Binary stars boost cosmic carbon footprint

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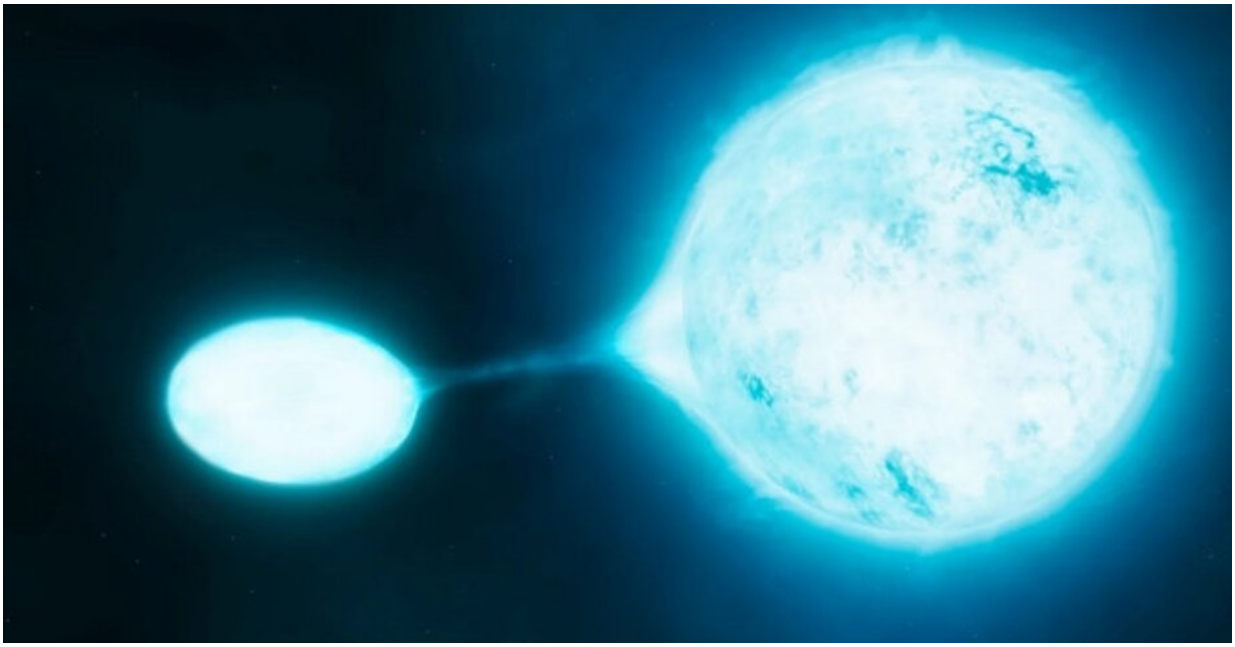

Massive stars are often found in close pairs, where one star strips mass from the other star. Credit: ESO/M. Kornmesser/S.E. de Mink

The cosmic origin of carbon, a fundamental building block of life, is still uncertain. Massive stars play an important role in the synthesis of all heavy elements, from carbon and oxygen to iron and so on. But even though most massive stars are born in multiple systems, the nucleosynthesis models so far have almost exclusively simulated single stars. An international team of astrophysicists has now calculated the "carbon footprint" of massive stars that lose their envelope in a binary

system.

Twice as much

"Compared to a single star, the average massive star in a binary system produces twice as much carbon," reports Robert Farmer (MPA & UvA), the lead author of the study. "Until recently, most astrophysicists ignored that massive stars are often part of a binary system. We investigated, for the first time, how being a binary changes the elements they produce."

Most stars, including our own star the Sun, are powered by fusing hydrogen into helium. In their 'golden years," after completing about 90% of their life, they start converting helium to carbon and oxygen. Stars like the Sun stop here, but massive stars can continue to fuse carbon into heavier elements up to iron.

The big challenge

The big challenge is not how to produce carbon, but how to get it out of the star, before it is destroyed. In single stars this is very hard. Stars in binary systems can interact and transfer mass to a companion. The star that is losing parts of its mass develops a carbon-rich layer close to the surface, which is ejected when the star explodes as a supernova.

"It may not be fair to blame binary stars for greenhouse gasses causing global warming," says Selma de Mink jokingly, coauthor of this study and director of the new stellar department at MPA, "but isn't it cool to pinch yourself in the arm and realize that the carbon in your skin was probably made in a binary star?"

Other types of stars

Astronomers are also investigating other types of stars that can produce carbon, such as for example, red giant stars or explosions of white dwarf stars. But so far it seems that massive stars, and according to this new study binary stars in particular, make the majority of the cosmic carbon.

"Our findings are a small but important step towards better understanding the role of massive stars in producing the elements we ourselves are made of," says second author Eva Laplace, who will soon defend her Ph.D. thesis on this topic at the UvA. "So far we have only investigated one type of binary interaction. There are many other possible fates for a star born in the close vicinity of a companion—and many other elements to investigate."

The results presented in this study are thus only the first in a systematic investigation of the impact of how a close companion will affect the chemical yields of massive stars.

More information: Selma de Mink et al, The cosmic carbon footprint of massive stars stripped in binary systems, arXiv:2110.04131 [astro-ph.SR] arxiv.org/abs/2110.04131

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