COMMENT : PUTTING THE NIF FUEL GAIN RESULTS IN PERSPECTIVE by Weston M. Stacey 2/17/14

In a recent Letter1, new results from the National Ignition Facility at the Lawrence Livermore Laboratory were reported which showed an order of magnitude improvement in fusion energy yield performance over previous deuterium-tritium implosion experiments, which is an impressive advance in the state-of-the-art. Although no such claims are made in the Letter, the title and abstract (and the accompanying press release) would seem to imply that a major threshold has been crossed and inertial fusion power is in the offing. The purpose of this Comment is to put these new results in perspective vis-à-vis the status of fusion power research in magnetic and inertial confinement and the requirements for practical fusion power.

 Since a certain amount of energy must be input from external sources to bring the deuterium-tritium fuel to the high energies at which the cross section for fusion becomes appreciable, the conventional energy yield performance parameter for a fusion experiment is the ratio of the fusion energy produced in the experiment to the external energy provided to the reaction chamber to create the conditions for fusion, . Conceptual design studies of various magnetic confinement fusion reactor concepts indicate that, in order to also provide the electrical power needed to operate the reactor and taking into account inefficiencies in converting the fusion energy first to thermal energy and then to electrical energy, a minimum value of  will be required for a net-power producing magnetic confinement fusion reactor. A larger value will likely be required for a net power producing inertial fusion reactor. Using and = 17.3 and 14.4 *kJ* results in = 0.0091 and 0.0076, or  0.01 for the two NIF shots described in the Letter. By comparison, the tokamak magnetic confinement fusion concept achieved = 0.27 in TFTR in 1994 and = 0.65 in JET in 1997, and the design value in the ITER experiment to operate in the 2020s is =10.

 A different fusion energy performance parameter is discussed in the Letter. In the NIF experiments, 192 lasers delivered 1.9 *MJ* of energy onto a small gold cylinder, which converted the laser energy to X-ray radiation, a fraction of which was absorbed by a mm-scale capsule containing a layer of D-T ice, compressing it. A fraction of the absorbed X-ray energy was converted to kinetic energy of the D-T which formed a hotspot to initiate the fusion reaction. The total energy delivered to the D-T fuel was = 9 and 11 *kJ* in these two shots, leading to values of = 1.9 and 1.3 and the statement that the fuel gain exceeded unity. Clearly,  (i.e. the coupling of input power to the D-T fuel < 1%). As noted previously2, the use of these two different “energy gain” parameters can potentially lead to confusion.

1. O. A. Hurricane, D. A. Callahan, D. T. Casey, et al., “Fuel gain exceeding unity in an inertially confined fusion implosion”, Nature 13008, Feb 13 (2014).
2. D. M. Meade,Princeton Plasma Physic Lab., personal communication; also <http://fire.pppl.gov>