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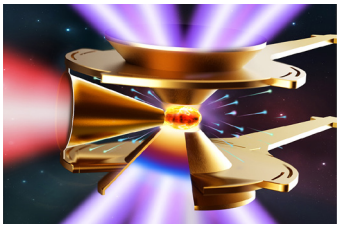
Creating high-density plasmas for the double cone ignition scheme



High-gain inertial confinement laser fusion involves compressing and heating targets to trigger nuclear fusion reactions. In contrast to the conventional ignition process, which simultaneously compresses and self-heats, “fast ignition” is far more efficient as it enables the separation — and optimization — of the compressing and external heating processes.

But generating high-density plasma with uniform density distribution has been a longstanding challenge because large corona regions on the plasma periphery typically deflect and scatter the heating electron beam away from its compressed center.

Using the double cone ignition (DCI) scheme, Liu et al. demonstrated that a high-density plasma can be robustly generated by head-on collision of compressed plasma jets with velocities about 220 km/s.

Their experimental results were collected using an X-ray streak camera that converts X-rays into electrons and then converts the ultrafast electronic signals into spatially ordered image information.

“Thanks to team collaboration and the improved x-ray streak camera, we can capture the colliding plasma jets in every shot,” said author Jie Zhang.

DCI employs focused nanosecond laser beams to implode fuels embedded in two head-on gold cones; collision of the plasma jets from the cone tips forms a plasma with sharp ends so the high-current relativistic electron beam, guided by a kilo-Tesla magnetic field, may be efficiently injected into the compressed fuel.

The team’s results were found to agree with hydrodynamic simulations and showed the kinetic energy of plasma jets can be efficiently converted into thermal energy.

“These results are not only critical for the fast heating process by a relativistic electron beam but also important for other applications in astrophysical studies,” said Zhang.

Source: “Observation of the colliding process of plasma jets in the double-cone ignition scheme using an x-ray streak camera,” by Zhengdong Liu, Fuyuan Wu, Yapeng Zhang, Xiaohui Yuan, Zhe Zhang, Xiangyan Xu, Yanhua Xue, Jinshou Tian, Jiayong Zhong, and Jie Zhang, *Physics of Plasmas* (2024). The article can be accessed at http://doi.org/10.1063/5.0188056.