Astronomers discover striking evidence of 'unusual' stellar evolution

July 17 2023, by Tatyana Woodall

Credit: Drew Evans / NASA

Astronomers have found evidence that some stars boast unexpectedly strong surface magnetic fields, a discovery that challenges current models of how they evolve.

In stars like our sun, surface magnetism is linked to stellar spin, a process similar to the inner workings of a hand-cranked flashlight. Strong magnetic fields are seen in the hearts of magnetic sunspot regions, and cause a variety of space weather phenomena. Until now, low-mass stars—celestial bodies of lower mass than our sun that can rotate either very rapidly or relatively slowly—were thought to exhibit very low levels of magnetic activity, an assumption which has primed them as ideal host stars for potentially habitable planets.

In a new study, published today in *The Astrophysical Journal Letters*, researchers from The Ohio State University argue that a new internal mechanism called core-envelope decoupling—when the surface and core of the star start out spinning at the same rate, then drift apart—might be responsible for enhancing magnetic fields on cool stars, a process which could intensify their radiation for billions of years and impact the habitability of their nearby exoplanets.

The research was made possible due to a technique that Lyra Cao, lead author of the study and a graduate student in astronomy at Ohio State, and co-author Marc Pinsonneault, a professor of astronomy at Ohio State, developed earlier this year to make and characterize starspot and magnetic field measurements.

Although low-mass stars are the most common stars in the Milky Way and are often hosts to exoplanets, scientists know comparatively little about them, said Cao.

For decades, it was assumed that the physical processes of lower mass stars followed those of solar-type stars. Because stars gradually lose their angular momentum as they spin down, astronomers can use stellar spins as a device to understand the nature of a star's physical processes, and how they interact with their companions and their surroundings. However, there are times where the stellar rotation clock appears to stop in place, Cao said.

Using public data from the Sloan Digital Sky Survey to study a sample of 136 stars in M44, a star crib also known as Praesepe, or the Beehive cluster, the team found that the magnetic fields of the low-mass stars in the region appeared much stronger than current models could explain.

While previous research revealed that the Beehive cluster is home to many stars that defy current theories of rotational evolution, one of Cao's team's most exciting discoveries was determining that these stars' magnetic fields may be just as unusual—far stronger than predicted by current models.

"To see a link between the magnetic enhancement and rotational anomalies was incredibly exciting," said Cao. "It indicates that there might be some interesting physics at play here." The team also hypothesized that the process of syncing up a star's core and the envelope might induce a magnetism found in these stars that would have a starkly different origin from the kind seen on the sun.

"We're finding evidence that there's a different kind of dynamo mechanism driving the magnetism of these stars," said Cao. "This work shows that stellar physics can have surprising implications for other fields."

According to the study, these findings have important implications for our understanding of astrophysics, particularly on the hunt for life on other planets. "Stars experiencing this enhanced magnetism are likely going to be battering their planets with high-energy radiation," Cao said.

"This effect is predicted to last for billions of years on some stars, so it's important to understand what it might do to our ideas of habitability."

But these findings shouldn't put a damper on the search for extraplanetary existence. With further research, the team's discovery could help provide more insight into where to look for planetary systems capable of hosting life. But here on Earth, Cao believes her team's discoveries might lead to better simulations and theoretical models of stellar evolution.

"The next thing to do is verify that enhanced magnetism happens on a much larger scale," said Cao. "If we can understand what's going on in the interiors of these stars as they experience shear-enhanced magnetism, it's going to lead the science in a new direction."

More information: Lyra Cao et al, Core-envelope Decoupling Drives Radial Shear Dynamos in Cool Stars, *The Astrophysical Journal Letters* (2023). DOI: 10.3847/2041-8213/acd780

Provided by The Ohio State University