Simulations solve a 20-year-old riddle about why nebulae around masssive stars don't disappear

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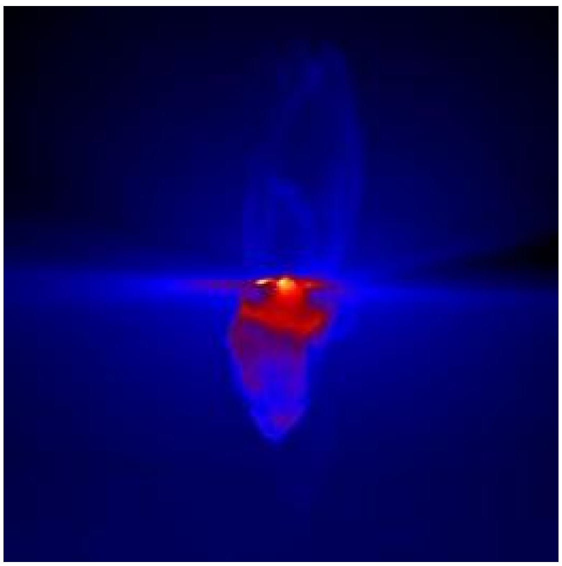

This is a simulated observation of a massive star viewed along the plane of the disk. This visualization of dust emission traces the density and temperature of the gas cloud that surrounds the star. The regions that are currently ionized (in red) and have been ionized in the past (blue structures) show how the nebula flickers. Credit: Peters, et al. 2010

The birth of the most massive stars -- those ten to a hundred times the mass of the Sun --has posed an astrophysical riddle for decades. Massive stars are dense enough to fuse hydrogen while they're still gathering material from the gas cloud, so it was a mystery why their brilliant radiation does not heat the infalling gas and blow it away.

New simulations by researchers affiliated with the University of Heidelberg, American Museum of Natural History, the National Autonomous University of Mexico, and the Harvard-Smithsonian Center for Astrophysics show that as the gas cloud collapses, it forms dense filamentary structures that absorb the star's radiation when it passes through them. A result is that the surrounding heated nebula flickers like a candle flame. The research is published in the current issue of *The Astrophysical Journal*.

"To form a massive star, you need massive amounts of gas," says Mordecai-Mark Mac Low, a co-author and curator in the Department of Astrophysics at the Museum. "Gravity draws that gas into filaments that feed the hungry baby stars."

Stars form when huge clouds of gas collapse. Once the central density and temperature are high enough, hydrogen begins to fuse into helium and the star begins to shine. The most massive stars, though, begin to shine while the clouds are still collapsing. Their ultraviolet light ionizes the surrounding gas, forming a nebula with a temperature of 10,000 degrees Celsius. This suggests that the growth of a massive star should taper off or even cease because the surrounding gas should be blown away by the heating.

First author Thomas Peters, a researcher at the Center of Astronomy at the University of Heidelberg and a former Annette Kade Fellow at the Museum, and colleagues ran gas dynamical simulations on supercomputers at the Texas Advanced Computing Center funded by the National Science Foundation and at the Leibniz and Jülich Computing Centers in Germany. The team's results show that interstellar gas around massive stars does not fall evenly onto the star but instead forms filamentary concentrations because the amount of gas is so great that gravity causes it to collapse locally while falling to the star. The local areas of collapse form spiral filaments. When the massive star passes through them, they absorb its ultraviolet radiation, shielding the surrounding gas. This shielding explains not only how gas can continue falling in, but why the ionized nebulae observed with radio telescopes are so small: the nebulae shrink again as they are no longer ionized, so that over thousands of years, the nebula appears to flicker, almost like a candle.

"So far, these ionized nebulae were just thought to be expanding bubbles of hot gas, and the measured size of these bubbles was used by observers to infer the age of its central star," says Peters. "Our results are of particular importance because the simulations show that there is, in fact, no direct relation between the size of the nebula and the age of the massive star, so long as the star is still growing. This is the case over a significant fraction of the total lifetime of a massive star."

More information: doi:10.1088/0004-637X/711/2/1017

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