Researchers create world's brightest X-ray source with high-power laser beam and novel metal foams

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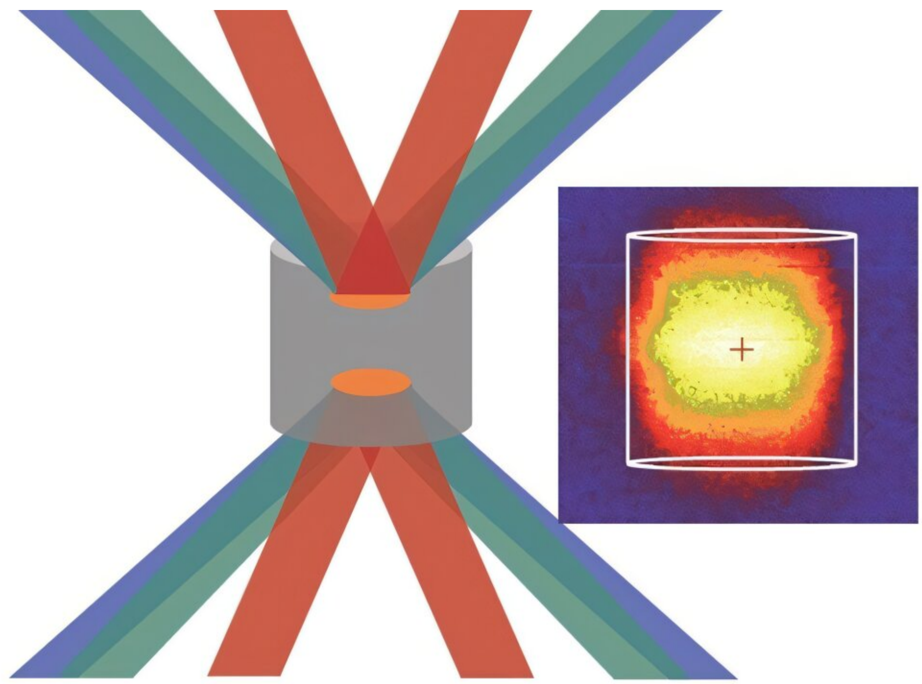

The NIF lasers overlap onto the millimeter-scale cylindrical silver foam target. The resultant heating creates X-rays, which are then imaged as shown on the right. Credit: Lawrence Livermore National Laboratory

By combining the National Ignition Facility (NIF) laser and ultra-light metal foams, researchers at Lawrence Livermore National Laboratory

(LLNL) have produced the brightest X-ray source to date—about twice as bright as previous solid metal versions.

These ultra-bright high-energy X-rays can be used to image and study extremely dense matter, like the plasmas created during inertial confinement fusion. The team's work was recently published in *Physical Review E.*

LLNL scientist Jeff Colvin compared the source to the machine used to find cavities at a dentist.

"Your dentist's machine creates an electron beam that is crashed into a heavy metal plate. The electrons in the beam interact with the electrons bound to the metal atoms to create X-rays," he said. "At NIF, we use the high-power laser beam instead of an electron beam to make the X-rays by 'crashing' the beam into silver atoms and creating a plasma."

The choice of silver is important, as the higher the atomic number of the metal atom, the higher the energy of the X-rays that it produces. The team used silver because they wanted to make X-rays with an energy greater than 20,000 electron volts.

The foam structure of the metal was also critical to achieving this goal. The team manufactured 4-mm-wide cylindrical targets using a mold and silver nanowires.

"We froze the nanowires suspended in solution in the mold, then applied a supercritical drying process to remove the solution, leaving the low-density porous metal foam," said LLNL researcher Tyler Fears.

"We made silver foam with a density of about 1/1000 of solid density, which is not much higher than the density of air," Colvin said.

In such a foam, the NIF laser heats up a larger volume of the material and the heat propagates much faster than in a solid. The whole cylinder of foam heats up in about 1.5 billionths of a second.

In addition to creating the X-ray source, the researchers explored differing foam densities to determine which provided the maximum energy output. They also applied a new data analysis technique to attempt to understand the physics of the generated plasma.

Using that data, they found that these bright, hot metal plasmas are far from thermal equilibrium. Models, like those used to examine inertial confinement fusion at NIF, typically assume plasmas are close to equilibrium, with electrons, ions and photons all having around the same temperature.

"Going forward, this means we need to rethink our assumptions about heat transport and how we calculate it in these particular metal plasmas," Colvin said.

More information: M. J. May et al, Thermal energy transport in laser-driven high X-ray conversion efficiency metallic silver nanowire foams, *Physical Review E* (2025). DOI: 10.1103/PhysRevE.111.015201

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