White dwarfs hide information on dark forces

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Birth of a white dwarf (bright spot at the center) in the Dumbbell Nebula. Credit: Telescopio Joan Oro - Observatori Astronomic del Montsec

Researchers from Europe and the USA have ruled out a multitude of possible parameters for dark photons - a type of dark matter and energy - with the help of white dwarfs. In some aspects, the shining of these dying stars gives more information on dark forces than is provided by earth-based laboratories. The journal *Physical Review D* has published the study.

White dwarfs represent the final life stage of stars with small or medium masses (less than a tenth of the mass of the Sun) and measures of their luminosity enable us to follow their cooling and the behaviour of their particles precisely in accordance with the standard model used in physics. Any diversion from predicted data should give scientists clues as to what could be out there, such as dark matter and energy.

"The cooling rate of white dwarfs can be measured, even in real time, if we accept as such observations made over the course of 30 years. The presence in their interior of any extra energy source or drain would disrupt this cooling rate, enabling us to discover its presence," explains Jordi Isern from the Institute of Space Sciences (CSIC-IEEC).

Based on this idea, Isern and other researchers from Europe and the USA plan to follow this "indirect and not very costly" method for studying the brightness of white dwarfs to test the validity of new theories and reduce the range of their parameters. This study has been published in the journal *Physical Review D*.

In particular, the scientists focused on the values between which dark photons can fluctuate (these also known as heavy photons due to their mass, which marks them apart from conventional photons, and because they can interact with ordinary matter). These hypothetical particles, related to the 'dark' version of electromagnetism, can only be detected indirectly when they are broken down into electrons and antielectrons (positrons).

"Many of the attempts to expand the standard model are based on introducing new interactions which use dark photons as mediators, which, if they exist, can be created inside white dwarfs and escape freely, behaving as an energy drain which disrupts the development of the star," explains Isern.

The researchers have demonstrated that this effect enables us to discount a wide range of possible masses and coupling intensities under conditions that are impossible or very difficult to achieve in research institutions on Earth.

Despite how useful white dwarfs are in exploring dark forces, the results of the study reveal that, in order to study other hypothetical particles beyond the standard model - such as neutralinos in supersymmetry models or axions in some quantum theories - Earth-based laboratories like CERN are still superior.

In any case, white dwarfs provide data of great interest to astrophysicists, including their capacity to give information on the past history of galaxies, such as their age, star formation rate or the remains of neighbouring galaxies that were captured by the Milky Way.

Developments in statistics in quantum mechanics and nuclear physics in the 20th Century enabled us to discover that these dying stars do not keep going due to thermonuclear reactions but because of the pressure exerted by 'degenerate' electrons (a microscopic property of quantum superposition) before the white dwarfs become stellar corpses.

More information: Herbert K. Dreiner, Jean-Francois Fortin; Jordi Isern; Lorenzo Ubaldi. "White Dwarfs constrain Dark Forces". *Physical Review D* 88(4), 2013.

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