Astronomers Use AI to Find Elusive Stars "Gobbling Up" Planets

Submitted by Matthew Bothwell on Wed, 31/07/2024 - 10:06

An international team (including IoA astronomers Laura Rogers and Amy Bonsor) have recently found hundreds of "polluted" white dwarf stars in our home galaxy, the Milky Way. These are white dwarfs caught actively consuming planets in their orbit. They are a valuable resource for studying the interiors of these distant, demolished planets. They are also difficult to find.

Traditionally, astronomers have had to manually review mountains of survey data for signs of these stars. Follow-up observations would then prove or refute their suspicions. By using a novel form of artificial intelligence, called manifold learning, a team led by University of Texas at Austin Graduate Student Malia Kao has accelerated the process, leading to a 99% success rate in identification.

This study highlights the power of big data sets, such as provided by Gaia, and data science techniques as the future means to identify exciting astronomical objects from their spectra. The IoA plays a big part of this revolution, with the IoA making a substantial contribution to data processing for the Gaia space satellite.

Findings were published July 31, 2024, in the Astrophysical Journal.

White dwarfs are stars in their final stage of life. They've used up their fuel, released their outer layers into space, and are slowly cooling. One day, our Sun will become a white dwarf – but that won't be for another 6 billion years.

Sometimes, the planets orbiting a white dwarf will be drawn in by their star's gravity, ripped apart, and consumed. When this happens, the star becomes "polluted" with heavy metals from the planet's interior. Because white dwarfs' atmospheres are made almost entirely of hydrogen and helium, the presence of other elements can be reliably attributed to external sources. "For polluted white dwarfs, the inside of the planet is literally being seared onto the surface of the star for us to look at," explained Kao. "Polluted white dwarfs right now are the best way we can characterize planetary interiors."

"Stated differently," added Keith Hawkins, an astronomer at UT Austin and co-author on the paper, "it's the only bona fide way to actually figure out what planets outside the solar system are made of, which means finding these polluted white dwarfs is critical."

Unfortunately, evidence of these stars – which are identified by the polluting metals in their atmospheres - can be subtle and hard to detect. What's more, astronomers must find them within a relatively brief window of time. "White dwarfs have very high surface gravity - about 100,000 times that of Earth's," said Kao. As a result, an object would weigh about 100,000 times more on a white dwarf than it would on Earth. "So heavy metals sink to the core very quickly."

While astronomers can identify these stars by manually reviewing data from astronomical surveys, this can be time intensive. To test out a faster process, the team applied artificial intelligence to data available from the Gaia space telescope. "Gaia provides one of the largest spectroscopic surveys of white dwarfs to date, but the data is so low resolution it wasn't thought that it would be possible to find polluted white dwarfs with it," said Hawkins. "This work shows that you can."

To find these elusive, polluted stars, the team used a type of artificial intelligence called manifold learning. With it, an algorithm looks for similar features in a set of data and clumps like items together in a simplified, visual chart. Researchers can then review the chart and decide what clumps warrant further investigation.

The astronomers created an algorithm to sort over 100,000 possible white dwarfs. Of these, one clump of 375 stars looked promising: they showed the key feature of having heavy metals in their atmospheres. Follow-up observations with the Hobby-Eberly Telescope at UT Austin's McDonald Observatory confirmed the astronomers' suspicions.

"Our method can increase the number of known polluted white dwarfs tenfold, allowing us to better study the diversity and geology of planets outside our solar system," said Kao. With more polluted white dwarfs to study, that means greater insight on the composition and distribution of planets in our galaxy. "Ultimately, we want to determine whether life can exist outside of our solar system. If ours is unique among planetary systems, it might also be unique in its ability to sustain life."

This research made use of data from the European Space Agency (ESA) mission Gaia. The data was processed by the Gaia Data Processing and Analysis Consortium. Follow-up observations were obtained with the Hobby-Eberly Telescope (HET), which is a joint project of the University of Texas at Austin, the Pennsylvania State University, Ludwig Maximilians-Universitaet Muenchen, and Georg-August Universitaet Goettingen, and with the Very Large Telescope (VLT) at the European Southern Observatory (ESO). The Texas Advanced Computing Center at UT Austin provided high performance computing, visualisation, and storage resources for this research.

Based on a press release from UT Austin. Media contact:
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