UH Hilo astronomer Pierre Martin and international research team discover extremely rare property in star

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Staff April 24, 2024

Observations revealed lithium is abundant in the gigantic star V470 Cas. Only seven other Cepheids among the several thousands in the entire Galaxy are known to display such a prominent lithium line.

By **Susan Enright**.

For two decades, an international collaboration of astronomers led by **R. Pierre Martin** from the University of Hawai´i at Hilo, and including his colleagues from Ukraine, has been studying a large number Cepheids distributed across the Milky Way disk, obtaining high quality spectra and then using models to accurately determine their chemical composition.

Pierre Martin

During a recent survey conducted with the spectrograph ESPaDOnS at the Canada-France-Hawaii Telescope on Maunakea, one of the stars observed in their program, named V470 Cas, showed a very unusual property: the spectral features revealed that lithium was very abundant in that star.

Martin's research team includes Ukrainian astronomers **Valery Kovtyukh** and **S. M. Andrievskii** from Mechnikov National University, Odessa, and **Sergey Korotin** from the Crimean Astrophysical Observatory located at Nauchnij research campus.

A report on their work, titled, "Lithium-rich Cepheid V470 Cas," was recently published in the peer-reviewed journal *Astronomy & Astrophysics*.

"Cepheids, named after the first star showing their characteristics, Delta Cephei, are large stars which have evolved from burning hydrogen into helium through nuclear reactions in their core during most of their lives," explains Martin, an associate professor of physics and

astronomy who serves as co-chair of his department and is director of the university's educational observatory. "When they reach that phase, the hydrogen is only burning in a shell structure around an inert core made of helium."

Cepheids also have become mechanically unstable and regular pulsations occur, the entire star "beating" at its own rhythm of several hours to several days, adds Martin.

"With their variable brightness, Cepheids play an important role in determining distances in the Universe, in our understanding of the evolution of stars in general, but also in mapping the different chemical elements across our Galaxy," Martin says.

The discovery of abundant lithium in V470 Cas

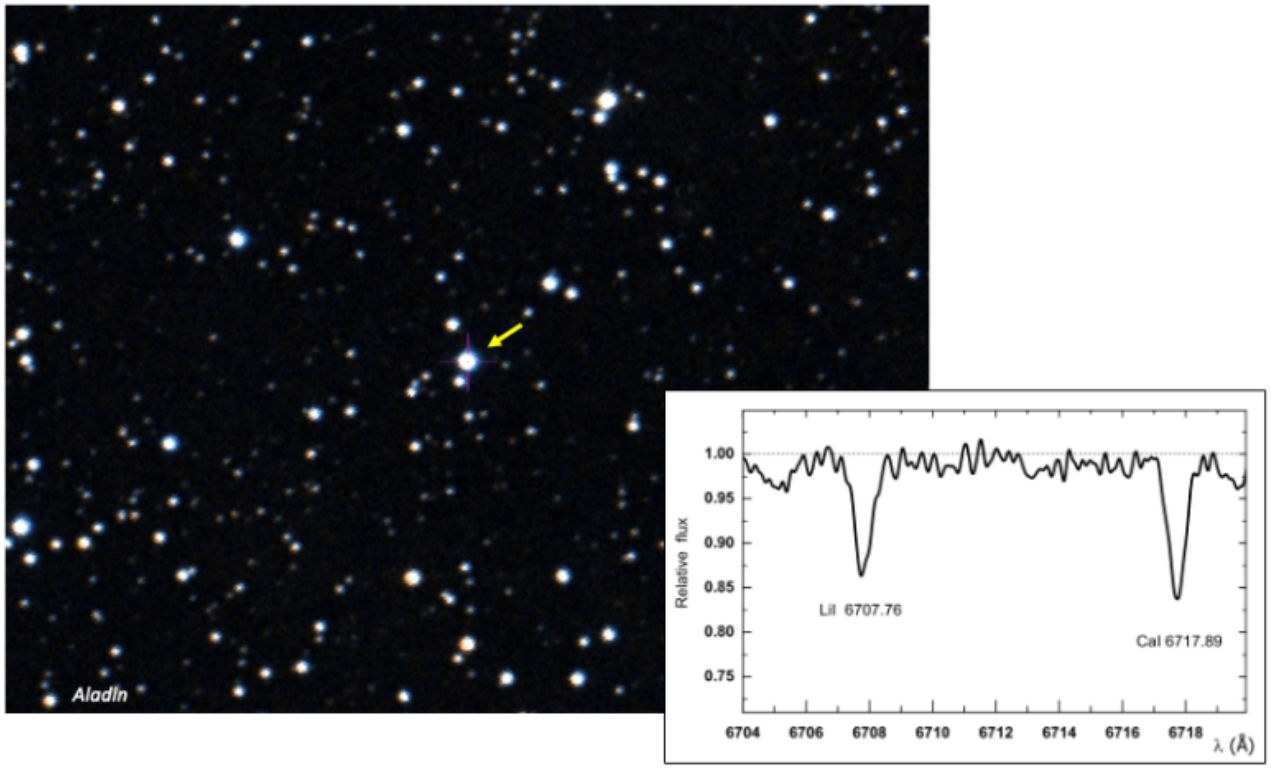
Why is this discovery so unusual?

Associate Professor Martin explains that V470 Cas is a faint Cepheid star located in the constellation of Cassiopeia.

"It pulsates with a period of about 21 hours and has four times the mass of our Sun," he says. "Contrary to what is observed in almost all of Cepheid stars, the group discovered that the spectral line of lithium — observed at 670.7nm — is very prominent for V470 Cas."

This discovery of abundant lithium is extraordinary because only seven other Cepheids among the several thousands of Cepheids in the entire Galaxy are known to display such a prominent lithium line.

Martin further explains that this line comes from the atoms of lithium in the atmosphere of the star, a very thin region near the surface absorbing light coming from the inner, hotter region.



V470 Cas is a Cepheid variable star in the constellation of Cassiopeia (arrow). On the right, a small section of its spectrum shows the strong absorption line at 6707 Ang. corresponding to a large abundance in lithium. (Images courtesy of Pierre Martin)

Why is it so surprising to see so much lithium in that star?

When such a massive star enters the so-called instability phase (becoming then a pulsating Cepheid), a series of large-scale mixing events occur in its interior (called dredge-up episodes). Elements near the surface of the star are brought into deeper zones in the star, where it is much hotter.

Martin explains that all models reveal that lithium, the third lightest element in the Universe, is rapidly destroyed in those hot zones. Spectra in almost all Cepheids show that this scenario is correct: lithium has disappeared in all those stars. “Except,” says Martin, “for some reason, in eight of them, including V470 Cas.”

The researchers discovered that V470 Cas has the third highest abundance value of lithium ever measured in a Cepheid.

“It is clear the Cepheids with lithium in their spectra, including V470 Cas, are just entering the instability phase,” says Martin. “Maybe the first dredge-up episode is still to occur, even if the star is already pulsating. But statistically, if this hypothesis is correct, we should also see many more of these young Cepheids with a large lithium abundance. We do not.”

“So,” says Martin, “we are facing a dilemma: Cepheids with lots of lithium should not exist at all, or rather should be very numerous across the Galaxy. This discovery of the lithium-rich V470 Cas, adding to a very select group of Cepheid stars, suggests that there is something we do not fully understand yet in the evolution of these stars. An enigma to solve.”

Story by Susan Enright, a public information specialist for the Office of the Chancellor and editor of UH Hilo Stories. She received her bachelor of arts in English and certificate in women’s studies from UH Hilo.