Planetary interiors in TRAPPIST-1 system could be affected by solar flares

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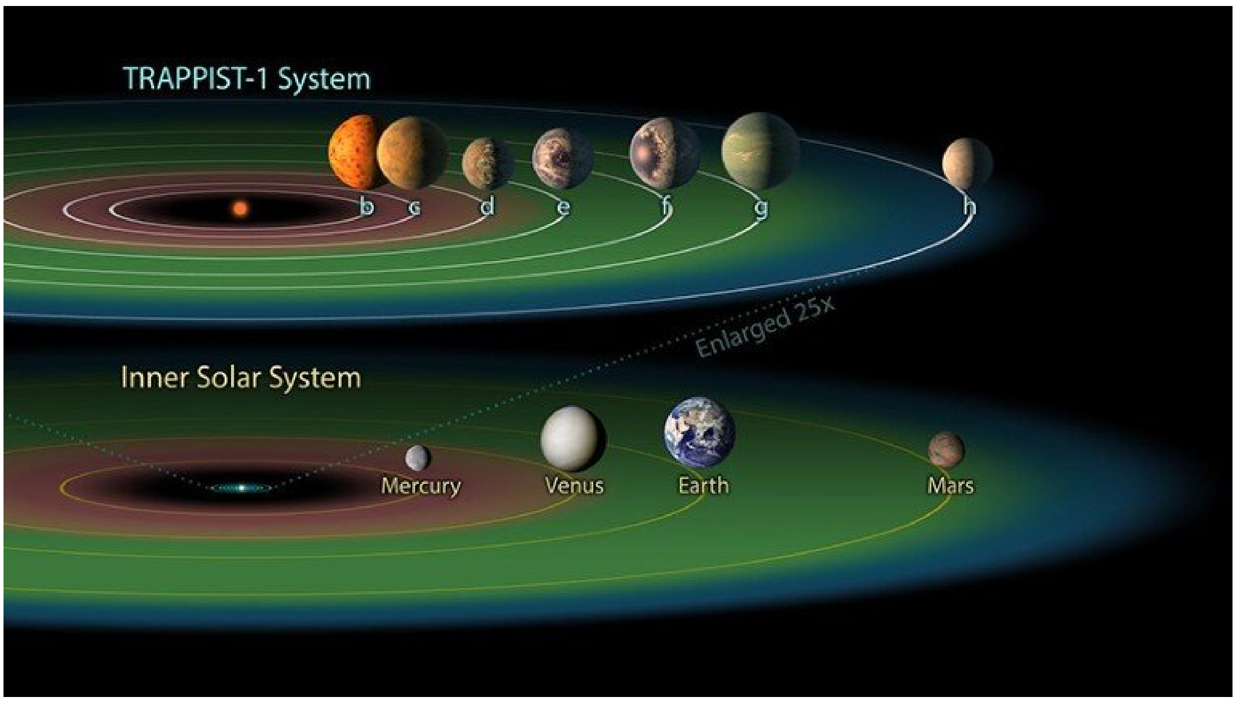

Credit: NASA/JPL-Caltech

In a recent study published in the *Astrophysical Journal Letters*, an international team of researchers led by the University of Cologne in Germany examined how solar flares erupted by the TRAPPIST-1 star could affect the interior heating of its orbiting exoplanets.

This study holds the potential to help us better understand how solar flares affect planetary evolution. The TRAPPIST-1 system is an exoplanetary system located approximately 39 light-years from Earth with at least seven potentially rocky exoplanets in orbit around a star that has 12 times less mass than our own sun. Since the parent star is much smaller than our own sun, then the the planetary orbits within the TRAPPIST-1 system are much smaller than our own solar system, as well. So, how can this study help us better understand the potential habitability of planets in the TRAPPIST-1 system?

"If we take Earth as our starting point, geological activity has shaped the entire surface of the planet, and geological activity is ultimately driven by planetary cooling," said Dr. Dan Bower, who is a geophysicist at the Center for Space and Habitability at the University of Bern, and a co-author on the study.

"The Earth has radioactive elements in its interior which generate heat and enable geological processes to persist beyond 4.5 Gyr. However, the question arises if all planets require radioactive elements to drive geological processes that may establish a habitable surface environment that allows life to evolve. Although some other processes can generate heat inside a planet, they are often short-lived or require special circumstances, which would advance the hypothesis that geological activity (and habitable environments?) are possibly rare."

What makes this study intriguing is that TRAPPIST-1 is known as an M-type star, which is much smaller than our sun and emits far less solar radiation.

"M stars (red dwarfs) are the most common star type in our stellar neighborhood, and TRAPPIST-1 has garnered significant attention since it was discovered to be orbited by seven Earth-sized planets," explained Dr. Bower.

"In our study, we investigated how stellar flares from TRAPPIST-1 impacted the interior heat budget of the orbiting planets and discovered that particularly for the planets closest to the star, interior heating due to ohmic dissipation from flares is significant and can drive geological activity. Furthermore, the process is long-lived and can persist over geological timescales, potentially enabling the surface environment to evolve towards habitable, or pass through a series of habitable states. Previously, the influence of stellar flares on habitability has mostly been deemed to be destructive, for example by stripping the protective atmosphere that enshrouds a planet. Our results present a different perspective, showing how flares may actually promote the establishment of a habitable near-surface environment."

Ohmic dissipation, also known as ohmic loss, is defined as "a loss of electric energy due to conversion into heat when a current flows through a resistance." Essentially, it's what scientists used to calculate the amount of heat a planet loses, also known as planetary cooling, which all terrestrial planetary bodies—even Earth—encounter.

The study's findings indicate that the planetary cooling occurring on the TRAPPIST-1 planets is enough to drive geological activity, which would lead to thicker atmospheres. The researchers' models also predict that the presence of a planetary magnetic field can enhance these heating results.

Recently, NASA's James Webb Space Telescope made its first observations of the TRAPPIST-1 system, finding that one of the planets in its system has a low probability of possessing a hydrogen atmosphere like the gas planets in our own solar system. This could indicate that at least one of TRAPPIST-1's planets could possess a more terrestrial-like atmosphere like Earth, Mars, and Venus. With TRAPPIST-1 holding potential for the field of astrobiology, what follow-up research is planned for this study?

"There are two obvious avenues to pursue," explains Dr. Bower. "First, our stellar neighborhood is dominated by M stars, so observational campaigns can assess the flaring nature of many more M stars besides TRAPPIST-1. Second, enhanced characterization of the TRAPPIST planetary system through observations and models will improve our understanding of the planetary interiors. This will enable us to refine our model in terms of whether the planets have an iron core and whether they have a large Earth-like silicate mantle."

"We plan to run more elaborated physical simulations to better understand the effect intrinsic magnetic fields," said Dr. Alexander Grayver, who is a Heisenberg Junior Research Group Leader at the University of Cologne, and lead author of the study. "The long-term goal is to couple our model with models of atmosphere formation and erosion."

More information: Alexander Grayver et al, Interior Heating of Rocky Exoplanets from Stellar Flares with Application to TRAPPIST-1, *The Astrophysical Journal Letters* (2022). DOI: 10.3847/2041-8213/aca287

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