Kinetic study of species separation in the hot spot in inertial fusion

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In inertial confinement fusion (ICF), a spherical target filled of deuterium (D) and tritium (T) is compressed and heated by lasers. This compression produce a serie of shock wave propagating through a DT plasma.

Recently, during experiments on OMEGA [1], some anomalies have been observed concerning the fusion yield : in particular, a deficit of neutron, which deviate from the scaling determined with numerical simulations. Some mechanisms are considered like a probable cause of this difference and in recent papers, species separation is considered like responsible of this anomalie. Multi-fluid [2] and kinetic simulations [3] have been used to study this separation in different kind of capsules. Analytical model [4, 5] presentes baro-, thermo- and electro-diffusion in a plasma as the origin of species separation.

This work addresses ionic species separation during the deceleration phase of a high-gain direct-drive target design. A multi-species ionic Fokker-Planck code named *FPion* [6] is used in a spherical geometry, in one spacial and two velocity dimensions, without thermonuclear reactions. Electrons are considered as a fluid.

We show that velocity distribution function of each ionic species remains a maxwellian function, during the whole deceleration. Nevertheless, a clear ionic species separation is seen due to baro-, thermo- and electro-diffusion. First, deuterium is predominant at the center of the target, followed by less-fast tritium, with a difference in the presence rate of about 10%. Comparison between a two ionic species (D and T) and an one ionic species cases (with an average mass A=2.5 g/mol) shows that multi-species hot-spot plasma is about 40% heater and 20% less dense than the average case. This difference acts directly on the reactivity of the plasma. At early time of deceleration phase, we show a weaker reactivity of the muti-species plasma, and at later time a more important reactivity due to the high temperature. Ionic species separation is seen in a wide variety of target design and huge interval of implosion velocities. The evolution of this species separation depends on hydrodynamics of each implosion.

References

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