Simulations fix the cracks in magnetic mirrors

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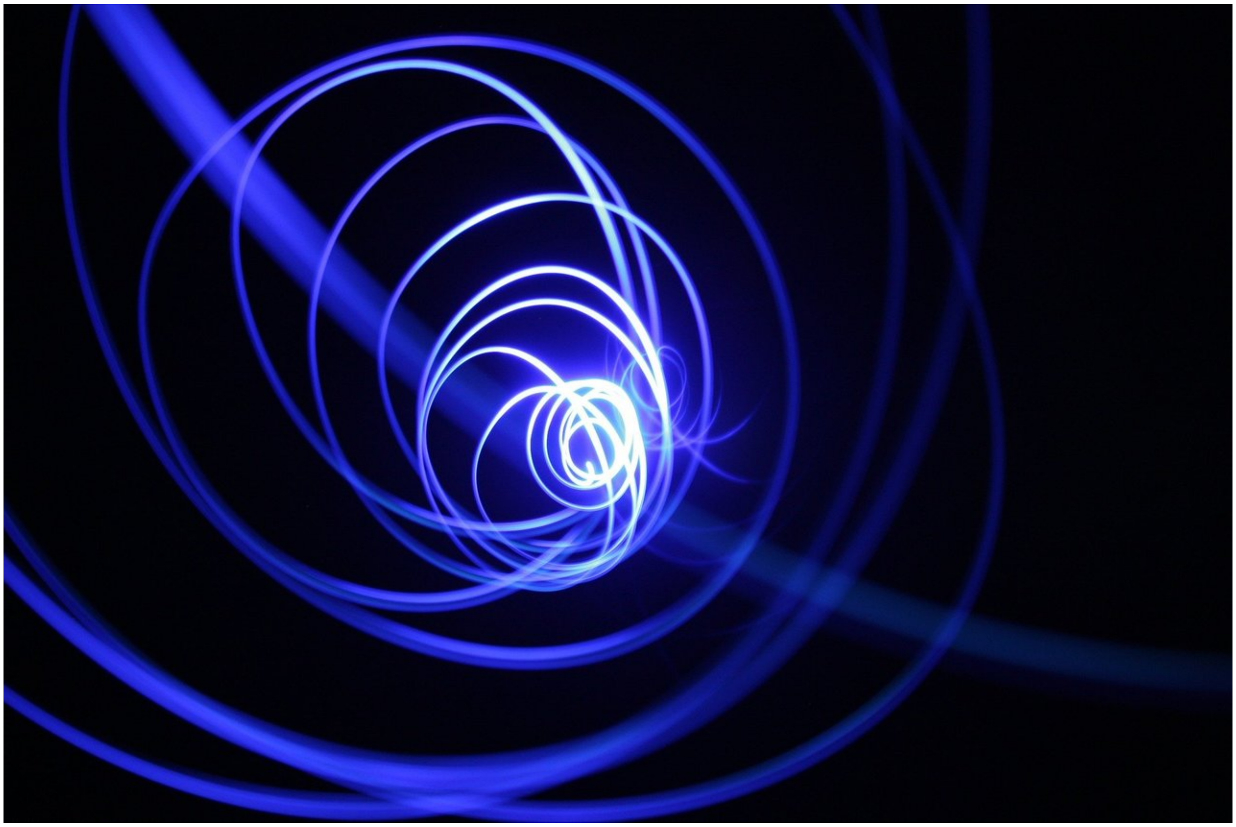

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When ring-shaped electromagnets are set up in linear arrangements, they can produce magnetic fields resembling a tube with a cone at each end—a structure that repels charged particles entering one cone back along their path of approach. Referred to as 'magnetic mirrors', these devices have been known to be a relatively easy way to confine plasma since the 1950s, but they have also proven to be inherently leaky. In a study published in *EPJ D*, physicists led by Wen-Shan Duan at Northwest Normal University, and Lei Yang at the Chinese Academy of Sciences, both in Lanzhou, China, show that these plasma leaks can be minimised if specific conditions are met. Using computer simulations, the physicists analysed the dynamic properties of a high-energy proton plasma beam within a magnetic mirror and fine-tuned the simulation settings to maximise its confinement.

Firstly, Duan, Yang and their colleagues varied the 'mirror ratio'—defined as the strongest magnetic field in the mirror (at the tip of each cone), divided by the weakest field (on the surface of the tube). They found that higher mirror ratios, which can be achieved using finely-tuned electromagnet configurations, directly corresponded to longer confinement times and lower loss rates. Secondly, the team found that the initial conditions of the plasma beam itself had an important effect, including its density, temperature, velocity, and trajectory. When each of these properties were optimised, the simulated high-energy beam moved in a tight spiral pattern within the mirror, ensuring maximum confinement.

The insights gathered by Duan and Yang's team could solve a decades-old problem of low plasma confinement times and high loss rates in magnetic mirrors. This could make them ideal for intriguing new particle physics experiments, including the production and confinement of antihydrogen atoms and electron-positron plasmas, as well as the deceleration of high-energy antiprotons.

More information: Fang-Ping Wang et al, Confinement of proton beam in a magnetic mirror, *The European Physical Journal D* (2019). DOI: 10.1140/epjd/e2019-90587-0

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