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Planetary remnants around white dwarf stars

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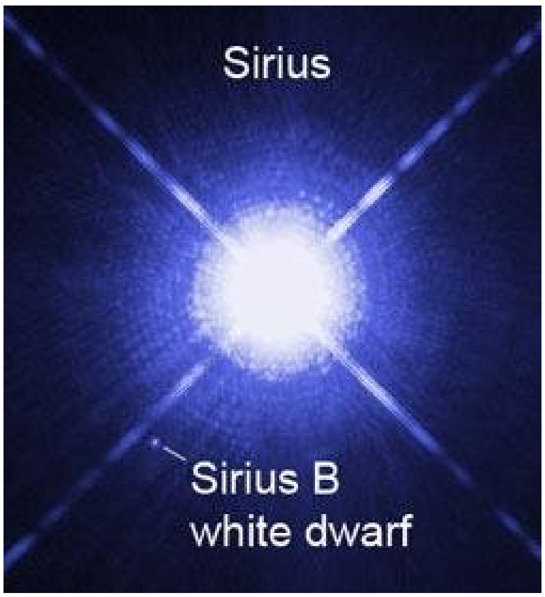

A Hubble image of Sirius and its white dwarf companion star. Remnants of planets in aged, white dwarf systems can be seen as dusty disks of material and a new study has discovered six such systems that also have gaseous components, a very rare combination. The hot gas can be analysed to reveal kinematic information about the disk. Credit: Harvard-Smithsonian Center for Astrophysics

When a star like our sun gets to be old, in another seven billion years or so, it will no longer be able to sustain burning its nuclear fuel. With only about half of its mass remaining it will shrink to a fraction of its radius and become a white dwarf star. White dwarf stars are common; over 95% of all stars will become white dwarfs. The most famous one is the companion to the brightest star in the sky, Sirius, but more particularly all stars known to host exoplanets will also end their lives as white dwarfs.

Astronomers have established that planets orbiting stars can usually survive the late stages of their host's evolution. The rocky planets are broken apart and disbursed into dusty debris disks, and so white dwarf stars should retain remnant evidence of their planetary companions. Emission from these dusty disks is seen as excess infrared radiation; when some of this material accretes onto the white dwarf itself, the elements produce features in the star's spectrum. A small fraction, about 4%, of white dwarfs with dust disks also have gaseous components that have been seen in emission . While very rare—only about a dozen are known—these gaseous disk white dwarfs are thought to provide a particularly useful diagnostic of dynamical instabilities and disruption events in white dwarf disks, and astronomers have been on the lookout for more cases.

CfA astronomer Warren Brown was a member of a team that combined new optical observations from the Gaia space mission's all sky survey with infrared catalog information to search for white dwarf stars whose infrared excesses signal the presence of a disk. They identified about 110 candidates which they followed up with optical spectroscopy using multiple ground-based telescopes, from which they discovered six new gaseous disk-hosting white dwarfs. Their analysis of the spectra of these objects revealed that the disks are more complex than expected: over 50 emission lines are seen and they differ in their widths, strengths, and shapes.

The lines also have strikingly different variability characteristics, with some stars showing lines that barely vary at all over about three years of monitoring while in at least one host the lines vary by 50%. Many of the observed lines have profiles that permit kinematic modeling, for example indicating a flat disk rotating in so-called Keplerian motion (with the faster velocities closer to the star, as in the case of the planets in our solar system). The new results show that white dwarf stars have rich, dynamically active environments that can be used to better understand how a star's system of planets evolves as the star enters old age.

More information: N P Gentile Fusillo et al, White dwarfs with planetary remnants in the era of Gaia – I. Six emission line systems, *Monthly Notices of the Royal Astronomical Society* (2021). DOI: 10.1093/mnras/stab992

Provided by Harvard-Smithsonian Center for Astrophysics

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