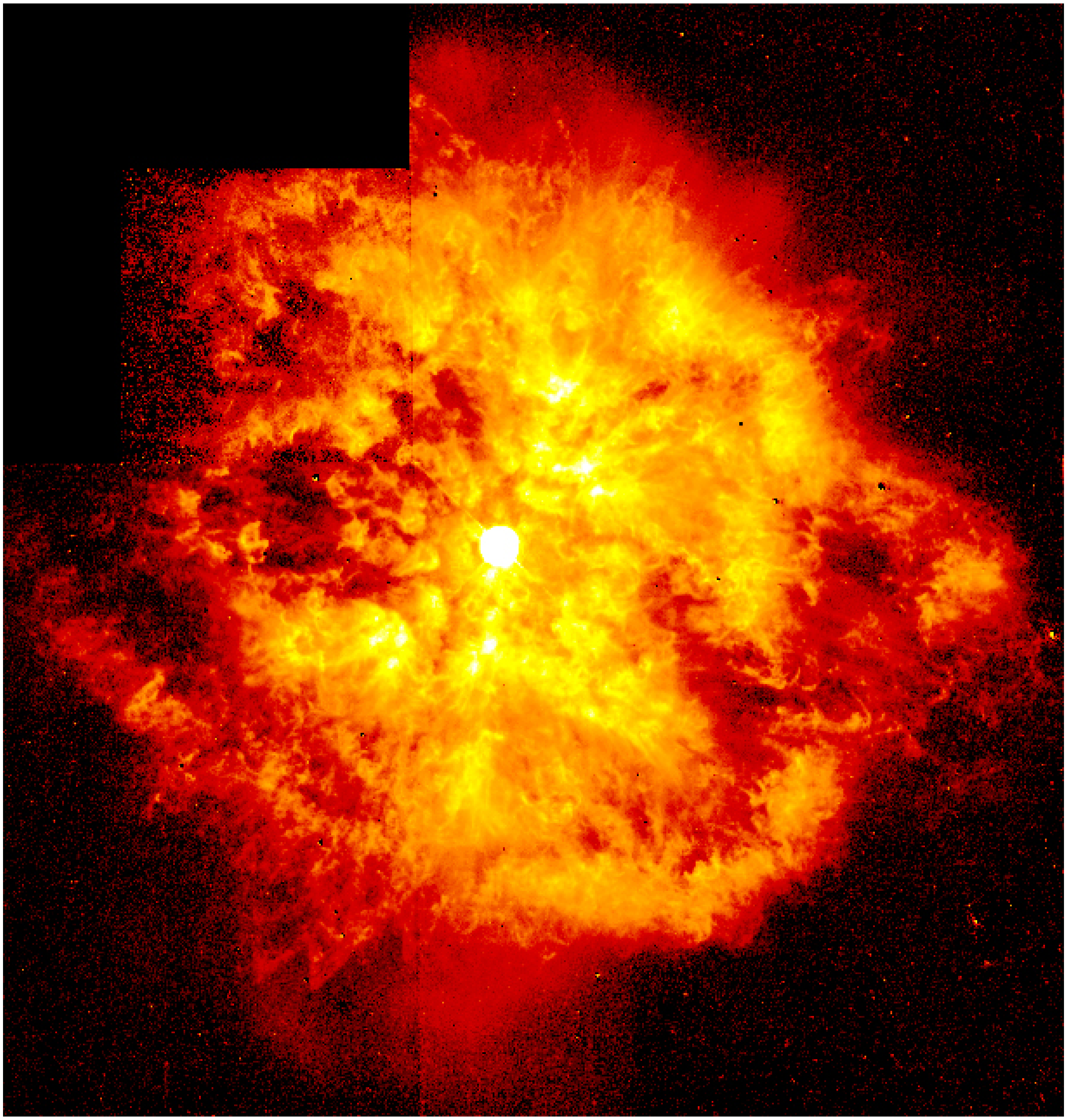

Composite image of an energetic star explosion taken by the Hubble Space Telescope in March of 1997. Credit: NASA

DNA is synonymous with life, but where did it originate? One way to answer this question is to try to recreate the conditions that formed

DNA's molecular precursors. These precursors are carbon ring structures with embedded nitrogen atoms, key components of nucleobases, which themselves are building blocks of the double helix.

Now, researchers from the U.S. Department of Energy's Lawrence Berkeley National Lab (Berkeley Lab) and the University of Hawaii at Manoa have shown for the first time that cosmic hot spots, such as those near stars, could be excellent environments for the creation of these nitrogen-containing molecular rings.

In a new paper in the *Astrophysical Journal*, the team describes the experiment in which they recreate conditions around carbon-rich, dying stars to find formation pathways of the important molecules.

"This is the first time anyone's looked at a hot reaction like this," says Musahid Ahmed, scientist in the Chemical Sciences Division at Berkeley Lab. It's not easy for carbon atoms to form rings that contain nitrogen, he says. But this new work demonstrates the possibility of a hot gas phase reaction, what Ahmed calls the "cosmic barbeque."

For decades, astronomers have pointed their telescopes into space to look for signatures of these nitrogen-containing double carbon rings called quinoline, Ahmed explains. They've focused mostly on the space between stars called the interstellar medium. While the stellar environment has been deemed a likely candidate for the formation of carbon ring structures, no one had spent much time looking there for nitrogen-containing carbon rings.

To recreate the conditions near a star, Ahmed and his long-time collaborator, Ralf Kaiser, professor of chemistry at the University of Hawaii, Manoa, and their colleagues, which include Dorian Parker at Hawaii, and Oleg Kostko and Tyler Troy of Berkeley Lab, turned to the Advanced Light Source (ALS), a Department of Energy user facility located at Berkeley Lab.

At the ALS, the researchers used a device called a hot nozzle, previously used to successfully confirm soot formation during combustion. In the present study the hot nozzle is used to simulate the pressures and temperatures in stellar environments of carbon-rich stars. Into the hot nozzle, the researchers injected a gas made of a nitrogen-containing single ringed carbon molecule and two short carbon-hydrogen molecules called acetylene.

Then, using synchrotron radiation from the ALS, the team probed the hot gas to see which molecules formed. They found that the 700-Kelvin nozzle transformed the initial gas into one made of the nitrogen-containing ring molecules called quinolone and isoquinoline, considered the next step up in terms of complexity.

"There's an energy barrier for this reaction to take place, and you can exceed that barrier near a star or in our experimental setup," Ahmed says. "This suggests that we can start looking for these molecules around stars now."

These experiments provide compelling evidence that the key molecules of quinolone and isoquinoline can be synthesized in these hot environments and then be ejected with the stellar wind to the interstellar medium – the space between stars, says Kaiser.

"Once ejected in space, in cold molecular clouds, these molecules can then condense on cold interstellar nanoparticles, where they can be processed and functionalized." Kaiser adds. "These processes might lead to more complex, biorelevant molecules such as nucleobases of crucial importance to DNA and RNA formation."

More information: "Gas phase synthesis of (iso)quinoline and its role in the formation of nucleobases in the interstellar medium." *Astrophysical Journal* Volume 803 Number 2 2015 ApJ 803 53 DOI: 10.1088/0004-637X/803/2/53

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