New technique reveals the age of massive Southern Cross star

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Southern Cross (view from Merna Mora, South Australia). Credit: James St. John/flickr, CC BY 2.0

An international team of astronomers from Australia, the United States and Europe has for the first-time unlocked the interior structure of Beta Crucis—a bright blue giant star that features on the flags of Australia, Brazil, New Zealand, Papua New Guinea and Samoa.

With an entirely new approach, the team led by Dr. Daniel Cotton, found the star to be 14.5 times as massive as the Sun and as young as 11 million years old, making it the heaviest star with an age determined from asteroseismology ever.

The findings will provide new detail on how stars live and die, and how

they impact the Galaxy's chemical evolution.

To crack the star's age and mass, the research team combined asteroseismology, the study of a star's regular movements, with polarimetry, the measurement of the orientation of light waves.

Asteroseismology relies on seismic waves bouncing around the interior of a star and producing measurable changes in its light. Probing the interiors of heavy stars that will later explode as supernovae has traditionally been difficult.

"I wanted to investigate an old idea," lead author Dr. Cotton, from The Australian National University (ANU), and Monterey Institute for Research in Astronomy in the U.S., said.

"It was predicted in 1979 that polarimetry had the potential to measure the interiors of massive stars, but it's not been possible until now."

Study co-author Professor Jeremy Bailey from the University of New South Wales (UNSW) said: "The size of the effect is quite small. We needed the world's best precision of the polarimeter we designed and built at UNSW for the project to succeed."

The study of Beta Crucis, also known as Mimosa, combines three different types of measurements of its light: space-based measurements of light intensity from NASA's WIRE and TESS satellites, 13 years of ground-based high-resolution spectroscopy from the European Southern Observatory, and ground-based polarimetry gathered from Siding Spring Observatory and Western Sydney University's Penrith Observatory.

"It was a lucky circumstance that we could use the world's most precise astronomical polarimeter to make so many observations of Mimosa at the Anglo-Australian Telescope while TESS was also observing the star,"

second author Professor Derek Buzasi from Florida Gulf Coast University said.

"Analyzing the three types of long-term data together allowed us to identify Mimosa's dominant mode geometries. This opened the road to weighing and age-dating the star using seismic methods."

Professor Conny Aerts of KU Leuven said: "This polarimetric study of Mimosa opens a new avenue for asteroseismology of bright massive stars. While these stars are the most productive chemical factories of our galaxy, they are so far the least analyzed asteroseismically, given the degree of difficulty of such studies. The heroic efforts by the Australian;polarimetrists are to be admired."

The study has been published in *Nature Astronomy*.

More information: The dawn of polarimetric asteroseismology and its application to blue giant star β Crucis, *Nature Astronomy* (2021). DOI: 10.1038/s41550-021-01547-1

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