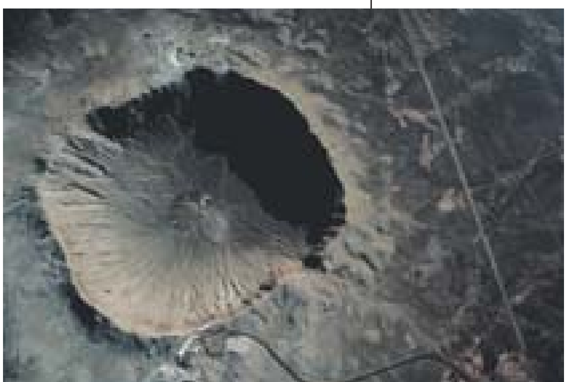
NEAR-EARTH OBJECTS

Planetary Protection

X-RAY TESTS SHOW HOW TO DEFLECT AN INCOMING ASTEROID BY STEVE NADIS

John L. Remo has a modest goal: he'd like to save the planet. Unlike some delusional people who share his interest, Remo is a level-headed physicist, based at the Harvard-Smithsonian Center for Astrophysics, and his research might actually further that goal. Since the mid-1990s he and his colleagues at Sandia National Laboratories have conducted the first experiments aimed at seeing how momentum from high-intensity radiation bursts is transferred to meteorite fragments. With access to Sandia's Z machine, the world's most powerful x-ray generator, Remo and his team could guide efforts to divert an incoming asteroid or comet.



DEEP IMPACT: A meteorite only about 25 meters wide was still able to make a 1.2-kilometer-wide crater in Arizona.

A devastating collision with a near-earth object (NEO) may be only a matter of time. Consider asteroid 2002 MN: this past June the 100-meter-wide rock came within 120,000 kilometers of our planet. "That's almost too close for comfort," Remo says, especially considering that 2002 MN was discovered three days *after* its near miss. More unnerving were initial reports of asteroid NT7: this two-kilometer-wide rock swings by in 2019; if it were to collide, it would cause global havoc (the latest calculations indicate that it will miss).

Researchers have contemplated NEO mitigation or deflection for more than a decade, but discussions have been hampered by the lack of data. When Remo joined a deflection panel at Los Alamos National Laboratory in 1992, he emphasized the importance of understanding the material properties of NEOs to predict how they would react to an impulse.

Physicist Bruce A. Remington of Lawrence Livermore National Laboratory considers this kind of research long overdue. Despite years of debate, mitigation has remained an "abstract idea," Remington says. "Finally, people are getting real numbers that can help us figure out how much energy it would take to divert a menacing object." The problem, he adds, is too complicated to be calculated without seeing what happens experimentally.

For Remo, the crucial parameter is the "momentum coupling coefficient," a gauge of the efficiency at which radiation striking an object is converted to kinetic energy. High-energy x-ray pulses produced by the Z machine impinge on the target material—six varieties of meteorites have been tested to date—boiling off the surface layer and creating a plasma jet that shoots backward. A momentum-conserving shock wave formed in its wake pushes the meteorite in the opposite direction. Remo, with Michael D. Furnish of Sandia, computed the velocity of these particles by measuring the Doppler shift of reflected laser light.

Because x-rays are a big component of nuclear blasts, the Z experiments are designed to simulate the detonation of a weapon near a threatening NEO to nudge it into a safe trajectory. Based on his computations of coupling coefficients, Remo believes that moderate-size nuclear explosives could do the job. A 25-kiloton device, for example, could move a one-kilometer-diameter object out of harm's way, assuming we had a few decades' advance notice. With longer lead times or smaller objects, nonnuclear options become more feasible.

There are, of course, serious challenges in scaling up results from centimeter-size shards to rocks hundreds of meters in diameter. Nevertheless, the coupling coefficients can be measured accurately in the lab, Furnish notes, because x-rays interact with matter on a microscopic scale—and that's true for giant asteroids and micrometeorites alike. Major uncertainty, however, stems from the question of whether asteroids are solid objects or loose assemblages of rocks. "If it's a rubble pile, you might move part of it the right way and other parts the wrong way," Furnish cautions.

Remo is devising experiments to investigate that possibility while also planning Z tests of different meteoritic and comet materials. Ultimately he hopes to turn the NEO peril into a straightforward physics and engineering problem. Rather than scaring people with forecasts of impending doom, Remo would like to tell them what can be done.

Steve Nadis is based in Cambridge, Mass.

OUT-OF-POCKET EXPENSES

In pursuing research on near-earth objects, John L. Remo has relied almost entirely on his own funds, underwritten by Quantum Resonance, a laser instrumentation company he runs in St. James, N.Y. "Using lasers and the Z machine to shock meteorites is so new, there weren't any programs to support it, because the work doesn't fit into any established research categories," explains Remo, a physicist affiliated with the Harvard-Smithsonian Center for Astrophysics. "If I had waited for funding, it would have taken years to start this work."

JONATHAN BLAIR *Corbis*