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Studying proton-^{11}boron fuel compositions for fast ignition IFE

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Proton-boron (p-^{11}B) fusion, proposed in the proton fast ignition approach to inertial confinement fusion, has regained interest following the recent re-evaluation of its cross-section data [1,2] and general progress in laser technologies. Its advantages— including abundance, safety, clean reaction products, and the absence of cryogenic requirements — support its potential for reducing electricity production costs.

Given the insufficient initial energy release in pB fusion hot spots, achieving commercially viable fusion requires a high hydrogen concentration to overcome the challenge of driving burn propagation via fast proton production from elastic scattering. A higher H:B ratio enhances proton-boron collision rates and improves fusion efficiency. This optimisation leads to a higher yield of alpha particles, a key factor in energy generation. Moreover, from a material point of view, a major challenge is that currently synthesized, stable compounds either contain a high boron concentration (as in boranes) [3] or include multi-element contamination (heteroelements) such as nitrogen (N) and carbon (C), both of which increase Bremsstrahlung radiation losses, thereby cooling the plasma and raising ignition temperature or impeding ignition. Therefore, ideal compounds should exhibit minimal contamination from elements other than hydrogen and boron.

This report examines the conditions relevant to fast ignition IFE, focusing on the feasibility of various boron-based compounds, considering significant Bremsstrahlung reabsorption and suprathermal effects due to the non-Maxwellian tail in reactivity [4]. Bremsstrahlung reabsorption, shown to notably improve fusion gain, is evaluated using the two-temperature 1D hydrodynamics code *HELIOS* and PROPACEOS opacity tables [5]. Based on the consideration of various compounds and structural assemblies ranging from theoretically ideal to naturally existing or recently manufactured ones, ignition temperatures depending on a set of fast ignition IFE-relevant plasma parameters are identified. These compounds may thus offer a promising pathway toward optimal proton–boron fusion fuel design.

References

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