development of extraordinary materials is not needed—a result of using thick liquid walls of lithium to protect HIF chamber materials from neutron damage.

The classical deposition of ion beams in fusion targets contrasts sharply with the complex plasma physics of laser–matter interaction. The greater effectiveness per beam megajoule amplifies HIF's crucial ability to deliver to fuel targets 10 times the goal of the National Ignition Facility's (NIF's) laser. More, and more effective, driver energy reduces the needed degree of fuel compression substantially. Reduced compression is accompanied by reduced growth of hydrodynamic instabilities, which in turn relaxes tolerances for pellet fabrication.

The compression requirement is reduced to the realm already demonstrated in ICF research by HIF's ability to use the fast-ignition method. Only a small fraction of the pre-compressed fuel is heated to ignition temperature to start propagating fusion burn. If fast ignition could be accomplished with laser beams, NIF's energy gain could be 10 times higher than its official goal. But fast ignition via laser driver holds exquisite challenges. In contrast, 10 years ago in Russia, Boris Sharkov and associates began designing fusion pellets and HIF driver layouts to exploit HIF's ability to achieve fast ignition with classical energy deposition, in fuel pre-compressed to a density already experienced in the lab, with a relatively long-duration ion pulse, in geometries simple to fabricate.[3]

Why has the US not taken advantage of HIF? The oil "shocks" of 1973 and 1979 were not taken seriously enough, nor were warnings of oil's approaching limits. The issue has been leadership. Elements of HIF are spread among the offices of DOE's three undersecretaries. Tellingly, all fusion work to date has been outside the office responsible for civilian energy systems. The National Academy of Sciences, in reviewing military ICF programs in 1985, noted HIF's advantages but averred that HIF was "supported primarily by other programs."[4] But there are no other programs. HIF has been an orphan—as Burton Richter put it, "starved and virtually ignored." While energy production is the sole purpose of HIF, its homelessness is shared by all inertial fusion energy work in the US.[5]

We could be much closer to ICF power than we are, but the situation is good overall. While the US has veered from HIF's founders' use of mainstream accelerator technology, European and Russian HIF programs steadily resolve details and use new facilities. Decades of ICF progress, using the laser driver and various other technologies, have built a formidable technical basis and community. The fast-ignition concept that benefits HIF enormously only came to light in the 1990s. And HIF enjoys the continuous advance of accelerator technology.

Heavy-ion fusion was discovered at DOE labs. DOE now has requested that the National Academy of Sciences assess the need for an office charged to develop civilian power from ICF. The NAS study is expected to take a year, beginning this summer. An unbiased examination will show, again, that through HIF, fusion power is much closer than it appears. Establishing a home for inertial fusion energy would accomplish a lot.

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Of wetting and osmotic transport

In his article "The First Wetting Layer on a Solid," Peter Feibelman (PHYSICS TODAY, February 2010, page 34) points out that the first layer of water molecules on a solid surface embodies the boundary condition for water transport, pollution, corrosion, and other molecular transport phenomena. That observation and the revealing high-resolution images presented bring to mind a fundamental problem of osmotic water transport.

In 1827 René Dutrochet pointed out that osmosis actually involves binary transport,[1] in which water moves one way and solute moves the other way. In 1855 Adolf Fick took the idea much further,[2] expanding on the work of other experimentalists. He considered a cylindrical pore in a hydrophilic membrane separating either water or a dilute salt solution on one side and a concentrated one on the other.[3] He reasoned that water will preferentially flow along the walls and salt will tend to migrate along the axis of the pore. As a consequence, he expected concentration gradients in the plane of the pore. Under certain conditions, he suggested, salt migration could be completely inhibited even though the pore might be large enough to allow migration of salt molecules. Subsequent contributions by Jacobus van't Hoff[4] and Walther Nernst[5] established that molecular diffusion in aqueous solutions involves the migration of a solute in one direction driven by the gradient of osmotic pressure, and the flow of water in the opposite direction.

Binary transport in aqueous solutions is widely recognized, but the actual mechanisms are not clear. Solute diffusion involves the random migration of free molecules or ions. However, because water is a condensed phase, its migration cannot be visualized in terms of random motion of molecules. It is not clear if such a flow of water can be considered viscous, because viscosity typically involves wall effects and external forces. If it is viscous, what is the nature of that flow?

Work along the lines described in Feibelman's article may throw more light on the nature of binary transport in osmosis and on molecular diffusion in which random motion of unattached molecules in one direction is accompanied by the migration of a condensed phase in the opposite direction.

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A two-color twist on test taking

Test taking is a humiliating experience for many students, with no perceived direct educational benefit. That need not be