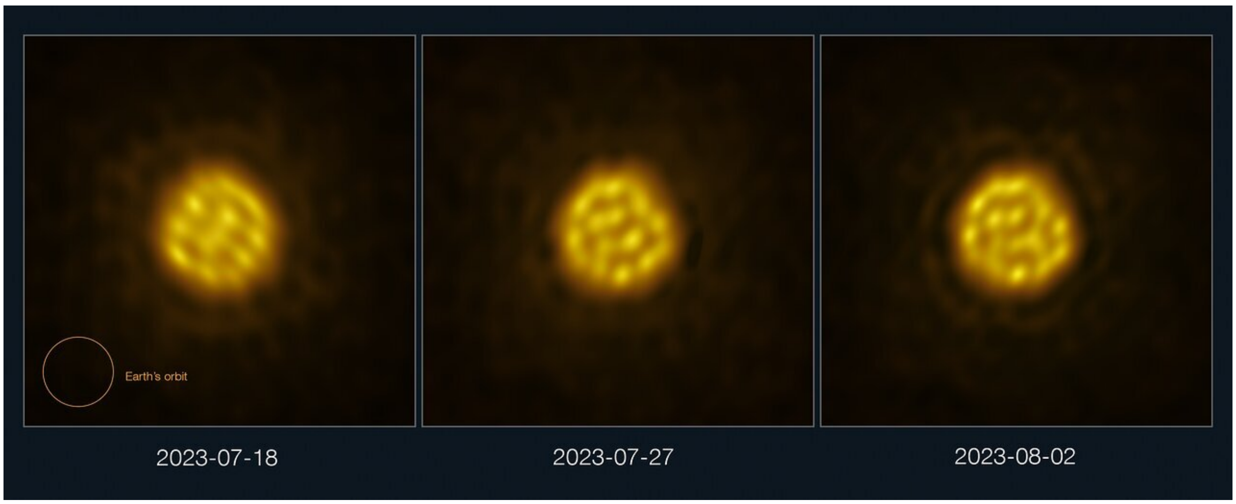
Astronomers track bubbles on star's surface

September 11 2024



Astronomers have captured a sequence of images of a star other than the sun in enough detail to track the motion of bubbling gas on its surface. The images of the star, R Doradus, were obtained with the Atacama Large Millimeter/submillimeter Array (ALMA), a telescope co-owned by ESO, in July and August 2023. This panel shows three of these real images, taken with ALMA on 18 July, 27 July and 2 August 2023. The giant bubbles—75 times the size of the sun—seen on the star's surface are the result of convection motions inside the star. The size of the Earth's orbit is shown for scale. Credit: ALMA (ESO/NAOJ/NRAO)/W. Vlemmings et al.

For the first time, astronomers have captured images of a star other than the sun in enough detail to track the motion of bubbling gas on its surface. The images of the star, R Doradus, were obtained with the Atacama Large Millimeter/submillimeter Array (ALMA), a telescope co-owned by the European Southern Observatory (ESO), in July and August 2023. They show giant, hot bubbles of gas, 75 times the size of the sun, appearing on the surface and sinking back into the star's interior faster than expected.

"This is the first time the bubbling surface of a real star can be shown in such a way," says Wouter Vlemmings, a professor at Chalmers University of Technology, Sweden, and lead author of the study published in *Nature*. "We had never expected the data to be of such high quality that we could see so many details of the convection on the stellar surface."

Stars produce energy in their cores through nuclear fusion. This energy can be carried out towards the star's surface in huge, hot bubbles of gas, which then cool down and sink—like a lava lamp.

This mixing motion, known as convection, distributes the heavy elements formed in the core, such as carbon and nitrogen, throughout the star. It is also thought to be responsible for the stellar winds that carry these elements out into the cosmos to build new stars and planets.

Convection motions had never been tracked in detail in stars other than the sun, until now. By using ALMA, the team were able to obtain high-resolution images of the surface of R Doradus over the course of a month. R Doradus is a red giant star, with a diameter roughly 350 times that of the sun, located about 180 light-years away from Earth in the constellation Dorado.

Its large size and proximity to Earth make it an ideal target for detailed observations. Furthermore, its mass is similar to that of the sun, meaning R Doradus is likely fairly similar to how our sun will look like in five billion years, once it becomes a red giant.

"Convection creates the beautiful granular structure seen on the surface of our sun, but it is hard to see on other stars," adds Theo Khouri, a researcher at Chalmers who is a co-author of the study. "With ALMA, we have now been able to not only directly see convective granules—with a size 75 times the size of our sun—but also measure how fast they move for the first time."

The granules of R Doradus appear to move on a one-month cycle, which is faster than scientists expected based on how convection works in the sun.

"We don't yet know what is the reason for the difference. It seems that convection changes as a star gets older in ways that we don't yet understand," says Vlemmings.

Observations like those now made of R Doradus are helping us to understand how stars like the sun behave, even when they grow as cool, big and bubbly as R Doradus is.

"It is spectacular that we can now directly image the details on the surface of stars so far away, and observe physics that until now was mostly only observable in our sun," concludes Behzad Bojnodi Arbab, a Ph.D. student at Chalmers who was also involved in the study.

More information: Wouter Vlemmings, One month convection timescale on the surface of a giant evolved star, *Nature* (2024). DOI: 10.1038/s41586-024-07836-9.
www.nature.com/articles/s41586-024-07836-9

Provided by ESO