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Julie Cohen

Stellar Revelations

Using a recently developed technique to detect magnetic fields inside stars, a group of astronomers — including Matteo Cantiello and Lars Bildsten from UC Santa Barbara's Kavli Institute for Theoretical Physics (KITP) — has discovered that strong magnetic fields are very common in stars. The group's findings appear in the journal Nature.

"We have applied a novel theoretical idea that we developed just a few months ago to thousands of stars and the results are just extraordinary," said Cantiello, a specialist in stellar astrophysics at KITP.

Previously, only a very small percentage of stars were known to have strong magnetic fields. Therefore, current scientific models of how stars evolve do not include magnetic fields as a fundamental component.

"Such fields have simply been regarded as insignificant for our general understanding of stellar evolution," said lead author Dennis Stello, an astrophysicist at the University of Sydney in Australia. "Our result clearly shows this assumption needs to be revisited because we found that up to 60 percent of stars host strong fields."

Until now, astronomers have been unable to detect these magnetic fields because such fields hide deep in the stellar interior, out of sight from conventional observation methods that measure only the surface properties of stars. The research team turned to asteroseismology, a technique that probes beyond the stellar

surface, to determine the presence of very strong magnetic fields near the stellar core.

“The stellar core is the region where the star produces most of its energy through thermonuclear reactions,” Cantiello explained. “So the field is likely to have important effects on how stars evolve since it can alter the physical processes that take place in the core.”

Most stars — like the sun — are subject to continuous oscillations. “Their interior is essentially ringing like a bell,” noted co-author Jim Fuller, a postdoctoral scholar from the California Institute of Technology in Pasadena. “And like a bell or a musical instrument, the sound produced reveals physical properties, such as size, temperature and what they are made of.”

The researchers used very precise data from NASA’s Kepler space telescope to measure tiny brightness variations caused by the ringing sound inside thousands of stars. They found that certain oscillation frequencies were missing in 60 percent of the stars due to suppression by strong magnetic fields in the stellar cores.

“It’s like having a trumpet that doesn’t sound normal because something is hiding inside it, altering the sound it produces,” Stello said.

This magnetic suppression effect had previously been seen in only a few dozen stars. However, the new analysis of the full data set from Kepler revealed that this effect is prevalent in stars that are only slightly more massive than the sun.

According to Cantiello, such intermediate mass stars are hotter and more luminous, and their cores are stirred by convection. “We believe that the magnetic field is created by this ‘boiling’ sequence and stored inside the star for the remaining evolutionary phase. Astrophysicists previously have suggested this but it was very speculative; now it seems clear that this is the case,” he said.

“This is a very important result that will enable scientists to test more directly current theories for how magnetic fields form and evolve in stellar interiors,” said co-author Bildsten, the director of KITP. “When a star dies, the presence of strong magnetic fields can have a profound impact, possibly resulting in some of the brightest explosions in the universe.”

This research could potentially lead to a better general understanding of stellar magnetic dynamos, including the one controlling the sun’s 11-year sunspot cycle, which is known to affect communication systems and cloud cover on Earth.

“So far, the study of stellar magnetic dynamos principally relied on computer simulations, which now can be tested using these new exciting observations,” said Fuller.

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