# NRC fusion laser

# Scratch a target

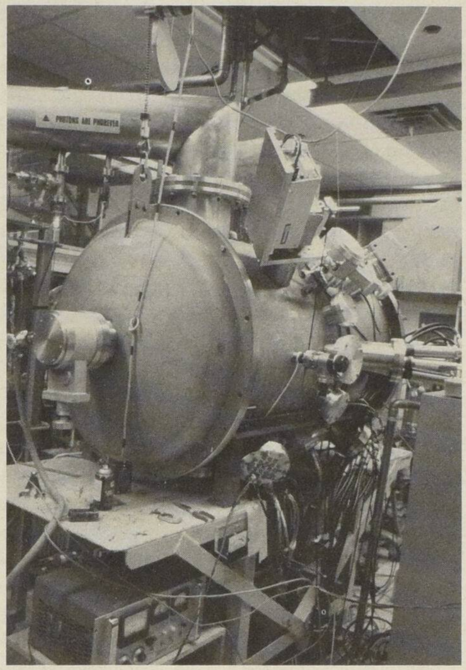
*With its amplifiers fully charged, the huge laser is set to go, aimed directly at a hollow glass sphere one-hundredth the diameter of a pinhead. Dr. Gary Enright, a physicist in NRC's Plasma Physics Section, sits in his copper-shielded control room making final preparations to fire. A monitor from a TV camera mounted on the target chamber magnifies the tiny target, called a "microballoon", to the size of a tennis ball. Enright sounds the klaxon, a warning to passersby that a high-power laser burn is imminent.*

*With the microballoon in perfect focus in the center of the screen, he pushes a button. A bullet of light in the far infrared shoots from the laser and smashes into the target. The 30-cm-long light bullet, passing a given point in one-billionth of a second, makes a harsh sound like the crack of a whip. The people watching the monitor see the target disappear. There are no fragments, no smoke. The solid target has, in an instant, become "plasma".*

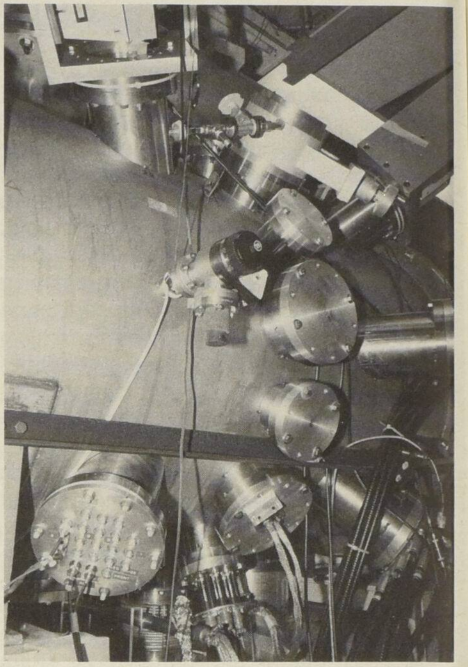
Scratch a target, gain valuable data: laboratory raw materials end up as scientific facts. In the five years since it first became operational, the NRC COCO-II laser has zapped a lot of targets, and gleaned an equivalent quantity of information. "It's been a real workhorse," Dr. Enright says. "Lasers, especially the big ones, are notoriously cranky, but we have managed to tinker COCO-II into a solid reliability."

The main limitation on that use, in fact, has been the Section's capacity to crunch the data that COCO-II turns out. As everyone caught in the jaws of a book club knows, it's a lot easier to get information than to go over it. "Going over it," in the COCO-II project, means a forest of 'diagnostics' whose sensors surround the metre-wide sphere of the target chamber, making it look like a floating mine. It is every schoolchild's image of science: flashing lights, gleaming metal, complex machines and the muted whine of power sources. To relax the otherwise serious atmosphere, researchers have pinned up a sign: "Photons are Phorever".

Ask Enright what he's been up to for the last few years and he'll leap into enthusiastic jargon like "interferometrically observed steepened density profiles." What it boils down to is this: society wants the perfect energy source - cheap, renewable, free of toxic wastes or dangerous fuels, and safe from unpredictable price-gouging or overextended lines of supply. Science may be on the trail of just such a source in the form of atomic fusion, the spark of the stars and sun. Man has mimicked this in the hydrogen bomb, but has not tamed it. Says Enright: "To bottle the incredible energies of fusion in a workable power plant is a staggering task. Even to contemplate it demands that we know much more about what fuses, how, and why."



Two views of the COCO-II target chamber. Ringed with a forest of sophisticated "diagnostics" which help NRC scientists discover what goes on within incredibly short time frames, the chamber can have its air evacuated to produce superhigh vacuum. Inside sit the targets, including tiny hollow "microballoons", which the research laser's photon pulses turn to plasma in mere billionths of a second. *(Photo: Bill Atkinson)*



L'enceinte de la cible de COCO-II sous deux angles différents. Elle est entourée de nombreux appareils à l'aide desquels les scientifiques du CNRC peuvent déceler ce qui s'y passe dans des périodes de temps incroyablement courtes. On peut même y faire un vide presque parfait. C'est à l'intérieur que se trouvent les cibles, y compris des "microsphères" creuses, que les impulsions lumineuses d'un laser transforment en plasma en quelques milliardièmes de seconde. *(Photo: Bill Atkinson)*

Fusion is the conversion of two light atomic nuclei into a single, heavier nucleus. In this process energy is released, the resultant nucleus at the end of the fusion reaction being a little lighter than the total weight of the two starting nuclei. The weight difference is completely converted to energy, according to that formula so famous it is almost a cliché: $E = MC^2$.

To get fusion, you first need plasma. Along with solid, liquid, and gas, plasma is one of the fundamental states of matter - the "fourth state", and, cosmologically speaking, the most common of all. Plasma contains not molecules, not atoms, but only atomic ions and free electrons; it is too energetic to allow neutral atoms to form. Plasma is the stuff of stars, and exists also in the center of an exploding nuclear bomb, but keeping it leashed for long in this cold, neutral Earth of ours is a daunting task. A plasma can be generated easily enough, but to obtain usable fusion power, it must stay hot enough long enough for many fusion collisions to occur. And, unfortunately, fusing plasma has an annoying habit of vaporizing the walls of its container. The invisible bonds of a strong magnetic field can keep it in place, but this has been compared to restraining gelatin with rubber bands. The plasma tends to bunch up, and its heat becomes uneven.

A better solution may lie in the laser. The light we live by, that emerges from a light bulb or the sun, is a jumble of wavelengths, all out of phase. Lasers on the other hand emit light of one single frequency, with every photon vibrating in lockstep. A beam of laser light can be among the most concentrated forms of energy known. Many substances can be made to lase: COCO-II uses carbon dioxide, the familiar $CO_2$ — or, a better description of the linear molecule, OCO; add a C, for Canadian, and you have COCO. (The II designates a model type for the main amplifiers.) A mixture of carbon dioxide and other elemental gases, all at atmospheric pressure, gives the laser an optimum burn pattern. COCO-II, designed by NRC scientists and built by NRC and Lumonics Research Limited technicians, also uses operational principles discovered and patented by NRC.

If you take a laser beam as powerful as possible, of as brief a duration as possible, and focus it on a target as small and as symmetrical as possible, the laser pulse will convert the substance of the target into plasma almost instantaneously. Further, the outer part of the target is blown away, and the reactive force "implodes" the central plasma, raising its temperature still