[http://web.archive.org/web/20100527154020/https://lasers.llnl.gov/programs/science\_at\_the\_extremes/](http://web.archive.org/web/20100527154020/https%3A/lasers.llnl.gov/programs/science_at_the_extremes/)

**Science at the Extremes**

**When laboratory experiments begin at the National Ignition Facility** in 2010, researchers will be able for the first time to study the effects on matter of the extreme temperatures, pressures and densities that exist naturally only in the stars and deep inside the planets. Results from this relatively new field of research, known as high energy density (HED) science, will mark the dawn of a new era of science. HED experiments at NIF promise to revolutionize our understanding of astrophysics and space physics, hydrodynamics, nuclear astrophysics, material properties, plasma physics, nonlinear optical physics, radiation sources and radiative properties and other areas of science.

 An artist's concept of a black hole in a binary system shows a star (at right) feeding an accretion disk surrounding the black hole. The insert shows an image recorded by the Hubble Space Telescope of a massive black hole at the center of the galaxy NGC4261.

NIF will achieve temperatures of more than 100 million Kelvin (180 million degrees Fahrenheit); densities of about 1,000 grams per cubic centimeter; pressures more than 100 billion times greater than the Earth's atmosphere; and neutron densities as high as 1026 per cubic centimeter. Only three places in the space and time of our universe have ever produced anything close to these conditions: the Big Bang, when the universe was born in a primordial fireball; the interiors of stars and planets; and thermonuclear weapons. Nothing within orders of magnitude of these extraordinary conditions has been available for laboratory experiments until now (see [How to Make a Star](http://web.archive.org/web/20100527154020/https%3A/lasers.llnl.gov/programs/nic/icf/)). Because these conditions are so extreme, the connection between NIF and astrophysics is certain to excite scientists interested in using NIF to try to understand the objects in the cosmos, even to the beginning of the universe.

"Now is a very opportune time for major advances in the physics understanding of matter under extreme high energy density conditions."
–Committee on High Energy Density Plasma Physics,
National Research Council

 Supernova explosion simulationThe temperature at which hydrogen undergoes fusion in the cores of stars for most of their lives is 10 to 30 million Kelvin, or 18 to 54 million degrees Fahrenheit – much lower than the temperature expected to be achieved in the NIF target. This phase of stellar evolution occurs at a density of some 100 grams per cubic centimeter, also well below what NIF will achieve. NIF's high pressures will permit planetary astrophysicists to study conditions at the cores of massive planets such as Jupiter and to understand the transition between large planets and stars. The extreme neutron density at NIF is larger than that achievedy by a core-collapse supernova – an exploding star – or when two neutron stars collide.

The conditions that NIF will produce will also permit research into:

* Materials at unprecedented pressures, and the possible phase changes that are certain to be discovered under these conditions (see [Planetary Physics](http://web.archive.org/web/20100527154020/https%3A/lasers.llnl.gov/programs/science_at_the_extremes/planetary_physics.php)).
* Plasmas, the material that makes up the stars and constitutes almost all of the known matter in the universe (see [Plasma Physics](http://web.archive.org/web/20100527154020/https%3A/lasers.llnl.gov/programs/science_at_the_extremes/plasma_physics/)). The turbulent collections of electrons and ions that can carry electrical currents and generate magnetic fields are of interest not only for the production of energy from laser fusion, but also to astrophysics (much of our understanding of extreme objects, such as black holes, arises from studies of the X-rays emitted from the plasmas that are produced around them) and to nuclear physics (the combination of extreme temperature and neutron density in NIF will permit never before possible studies of nuclear reactions on short-lived nuclear excited states).
* Instabilities produced by laser fusion (see [Laser-Plasma Interactions](http://web.archive.org/web/20100527154020/https%3A/lasers.llnl.gov/programs/science_at_the_extremes/plasma_physics/laser-plasma_interactions.php)). Although these phenomena are the bane of laser fusion researchers, they are the same instabilities that are produced in some stellar objects, such as supernovae, and so will provide a unique opportunity for astrophysicists to understand what makes stars, even exploding stars, operate the way they do.

**More Information**