Stellar murder: When stars destroy and eat their own planets

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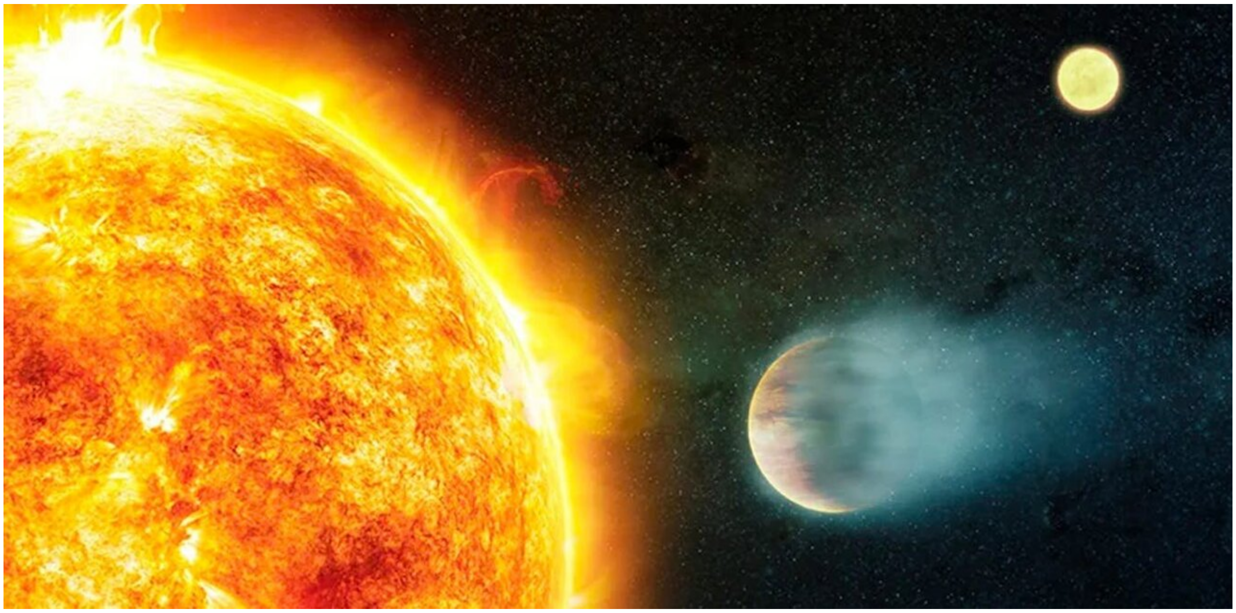

Credit: NASA/CXC/M.Weiss

Our sun is both our best friend and our worst enemy. On the one hand, we owe our very existence to our star. Earth and the other planets in the solar system formed out of the same cloud of gas and dust as the sun.

And without its light, there could be no life on this planet. On the other hand, there will come a day when the sun ends all life on Earth and, eventually, destroys Earth itself.

The risks that stars can pose to their planets are highlighted by a new study published in *Nature*. The authors looked at stars similar to our sun and found that at least one in 12 stars exhibits traces of metals in its atmosphere. These are thought to be the scars of planets and asteroids that have been ingested by the stars.

Planets should never feel too comfortable as they orbit their parent star, as there are at least two ways in which their star can betray their trust and bring about their violent demise.

Tidal disruption

The first is through a process called "tidal disruption". As a planetary system forms, some planets will find themselves orbiting their star along paths that are either not quite circular or are slightly inclined relative to the plane of the star's rotation. When that happens, the gravitational force exerted by the star on the planet will slowly correct the shape or the alignment of the wayward planet's orbit.

In extreme cases, the gravitational force applied by the star will destabilize the planet's orbit, slowly pulling it closer and closer. If the hapless planet strays too close, it will be torn apart by the star's gravity. This happens because the side of the planet facing the star is slightly closer than the side facing away (the difference is the planet's diameter).

The strength of the gravitational pull exerted by the star depends on the distance between it and the planet, so that the side of the planet facing the star feels a slightly stronger pull than the side facing away.

On Earth, this difference in the strength of the force of gravity creates the daily ebb and flow of the tides. In essence, the sun is trying to deform Earth, but is far enough away that it only manages to pull on the waters of its oceans. But a planet dangerously close to its star will find its very crust and core being pulled apart by these tides.

If the planet is not too close to the star, its shape will merely be deformed into that of an egg. Just a little closer to the star, and the difference between the gravitational pull on its different sides will be enough to completely tear it apart, reducing it back to a cloud of gas and dust that spirals into the star and vaporizes in its hellish fires.

The process of tidal disruption was first suggested some 50 years ago. For the last couple of decades, astronomers—including my group—have observed dozens of bright tidal disruption flares caused by stars shredded by supermassive black holes in the centers of galaxies.

Last year, for the first time, a group of astronomers reported observing a similar, dimmer flare that was consistent with a planet being disrupted and consumed by its star.

Tidal disruption of planets may be quite common, as shown by the new finding that at least 1 in 12 stars exhibits signs that they have ingested planetary material.

Other studies have found that between a quarter to half of all white dwarfs—the remnants of stars up to twice as massive as our sun—sport similar scars. As their name implies, white dwarfs are white hot. With surface temperatures of tens of thousands of degrees, the hottest white dwarfs emit ultraviolet and X-ray light energetic enough to vaporize their orbiting planets.

The end of Earth

Rest assured; Earth won't be destroyed via tidal disruption. Our planet's end will come in about five billion years, when the sun will transition into a red giant.

Stars are powered by the process known as fusion, where two light elements are combined to make a heavier one. All stars start out their lives fusing the element hydrogen in their cores into the element helium. This fusion process both stabilizes them against implosion, due to the incessant pull of gravity, and creates the light that makes them shine. Our sun has been fusing hydrogen into helium for roughly 4.5 billion years.

But 4.5 billion years from now, the hydrogen in the sun's core will run out. All fusion in the core will stop, and gravity, unopposed, will force the star to contract. As the core contracts, it will heat up until the temperature is high enough for helium to fuse into carbon.

Fusion will once again stabilize the star. In the meantime, though, the outer envelopes of the star will expand and cool, giving the now giant star a redder hue. As the red giant sun expands, it will engulf Mercury, Venus and Earth—it may even reach all the way out to the orbit of Mars.

Earth may have another 5 billion years to go, but we will not be here to witness its extinction. As the sun burns through its hydrogen stores, it steadily grows brighter: every billion years, its luminosity increases by about 10%.

A billion years from now, the sun will be bright enough to boil away Earth's oceans. So the next time you bask in the warm rays of the sun, remember: it's got it in for us.

More information: Elizabeth Gibney, Planet-eating stars hint at hidden chaos in the Milky Way, *Nature* (2024). DOI: 10.1038/d41586-024-00847-6

Fan Liu et al, At least one in a dozen stars shows evidence of planetary ingestion, *Nature* (2024). DOI: 10.1038/s41586-024-07091-y

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