Physicist finds colder isn't always slower as electron emissions increase at temps to -452 F

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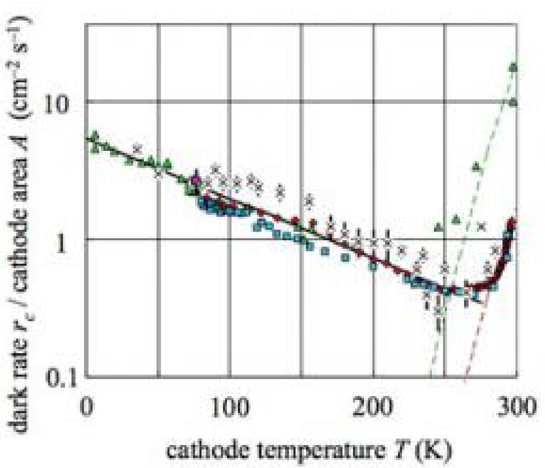

Using two different photomultipliers (denoted by triangles and squares), Meyer found that dark rate electron emission decreased as the temperature (noted above in Kelvin) decreased until about -63.4 F (220 K), when the emission rate then began increasing while temperatures continued dropping to -452 F (4 K).

(PhysOrg.com) -- Science is detective work so it was not unexpected that new questions would follow old ones as Indiana University Bloomington nuclear physicist Hans-Otto Meyer's work progressed on testing a fundamental symmetry of nature that could lead to understanding the matter-antimatter asymmetry in the universe.

At the heart of this search to uncover a violation of time-reversal symmetry by observing a permanent electric dipole moment of the neutron (nEDM) is the $25 million nEDM experiment that Meyer and 60 other researchers from 15 institutes are working on.

But while searching for a non-zero separation of positive and negative charge inside a neutron (the symmetry-violating nEDM), Meyer ran into another mystery scientists have yet to explain.

Working with highly sensitive photomultipliers intended to detect the scintillation light given off during the nEDM experiment as charged particles emerge from reactions between neutrons and a rare isotope of helium, Meyer identified new attributes to a phenomenon called cryogenic electron emission.

In a recent paper in *Europhysics Letters* (Vol. 89, Issue 5), Meyer presents a thorough experimental investigation of the electron emission rate in the absence of light -- called the dark rate -- in which the rate of electron emission unexpectedly increases as a photomultiplier is cooled to liquid-helium temperature.

Once the temperature hit around -64 F (220 K) and as it continued down to the lowest temperature measured during the experiment, -452 degrees F (4 K), electron emission from the cathode surface of the photomultiplier steadily increased. This is in contrast to the usual behavior of nature where processes tend to slow down as things get colder.

Meyer saw the electrons being emitted in bursts, noted that the burst duration distribution followed a power law and, as the temperature decreased, that both the rate of bursts and their size increased. Furthermore, he found that while the bursts occurred at random times, that within a given burst the emission of electrons obeyed a peculiar pattern in time.

Scientists have known about cryogenic emission for about 50 years. While other types of spontaneous electron emission without light are understood (thermal or heat, electrical field, and penetrating radiation electron emission), Meyer points out, "at this time, regrettably, a quantitative explanation of the observed characteristics of cryogenic emission is still eluding us."

"Most likely, this observation can eventually be explained within the known laws of physics, but there is always a small chance that we are seeing something new, and that this is a real discovery," he said.

Meyer suggests a trapping mechanism may be at work. How the trap is created and how it fills with or empties itself of electrons might be related to the behavior of traps in semiconductors. One clue pointing to a trap mechanism is the longer intervals between emitted electrons, from about three microseconds apart to three milliseconds apart as a given burst evolved.

A trap would hold electrons until full, then empty some electrons that become dark events measured by the photomultiplier, while others would recombine with an electron hole and thus go undetected. As fewer electrons remained, the release rate would slow.

Retired from teaching duties at the IU College of Arts and Sciences' Department of Physics and having graduated his last student two years ago, Meyer is still active in research at the IU Cyclotron Facility's new Center for Matter and Beams. He estimated continuing the experiment would cost about $500,000.

"I would be very pleased if someone younger would take up this investigation," he said.

And if someone else were to take up this mystery, a semi-retired Meyer has some thoughts on how to proceed.

"Ideally you would want to build an apparatus capable of presenting different surfaces of your choice, like copper, carbon or silicon for example, to an electron multiplier," he said. "The apparatus requires ultra-high vacuum, and the surfaces must be cooled to cryogenic temperatures. Such an experiment will tell us whether these trapping events are present only in semiconductors such as the cathode of a photomultiplier, or are of a more general nature."

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