

A New Era of Experimental Science

Laboratory experiments at the National Ignition Facility will enable researchers for the first time to study the effects on matter of extreme temperatures, pressures, and densities that exist naturally only in stars and deep inside 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 experimental science. HED research at NIF promises to revolutionize our understanding of astrophysics and space physics, hydrodynamics, nuclear astrophysics, material properties, plasma physics, nonlinear optical physics, radiation sources, radiative properties, and other areas of science.



Supernova 1987A

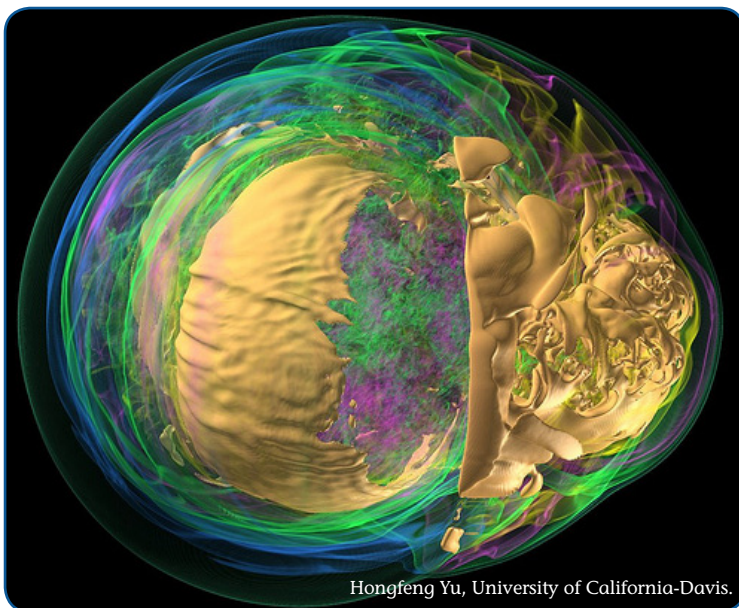
Experiments on NIF will reveal the nature and behavior of many astrophysical phenomena, such as Supernova 1987A.

within orders of magnitude of these extraordinary conditions has been available for laboratory experiments until now. Because these conditions are so extreme, many scientists are interested in using NIF to try to understand the objects in the cosmos, even to the beginning of the universe.

NIF's high pressures will permit planetary astrophysicists to study conditions at the cores of massive planets such as Jupiter and to understand why they are planets and not stars. The extreme neutron density at NIF is considerably greater than that of a core-collapse-type supernova—an exploding star—or a collision of two neutron stars.

The conditions that NIF can produce also will allow scientists to investigate:

- Materials at unprecedented pressures, and the possible phase changes that are certain to be discovered under these conditions.



Hongfeng Yu, University of California-Davis.

Supernova

This astrophysics simulation from Argonne

National Laboratory seeks to discover the mechanism behind core-collapse supernovas, or the violent death of short-lived, massive stars.

The image shows entropy values in the core of the supernova, with different colors and transparencies assigned to different values of entropy.

NIF will generate temperatures of more than 100 million kelvins (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 of about 100 septillion (10^{26}) 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

National Ignition Facility & Photon Science

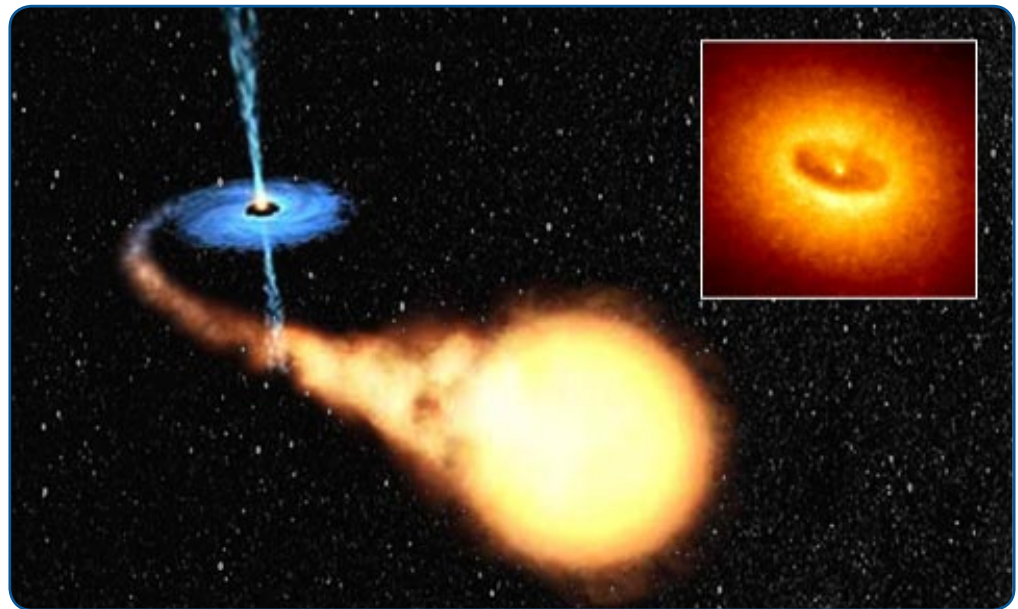
- Plasma, the material that makes up the stars and constitutes almost all of the known matter in the universe. Plasmas are turbulent collections of electrons and ions that can carry electrical currents and generate magnetic fields. They are of interest not only for the production of energy from laser 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 extreme neutron density in NIF will make possible studies of nuclear reactions in short-lived nuclear excited states).

- Instabilities produced by laser fusion. These phenomena are the same instabilities that are produced in some stellar conditions, such as supernovas, providing a unique opportunity for astrophysicists to understand what makes stars, even exploding stars, behave the way they do. ■

A Massive Black Hole

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 inset image, recorded by the Hubble Space Telescope is of a massive black hole at the center of the galaxy NGC4261.



Laser-Plasma Interactions

Results of a laser-plasma interaction experiment compare favorably with a computer simulation of the same interaction. The target is similar in size to a pencil eraser.

