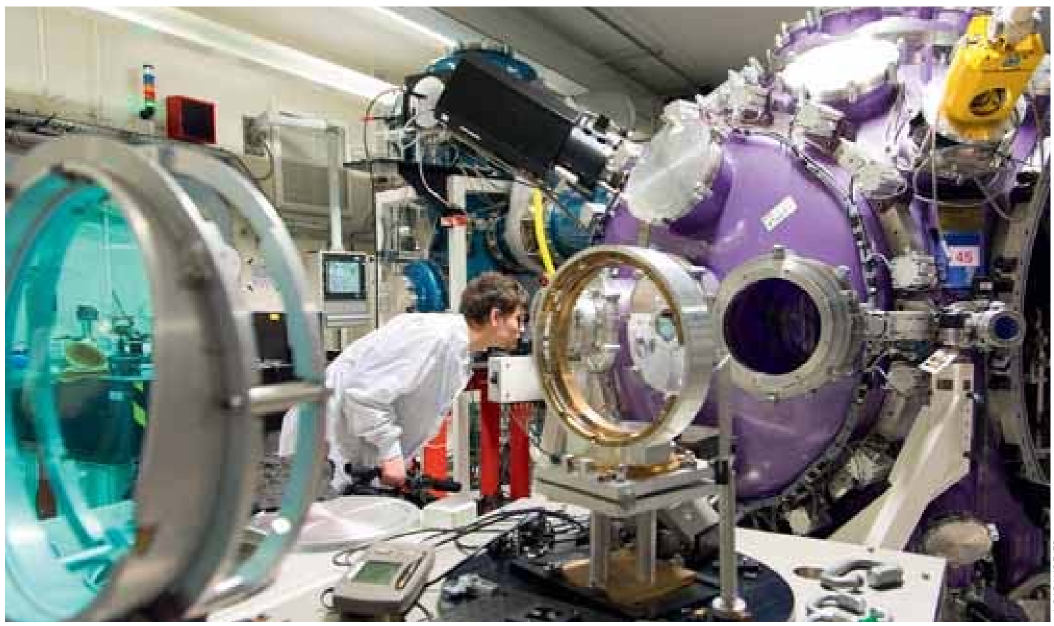
Energy By using a beam of protons accelerated by ultra-intense laser pulses, CNRS researchers increase the yield of proton-boron fusion reaction a hundredfold.

Improving Neutron-Free Fusion

BY BRETT KRAABEL

Nuclear fusion has powered stars for eons, and mankind now hopes to harness its promise of abundant clean energy. Recently, CNRS researcher Christine Labaune and colleagues at LULI[1] and the University of Arizona (US) took an important step toward this goal by using two pulsed lasers to generate a hundredfold increase in the yield of helium nuclei ("alpha particles") from the fusion of boron and hydrogen nuclei (protons).[2]

For years, science has pinned its hopes of fusion energy on the deuterium-tritium (D-T) reaction, essentially because igniting it requires an equilibrium temperature of "only" 25 million degrees Celsius. However, tritium is not a natural element and must therefore be continually produced. Moreover, the reaction creates high-energy neutrons that are very hard to handle. An alternative is the proton-boron (pB) reaction, for which all elements involved are abundant in nature and the alpha particles created are easy to convert into thermal energy to run a turbine. The problem is that the equilibrium temperature for igniting the pB reaction is ten times higher than for the D-T reaction, and techniques to run the pB reaction without reaching thermal equilibrium have had very low yields.



© J. BARANDE/EP

→ Experiment chamber at LULI, in which aneutronic, proton-bore reactions took place.

"To increase the yield of the pB reaction, our idea was to produce a beam of protons accelerated by an ultra-intense laser pulse and to use this beam to create pB reactions in a boron target without attaining thermal equilibrium," explains Labaune.

To do this, the team irradiated a solid boron target with a first laser pulse, creating a boron plasma. A second laser pulse irradiated an aluminum foil target, creating a proton beam from the hydrogenated foil surface. By tuning the experimental parameters, the proton energy could be adjusted to better match the low-energy resonances of the cross section of the pB reaction, thereby increasing the reaction yield.

Much work is left to optimize this approach and Labaune is confident that the yield can be significantly improved. Considering the advantages of the pB reaction, she has already shown that the proposed scheme deserves further study.

01. Laboratoire pour l'utilisation des lasers intenses (CNRS / CEA / Ecole polytechnique / UPMC).
02. C. Labaune et al., "Fusion reactions initiated by laser-accelerated particle beams in a laser-produced plasma," *Nat. Commun.*, 2013. 4:2506. doi: 10.1038/ncomms3506.

CONTACT INFORMATION:
LULI, Palaiseau.
Christine Labaune
› christine.labaune@polytechnique.fr