New Dark Matter Candidate Proposed

A vacuum – space essentially void of any matter whatsoever – is a strange thing. And it may be even stranger, according to recent research. Motivated by the results of an experiment known as PVLAS, which showed that not only is the vacuum empty but can act like a crystal under a strong magnetic field, a group of physicists has proposed a dark-matter candidate particle produced during the early universe and within stars.

Crystals, materials with ordered atomic structures, are nothing new in the world of physics. Physicists use them in many ways, such as to cause light that is oscillating in one direction ("linearly polarized" light) to spin around while oscillating (becoming "circularly polarized" light). But a vacuum acting like a crystal is something altogether different.

In the PVLAS experiment, which is located at Italy's Legnaro National Laboratory, researchers created a vacuum in a chamber, applied a strong magnetic field to the chamber using powerful magnets, and directed a beam of light into one end. They observed that the light coming out spun around as if it had passed through a crystal.

"We propose that the intense magnetic field causes light to mix with certain hypothetical particles, which are called pseudoscalars," explained corresponding scientist Pankaj Jain, a physicist at the Indian Institute of Technology in Kanpur, to *PhysOrg.com*. "Essentially, light gets partially converted into these particles, which then convert back after a short time interval. The interaction of these particles with light and other known particles is very weak. Hence they could be candidates for dark matter."

Standing in their way, however, are the astrophysical bounds that govern how light couples with these particles. These bounds suggest that the coupling must be far weaker than the bounds suggested by the results of laboratory experiments. However, Jain and his collaborators propose that the bounds are not applicable if the pseudoscalars also interact strongly enough with other pseudoscalars.

Jain and his colleagues propose that pseudoscalars, if they exist, were likely produced in the early universe and then spread throughout it. They suggest that, in the current universe, as clouds of dust collapse into stars, pseudoscalars are sucked inside due to gravity. Furthermore, highly energetic pseudoscalars are produced inside the cores of these stars.

Pseudoscalars can pass through a cloud of normal particles but not one consisting of other pseudoscalars. This is what traps them inside stars: A pseudoscalar in the Sun cannot travel very far, only about one centimeter, before colliding with another pseudoscalar. As a result, pseudoscalars – unlike photons – never make it to the surface.

In this scenario, stars therefore take on a dark-matter balancing role. Their enormous gravity pulls in galactic pseudoscalars and other matter while, within the stars, photons and newly formed pseudoscalars push to get out. Eventually, these forces equalize, trapping some pseudoscalars.

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