ON THE EXPEDIENCY OF MAKING DOUBLE-PULSE LASERS FOR LASER THERMONUCLEAR FUSION

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The paper demonstrates the expediency of development of double-pulse lasers for studying the thermonuclear laser target performance based on moderate fuel pre-compression and subsequent ignition of the center by the focusing shock wave.

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Cryogenic targets are being considered as most promising for the laser thermonuclear fusion. In the targets, low-density DT gas located in the central spherical cavity is surrounded with DT ice frozen on the inner side of the ablator. Computationally, they give the highest thermonuclear amplification factor with minimum laser energy input into the target and with acceptable temporal laser pulse shape. Appropriate laser facilities, for example, US laser facility NIF [1], are designed for generation of the pulse.

However, compression of the central part in the targets near the burst time is gravitationally unstable: the DT fuel density distribution by mass is growing from the center, whereas the pressure distribution is dropping from the center. In particular, the instability can cause gravitational turbulent mixing of the hot central region with ambient colder DT fuel material, hence, the central hot spot temperature reduces and ignition may not occur. "Bodies" of relatively cold material surrounding the center that grow with time due to gravitational instability also contribute to this.

The above effects (whose calculation accuracy has been yet insufficient) may have showed up in recent cryogenic target experiments: they are only an evidence of higher fuel density in those targets than that in gas targets, but give no evidence of appearance of a hot central region in the targets (which can be judged by the quantity of produced thermonuclear neutrons).

An alternative of the cryogenic target performance is the laser (not necessarily cryogenic) target performance, in which DT fuel is moderately pre-compressed (to densities of several tens of g/cm^3) and then the center is ignited by the focusing shock wave [3]. In so doing both density and pressure increase in the hot central region, so the above gravitational instability did not take place.

Of course, the issues of stability and symmetry are therewith significant. As for the pre-compression, it roceeds to significantly lower densities (~10 g/cm^3) than those in ordinary cryogenic target performance (~10^3 g/cm^3). In the focusing of the igniting spherical shock wave, asymmetry develops according to other (less stringent) laws than in spherical compression.

This laser target performance needs a double pulse: first moderate pre-compression of thermonuclear DT fuel is achieved under action of small-intensity laser pulse ($I \leq 10$ TW, $q \leq 10^{13}$ W/cm^2, pulse duration, τ_1, on the order of several tens of nsec), then the focusing shock wave produced by the second powerful laser pulse ($I \sim 10^4$ TW, $q \sim 10^{16}$ W/cm^2, pulse duration, τ_2, on the order of a few tenths of nsec) heats and ignites the center [2,3].

Practical (experimental) study of the laser target performance requires double-pulse lasers with the following parameters:

$I \leq 10$ TW, $q_1 \leq 10^{13}$ W/cm^2,
τ_1 ~ several tens of nsec,
$I \leq 10^4$ TW, $q \leq 10^{16}$ W/cm^2,
τ_2~a few tenths of nsec.

Conditions for thermonuclear ignition of deuterium-tritium (DT) gas by a focusing ideally symmetric shock wave are estimated are estimated in the next article of this issue [4].

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