Fusion Burn and Target Design Criteria for the Proton-Boron Fuel Cycle Driven by Short Pulse Lasers

Thomas MEHLHORN[1], Dale WELCH [2], Carsten THOMA[2], Max TABAK[1,] and Igor GOLOVKIN [3]

1) *Consultant to HB11 Energy Holdings Pty, LTD, Australia*
E-mail: tamehlhorn97@gmail.com
2) *Voss Scientific, Albuquerque, NM*
3) *Prism Computational Sciences, Madison WI*

The Lawson criterion for aneutronic p-^{11}B fusion is substantially higher than for DT because the fusion cross section is lower and peaks at higher ion energies where bremsstrahlung losses may dominate over fusion reactions if electrons and ions are in thermal equilibrium and the losses are unrestricted. Nonequilibrium burn has often been suggested to realize the benefits of this aneutronic reaction, but the predominance of elastic scattering over fusion reactivity makes this difficult to achieve. Ultrashort-pulse lasers have opened new possibilities for initiating nonequilibrium thermonuclear burns and significant numbers of p-^{11}B alpha particles have been reported by irradiating normal density targets. We find these alphas come from beam fusion reactions that do not scale to net energy gain [1]. We are mapping out the proton fast ignition space for p-^{11}B, including hybrid burn scenarios that use CPA-accelerated protons that undergo beam fusion reactions that provide fast alpha particles. These alphas heat the fuel and up-scatter protons in compressed targets. Our goal is to generate a propagating burn from the ignitor region into the adjacent compressed fuel. We are using the kinetic algorithms in CHICAGO to track the proton distribution function, including both Rutherford and nuclear elastic scattering. We report on the possibility of ignition and burn in these fast ignition-like configurations, accounting for the power balance between heating, thermonuclear and inflight fusion reactions, charged particle deposition, bremsstrahlung, thermal conduction, photon-matter scattering reactions to recapture bremsstrahlung losses, and hydrodynamic expansion, as a function of compressed fuel density, USPL power and energy, and pulse length. We also use analytic scaling, as well HELIOS-CR and PROPACEOS to study the fusion burn space in a fluid approximation.

T. A. Mehlhorn *et al.*, "Path to Increasing p-B11 Reactivity via ps and ns Lasers," *LPB*, 2022, p. 2355629, 2022.