A Multi-Fluid Ignition Analysis

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The so-called Lawson parameter is a standard figure of merit for magnetic-confinement experiments for controlled nuclear fusion. In particular, ignition and burning-plasma conditions are defined in terms of the Lawson criterion. The criterion is calculated via a zero-dimensional power balance, taking into account thermal losses through the confinement time τ_E, α-particle power and Bremsstrahlung losses, in addition to external heating power. As a steady-state expression, the original Lawson criterion does not take into account several plasma properties that greatly influence the time-dependent behavior of the plasma. Among others, ion and electron temperatures are not automatically identical during transients and α particles do not instantaneously deposit their heating power into the plasma. A time-dependent analysis of the ion, electron and α system provides more accurate information than the standard single-fluid analysis on parameters such as temperature stability (the well-known "$\dot{T}$ vs. T" curve) and the amount of heating power needed to reach ignition. The results of a multi-fluid zero-dimensional model with respect to ignition are presented and critically discussed. The steady-state modifications of the Lawson criterion due to multi-fluid effects are also discussed.

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