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PRESS RELEASE (2026/09/17)

Investigating the underlying mechanisms of magnetic reconnection in space weather events

Experiments reveal that the rate at which magnetic fields release energy is controlled by the local physics of reconnection layer

Fukuoka, Japan—Magnetic reconnection is a process that occurs when the magnetic fields of a conductive plasma quickly rearrange and release massive amounts of stored magnetic energy. It is widely thought to be the underlying mechanism behind cosmic events such as solar flares and substorms in Earth's magnetosphere. Now, researchers from Kyushu University have used high-power lasers to recreate and investigate this puzzling physical phenomenon of magnetic reconnection in a controlled environment. Their results indicate that fast magnetic reconnection is governed by the local physics of the reconnection layer and not the properties of the surrounding plasma.

Briefly put, magnetic reconnection involves the splicing and reconnection of magnetic field lines pointing in opposite directions as two plasma flows meet, which causes plasma heating and high-speed plasma outflows. Although scientists have studied magnetic reconnection through space observations and computer simulations, important questions remain unanswered. In particular, it was unclear how strongly the reconnection process depends on the conditions of the plasma flowing into the reconnection region. Understanding this relationship could help explain why magnetic reconnection rates appear to take a 'universal' value.

In the present study, a research team led by Associate Professor Taichi Morita from Kyushu University's Faculty of Engineering Sciences, in collaboration with researchers from Osaka University, employed lasers to produce interacting plasmas and probe their magnetic reconnection processes. The study was published in the journal *Physical Review E* on September 8, 2026.

Using the Gekko-XII laser at Osaka University, the team fired high-power laser beams at two separate spots on a carbon target, producing two expanding plasma clouds. As the two plasmas collided, their magnetic fields reconnected. By changing the distance between the two laser spots, the researchers could substantially vary the density and magnetic field conditions flowing into the reconnection region. To follow the process, they developed a two-directional laser Thomson-scattering system, which analyzes laser light scattered by the plasma to measure properties such as its temperature, density, and flow.

The results show that even though the expansion and transport histories of the magnetic fields and reconnection timings differed substantially, the reconnection rates were strikingly similar once a current sheet had formed. "Our study provides experimental evidence for the robustness of the magnetic reconnection process by demonstrating that fast reconnection can occur at similar rates despite substantially different upstream conditions," says Morita.

The researchers also quantified how the released magnetic energy was divided between heating the plasma and accelerating it into high-speed flows. “The measurement techniques established in this study now make it possible to quantitatively evaluate the magnetic reconnection rate and its energy conversion,” explains Morita.

The findings of this work provide experimental benchmarks that can be used to test theoretical models and numerical simulations of magnetic reconnection. The team plans to extend the experiments to conditions that more closely resemble those found in space plasmas, including cases with oblique magnetic fields and asymmetric plasma flows.

“Our study contributes to experimental evidence on one of the central unresolved problems in magnetic reconnection physics. The improved understanding of magnetic reconnection will aid in prediction of space weather events that have an impact on satellites, communications systems, navigation technologies, and power infrastructure,” concludes Morita.

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For more information about this research, see “Characterizing the temporal evolution of Biermann-battery-driven magnetic reconnection in laser-ablated plasmas,” T. Morita, Y. Muramoto, S. Isayama, M. Edamoto, M. Hanano, R. Ishikawa, Y. Kanesada, K. Koba, H. Kondo, S. Kurimaru, K. Maeda, Y. Maenosono, S. Matsukiyo, A. Morita, Y. Nagamatsu, G. Nakayama, T. Ogawa, K. Oshida, Y. Pan, K. Sakai, T. Sano, Y. Sato, N. Shimoda, J. Shiota, Y. Sudo, Y. Suzuki, T. Takezaki, S. J. Tanaka, K. Tomita, S. Ueno, S. Yakura, R. Yamazaki, and Y. Sakawa, *Physical Review E*, https://doi.org/10.1103/2b4s-5m1n.

About Kyushu University

Founded in 1911, Kyushu University is one of Japan's leading research-oriented institutions of higher education, consistently ranking as one of the top ten Japanese universities in the Times Higher Education World University Rankings and the QS World University Rankings. Located in Fukuoka, on the island of Kyushu—the most southwestern of Japan’s four main islands—Kyushu U sits in a coastal metropolis frequently ranked among the world’s most livable cities and historically known as Japan’s gateway to Asia. Its multiple campuses are home to around 19,000 students and 8,000 faculty and staff. Through its VISION 2030, Kyushu U will “drive social change with integrative knowledge.” By fusing the spectrum of knowledge, from the humanities and arts to engineering and medical sciences, Kyushu U will strengthen its research in the key areas of decarbonization, medicine and health, and environment and food, to tackle society’s most pressing issues.

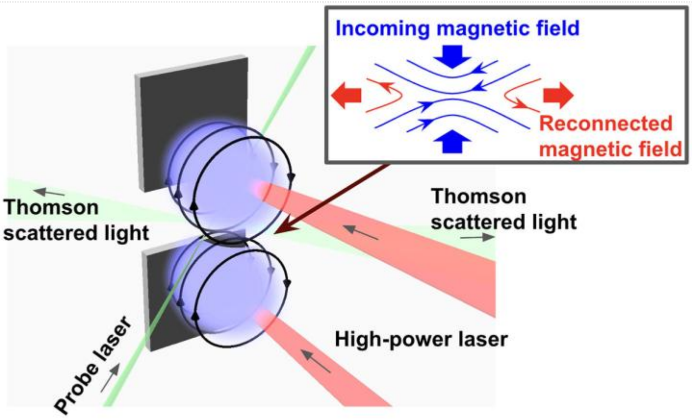

FIG.1 A diagram of the experimental setup. The team fired high-power laser beams at two separate spots on a carbon target, producing two expanding plasma clouds. As the two plasmas collided, their magnetic fields reconnected at the point where they met. (Taichi Morita/Kyushu University)

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