New insights into neutrino interactions

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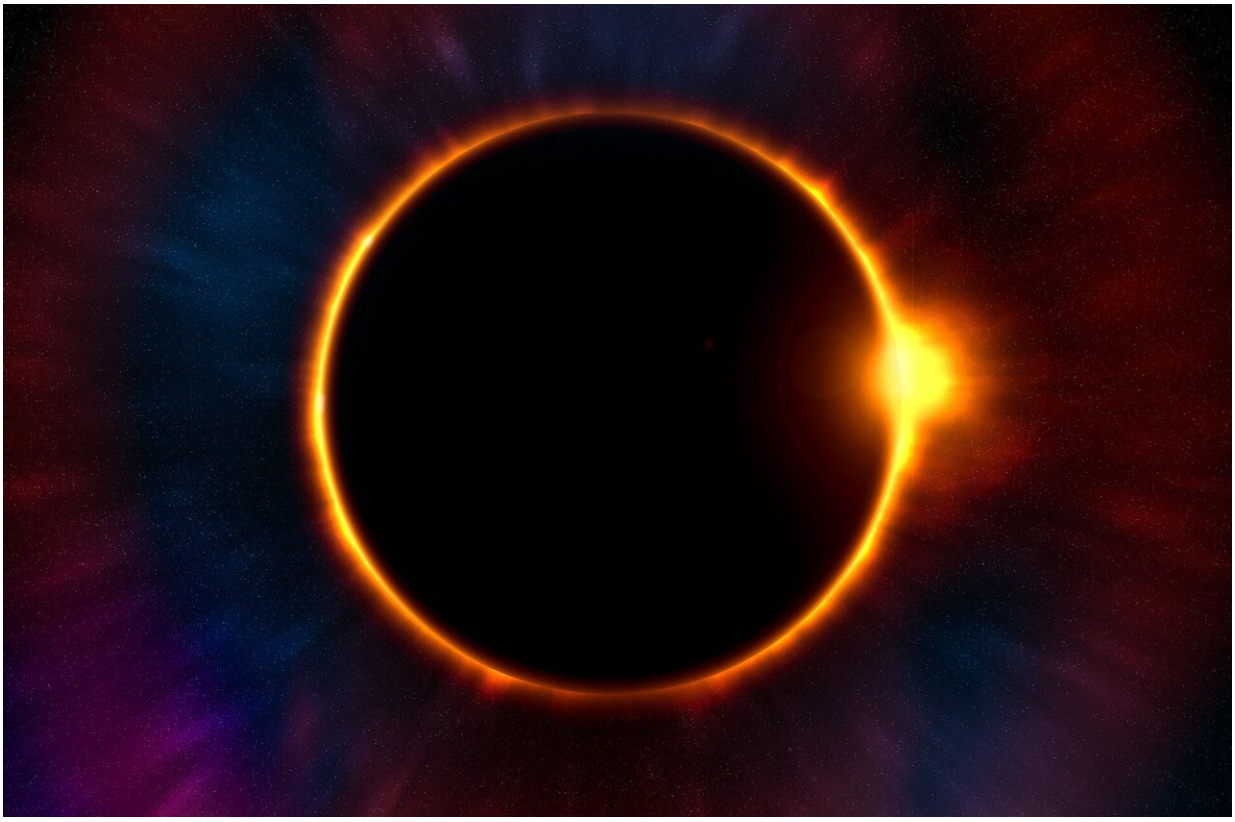

A total solar eclipse, with the solar corona visible. Credit: ipicgr/Pixabay

Research at Hokkaido University has revealed that elusive particles called neutrinos can interact with photons, the fundamental particles of light and other electromagnetic radiation, in ways not previously detected. The findings from Kenzo Ishikawa, Professor Emeritus at Hokkaido University, with colleague Yutaka Tobita, lecturer at

Hokkaido University of Science, were published in the journal *Physics Open*.

"Our results are important for understanding the quantum mechanical interactions of some of the most fundamental particles of matter," says Ishikawa. "They may also help reveal details of currently poorly understood phenomena in the sun and other stars."

Neutrinos are one of the most mysterious fundamental particles of matter. They are extremely difficult to study because they barely interact at all with other particles. They are electrically neutral and have almost no mass. Yet they are highly abundant, with vast numbers constantly streaming from the sun and passing through the Earth, and indeed ourselves, with barely any effect. Learning more about neutrinos is important for testing and perhaps refining our current understanding of particle physics, known as The Standard Model.

"Under normal 'classical' conditions, neutrinos will not interact with photons," explains Ishikawa "We have revealed, however, how neutrinos and photons can be induced to interact in the uniform magnetic fields of the extremely large scale—as large as 10^3 km—found in the form of matter known as plasma, which occurs around stars." Plasma is an ionized gas, meaning that all of its atoms have acquired either an excess or a deficiency of electrons, making them negatively or positively charged ions, rather than the neutral atoms that can occur under everyday conditions on Earth.

The interaction described by the researchers involves a theoretical phenomenon called the electroweak Hall effect. This is an interaction of electricity and magnetism under extreme conditions where two of the fundamental forces of nature—the electromagnetic and the weak forces—merge into the electro-weak force. It is a theoretical concept, expected to apply only in the very high energy conditions of the early

universe or within collisions in particle accelerators.

The research has derived a mathematical description of this unexpected neutrino-photon interaction, known as the Lagrangian. This describes everything known about the energy states of the system.

"In addition to its contribution to our understanding of fundamental physics, our work might also help explain something called the solar corona heating puzzle," says Ishikawa. "This is a long-standing mystery concerning the mechanism by which the outermost atmosphere of the sun—its corona—is at a much higher temperature than the sun's surface. Our work shows that the interaction between neutrinos and photons liberates energy that heats up the solar corona."

"We now hope to continue our work in search of deeper insights, especially in connection with energy transfer between neutrinos and photons under these extreme conditions," says Ishikawa.

More information: Kenzo Ishikawa et al, Topological interaction of neutrino with photon in a magnetic field—Electroweak Hall effect, *Physics Open* (2023). DOI: 10.1016/j.physo.2023.100174

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