Solar physics: Why study it? What can it teach us about finding life beyond Earth?

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Image of a coronal mass ejection being discharged from the sun. Credit: NASA/Goddard Space Flight Center/Solar Dynamics Observatory

Universe Today has investigated the importance of studying impact craters, planetary surfaces, exoplanets, and astrobiology, and what these disciplines can teach both researchers and the public about finding life beyond Earth. Here, we will discuss the fascinating field of solar physics (also called heliophysics), including why scientists study it, the benefits

and challenges of studying it, what it can teach us about finding life beyond Earth, and how upcoming students can pursue studying solar physics. So, why is it so important to study solar physics?

Prof Maria Kazachenko, who is a solar astrophysicist and assistant professor in the Astrophysical & Planetary Science Department at the University of Colorado, Boulder, tells Universe Today, "Solar physics studies how our sun works, and our sun is a star. We should understand how our home star works for various reasons. First, stars are the building blocks of our universe. Even we are made of stardust. Second, our sun provides energy for life and affects our life here on Earth (space weather, digital safety, astronauts' safety). So, to be safe we need to understand our star. Finally, the sun is the only star where we could obtain high-quality maps of magnetic fields, which define stellar activity. To summarize, studying the sun is fundamental for our space safety and for understanding the universe."

The field of solar physics dates to 1300 BC Babylonia, where astronomers documented numerous solar eclipses, and Greek records show that Egyptians became very proficient at predicting solar eclipses. Additionally, ancient Chinese astronomers documented a total of 37 solar eclipses between 720 BC and 480 BC, along with keeping records for observing visible sunspots around 800 BC, as well. sunspots were first observed by several international astronomers using telescopes in 1610, including Galileo Galilei, whose drawings have been kept to this day.

Presently, solar physics studies are conducted by both ground- and space-based telescopes and observatories, including the National Science Foundation's (NSF) Daniel K. Inouye Solar Telescope located in Hawai'i and NASA's Parker Solar Probe, with the latter coming within 7.26 million kilometers (4.51 million miles) of the sun's surface in September 2023. But with all this history and scientific instruments, what are some

of the benefits and challenges of studying solar physics?

Prof. Kazachenko tells Universe Today that some of the scientific benefits of studying solar physics include "abundant observations and many science problems to work on; benefits from cross-disciplinary research (stellar physics, exoplanets communities)" with some of the scientific challenges stemming from the need to use remote sensing, sometimes resulting in data misinterpretation.

Regarding the professional aspects, Prof. Kazachenko tells Universe Today that some of the benefits include "small and friendly community, large variety of research problems relying on amazing new observations and complex simulations, ability to work on different types of problems (instrumentation, space weather operation, research)" with some of the professional challenges including finding permanent employment, which she notes is "like everywhere in science".

As noted, the study of solar physics involves investigating space weather, which is when the solar wind interacts with the Earth, specifically with our magnetic field, resulting in the beautiful auroras observed in the high northern and southern latitudes. On occasion, the solar wind is strong enough to wreak havoc on satellites and even knock out power grids across the Earth's surface.

This was demonstrated with the Carrington Event on September 1–2, 1859, when fires at telegraph stations were reported across the globe, along with several strong aurora observations, as well. While this event occurred with the Earth's magnetic field largely deflecting the incoming solar wind, life on this planet could be doomed without our magnetic field protecting us. Therefore, what can solar physics teach us about finding life beyond Earth?

Prof. Kazachenko tells Universe Today, "The sun can tell us about stellar

activity, including flares and coronal mass ejections that might be crucial for the creation of life on the planets. How frequent are these flares? How strong could they be? Why are some flares eruptive (leaving the star) and others confined (keeping erupted plasma on the star)? Why do we observe mostly confined flares on other stars? The sun could also tell us about the science behind the long-term stellar evolution (stellar cycles, stellar dynamo)."

Like most scientific disciplines, solar physics encompasses researchers from myriad backgrounds, including the aforementioned exoplanet communities, but also includes standard physics, astrophysics, computer science, plasma physics, and fluid dynamics, just to name a few. It is through constant collaborative and innovative efforts from these backgrounds that researchers can study not only our own sun, but suns in other solar systems throughout the cosmos. Therefore, what advice can Prof. Kazachenko offer upcoming students who wish to pursue studying solar physics?

"Be brave, ambitious, and work hard," Prof. Kazachenko tells Universe Today. "Talk to students and scientists who work in the field and do not be afraid to contact scientists you would like to work with. Work on your math and communication skills."

As noted, solar eclipses are an important facet of studying solar physics, as they have been both observed and documented for thousands of years by a myriad of civilizations across the globe. The Holy Grail of eclipses are total solar eclipses, which is when the moon completely blocks out the sun, offering solar physicists a rare opportunity to observe and study coronal mass ejections, which Prof. Kazachenko mentions could be vital to the creation of life.

The upcoming total solar eclipse that will cross the United States in a couple of months will provide scientists with even greater opportunities

to study the sun's many attributes, even more than the 2017 total solar eclipse. For this upcoming eclipse, Prof. Kazachenko plans to lead an expedition "Eclipses en la Frontera" to Eagle Pass, TX, with the National Solar Observatory's Education & Public Outreach Team.

Prof. Kazachenko tells Universe Today, "We had such a wonderful time during the annular solar eclipse (in October 2023), so now we are coming back for totality."

Prof. Kazachenko continues, "The solar eclipse on April 8, 2024, is around the corner. It is a life-changing experience. Not because I am a solar physicist, but because it makes you feel like you are part of the universe. The best place to see it in the US will be in Texas (e.g. San Antonio, Austin, or Dallas), as it might be cloudy in the rest of the eclipse path."

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