Another reason red dwarfs might be bad for life: No asteroid belts

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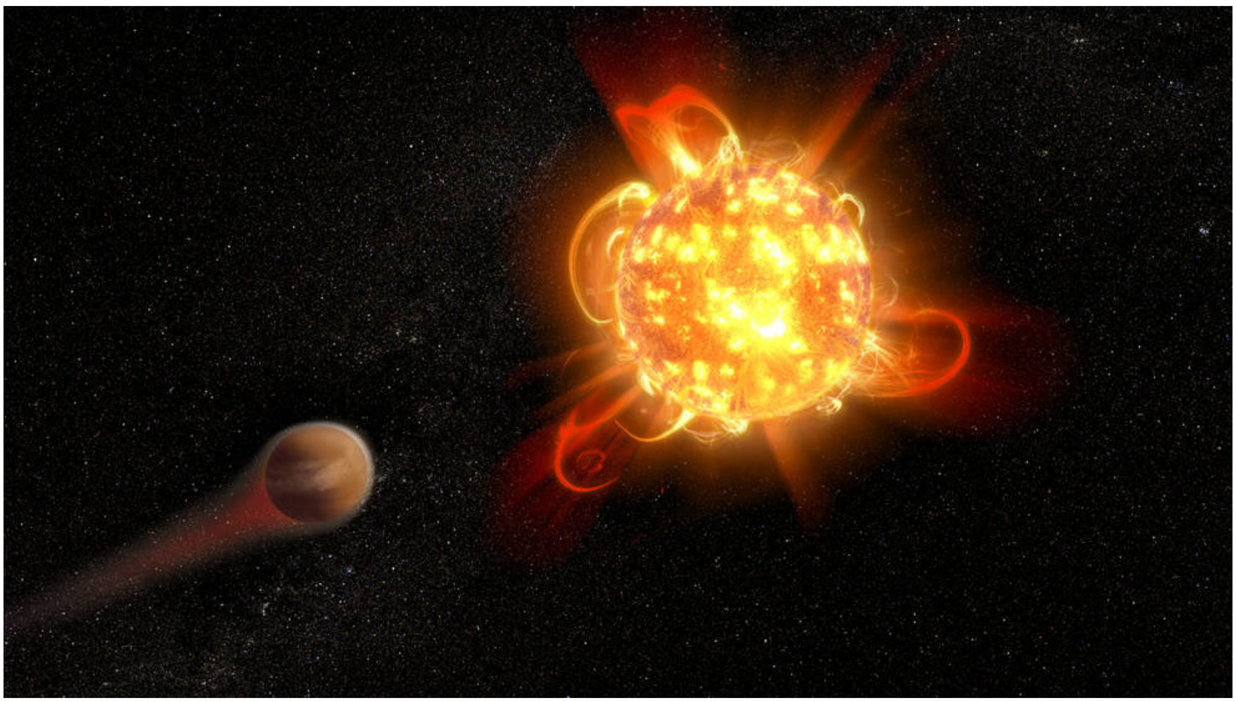

Artist's rendition of a very active red dwarf star. Credit: NASA, ESA and D. Player (STScI))

In a recent study accepted to *The Astrophysical Journal Letters*, a team of researchers at the University of Nevada, Las Vegas (UNLV) investigated the potential for life on exoplanets orbiting M-dwarf stars, also known as red dwarfs, which are both smaller and cooler than our own sun and is currently open for debate for their potential for life on their orbiting planetary bodies. The study examines how a lack of an asteroid belt might indicate a less likelihood for life on terrestrial worlds.

For the study, the researchers observed several M-dwarf systems with exoplanets within the habitable zone (HZ) and noted a lack of giant planets outside what they refer to as the "snow line radius," which is the distance from a star where water ice permanently forms.

In our own solar system, the giant planets beyond the asteroid belt also orbit beyond our own snow line radius. The researchers note that it is because of these giant planets that the asteroid belt exists, thus resulting in some of those asteroids being pushed to the inner solar system, and possibly bringing life with it.

The findings concluded that, "None of the currently observed planets in the habitable zone around M-dwarfs have a giant planet outside of the snow line radius and therefore are unlikely to have a stable asteroid belt." Given these findings, should we, therefore, increase or decrease our search for life in M-dwarf systems?

"I think M-dwarfs are still a great place to look for life since these systems can offer the most detailed observations of Earth-sized planets," said Dr. Anna Childs, who is a postdoctoral scholar at the Center for Interdisciplinary Exploration and Research in Astrophysics (CIERA) at Northwestern University, lead author of the study, and conducted the research while a Ph.D. student at UNLV.

"Because M-dwarf stars are so small and the habitable zone is closer to the star than around larger stars, it allows us to detect smaller planets and to also better characterize the atmospheres of planets that are potentially habitable. This is what the James Webb Space Telescope will be doing with some planetary systems around M-dwarfs such as TRAPPIST-1. Having more detailed information on the atmospheres of Earth-sized planets will provide us with a lot more information about the planet's climate, composition, and formation process. There are still a lot of uncertainties when it comes to these important details about exoplanets. More detailed observations of smaller planets around M-dwarfs will place better constraints on these parameters which will help us characterize these planets in a more complete way."

As stated, M-dwarf stars are both smaller and cooler than our own sun, and range in size from 0.08 to 0.6 solar masses while exhibiting luminosities from 0.0001 to 0.1 times our sun. This means the HZ is also much farther in towards the star, which could result in some interesting star-planetary interactions. So, what can M-dwarf stars teach us about planetary formation and evolution?

"The M-dwarf systems that have been discovered are fascinating because they are so different from the solar system," said Dr. Childs. "We are finding more super-Earths and less giant planets around low mass stars than we are around larger stars like our sun. For a long time, planet formation theory was dominated by theories that did a good job at explaining the solar system. But these M-dwarf systems suggest that either we need a more generalized planet formation theory that is able to explain systems that form around both low mass and high mass stars or, that planet formation does take different formation pathways around low mass and higher mass stars. New theories for planet formation around low mass stars are still being put forward and new detailed observations of these planets offer an exciting opportunity to test these new theories."

Our sun is classified as a G-type star and including M-dwarfs there are seven types of stars in our universe: O, B, A, F, G, K, and M that range from largest to smallest in both size and luminosity, but range from smallest to largest in terms of lifetimes. While our sun's lifetime is on the order of approximately 10 billion years, M-type stars like the one in this study can live up to approximately 200 billion years, which makes them intriguing for the study of life beyond Earth. So, which star-system should we most aggressively search for life beyond Earth?

"Right now, we know of only one place in the universe that has life and that's around our sun," said Dr. Childs. "While there are a lot of practical reasons for looking for life around M-dwarfs, there might come a time when we've exhausted our methods and we'll need to change our tactics and our targets. If we are unsuccessful at finding life around M-dwarfs the next logical place to look will be around sun-like stars–specifically in systems that have planetary architectures similar to the solar system."

For now, the search for life beyond Earth continues at a fever pitch. With new tools just the James Webb Space Telescope, and more ground-based telescopes coming online in the coming years, it could be only a matter of time until we find even the smallest traces of life beyond Earth. Unless we've already found, and just don't know it.

"It's possible that we've observed planets that do host life, but we just don't yet have the technology capable of observing any subtle traces of it," said Dr. Childs. "Life elsewhere could also be so drastically different from our current understanding of it that we fail to recognize it when we do observe it. I think it's an important philosophical and scientific question: Would we recognize life on another world if we observed it? Continuously asking this question and attempting to answer it in a fundamental way will increase our chances of finding life elsewhere."

More information: Anna C. Childs, Rebecca G. Martin, and Mario Livio, Life on Exoplanets in the Habitable Zone of M Dwarfs? *The Astrophysical Journal Letters* (2022). DOI: 10.3847/2041-8213/ac9052
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