IPFN – INSTITUTO DE PLASMAS E FUSÃO NUCLEAR

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Solving a 25-year-old mystery brings compact particle accelerators closer to reality

An international team of physicists led by researchers from Portugal and Germany has discovered a new model for plasma particle acceleration that explains correctly a large number of experimental results and represents a crucial breakthrough for the new generation of accelerators.

Particle accelerators are important for the advancement of science, the development of the economy and the improvement of society. They are used for advanced medical therapies (such as cancer treatment), medical imaging and lithographic industry, to name but a few. The development of new types of particle accelerators may one day allow the construction of more compact and economical devices, while at the same time contributing to clarify the fundamental questions associated with the universe, the existence of space, time and matter.

Now, an international team of physicists led by researchers at IST in Portugal and DESY (Deutsches Elektronen-Synchrotron) in Germany have published a paper that addresses a challenge posed by US physicists in the early 1990s. According to them, a new class of plasma particle accelerators, more compact and economical than the current ones, would be so unstable that they would self-destruct. It would then be impossible to use this technology to study high-energy physics – the branch of physics explored in the large Hadron Collider (LHC) at CERN that recently culminated with the discovery of the Higgs particle.

But contrary to the theoretical predictions of the American physicists, and explaining for the first time a number of experimental results, the current study, published on April 26 in the prestigious journal *Physical Review Letters*, explains that these types of accelerators are actually intrinsically stable.

The team of researchers turned to supercomputers at IST and Juelich, Germany, to test a new theory on these accelerators, incorporating effects ignored so far, through sophisticated computer simulations.

This result fits within a set of techniques that explore the properties of the fourth state of matter, the plasma. In the plasma state, the temperature of the atoms and molecules exceeds that of the gas state. Plasmas are very common and make up about 99% of the known matter in the universe. Examples of its importance range from the processes of light emission in neon lamps to the dynamics associated with solar explosions. Plasma-based particle accelerators are being actively developed around the world, including in the largest particle physics laboratory, CERN.

In addition to solving a fundamental question and explaining many experimental results obtained so far at different laboratories, such as the Stanford Linear Accelerator (California, US), this paper also poses "new issues that will be explored in the near future with new theories in conjunction with experiments," says Jorge Vieira, a researcher at the Group for Lasers and Plasmas, IST's Institute of Plasmas and Nuclear Fusion, who coordinated the work that led to this discovery.

Link to the paper:
https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.118.174801

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