ON THE POSSIBILITY OF D-^{3}HE FUSION BASED ON FAST-IGNITION INERTIAL CONFINEMENT SCHEME

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ABSTRACT

Although nuclear fusion reactors adopting D^{3}He fuel could provide many advantages, such as low neutron generation and efficient conversion of output fusion energy, the achievement of ignition is a difficult problem. It is therefore of particular importance to find some methods or schemes that relax the ignition requirements. In inertial confinement scheme, the use of pure D^{3}He fuel is impractical because of the excessive requirement on driver energy. A small amount of DT fuel as "igniter" is hence indispensable.[1] Our previous burn simulation[1] for DT/D^{3}He fuels compressed to 5000 times the liquid density showed that substantial fuel gains (~500) are obtained from fuels having parameters ρR_{DT} = 3 g/cm^2, ρR_{total} = 14 g/cm^2 and a central spark temperature of 5 keV. The driver energy needed to achieve these gains is estimated to be~30 MJ when the coupling efficiency is 10%; in this case the target gain is ~50. Subsequent implosion simulation[2], however, showed that after void closure the central DT fuel is ignited while the bulk of the main D^{3}He fuel is still imploding with high velocities. This pre-ignition of DT fuel leads to a low compression of the main fuel and prevents the DT/D^{3}He fuel from obtaining required gain. These difficulties associated with the pre-ignition of DT fuel could be resolved or mitigated if other ignition schemes such as fast-ignition[3] and/or impact-ignition[4] are adopted, because in these schemes compression and ignition phases are separated. Furthermore, the reduction of driver energy can be expected. In the present study, we examine the possibility of D^{3}He fusion in the fast-ignition scheme. Simulations until now have been made for a DT/D^{3}He fuel compressed to 5000 times the liquid density by using FIBMET (2D fusion ignition and burning code) [5] and a newly developed neutron diffusion code. DT igniter was assumed to be placed at a corner of the compressed fuel. The ρR values and temperature of compressed fuel were assumed as ρR_{DT} = 4 g/cm^2, ρR_{total} = 12 g/cm^2 and 0.2 keV. The coupling efficiencies of implosion and heating lasers were respectively taken as 10% and 30%. The work shows that it is possible to obtain sufficient target gains (~60) with realistic driver energy below 10 MJ (~8 MJ for implosion plus ~0.3 MJ for heating). Crucial role of DT fusion neutrons in the D^{3}He main fuel heating was clarified. The possibility to reduce the amount of DT igniter will be discussed.

References

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