The Proton-^{11}Boron Enigma: New Clues from Stopping Power to the Stars

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The National Ignition Facility's ignition achievement has shown that laboratory fusion burn is possible, yet the path to a reactor remains defined by materials, tritium, and economic challenges. This reality invites a reconsideration not only of how we confine plasmas, but of which fuel we choose to burn. Proton-^{11}Boron offers a quasi-neutron-free pathway with abundant fuel and no tritium breeding, but its viability hinges on physics that remains incompletely understood—particularly how proton energy is deposited in boron plasma and what the reaction can tell us about extreme astrophysical environments. We report systematic investigations of the p-^{11}B reaction using complementary platforms: the 320 kV accelerator at IMP Lanzhou and intense laser-driven proton beams at the Laser Fusion Research Center in Mianyang. Hydrogen-doped boron targets showed an approximately 30These results connect to a second line of inquiry: ion stopping in plasma. The stopping power determines where protons deposit energy, and thus where the fusion resonance is actually sampled. Recent work indicates that stopping dynamics can shift the optimal proton energy away from the canonical 672 keV resonance, and that collective and degeneracy effects in dense boron plasma may alter energy loss in ways single-particle models do not capture. This matters not only for yield optimization in beam-target schemes, but for understanding energy transport in high-energy-density regimes more broadly. The astrophysical connection sharpens the enigma. Stellar interiors destroy boron rather than produce it, and its abundance in white dwarf atmospheres—recently detected for the first time—raises questions about accretion, mixing, and the survival of light elements in extreme gravitational environments. The same nuclear physics that

governs p-^{11}B in the laboratory informs how we interpret trace boron and beryllium in stellar remnants, and how energy deposition by charged particles shapes the thermal and compositional structure of dense matter. These results do not yet constitute a path to a reactor. The challenge of maintaining ion temperatures significantly above electron temperatures remains formidable. But they demonstrate that the nuclear physics of p-^{11}B is richer—and potentially more favorable—than textbook assumptions suggest, and that the reaction serves as a laboratory for physics spanning stopping power, high-energy-density matter, and stellar remnants. The enigma is not whether p-^{11}B belongs at the table, but what its clues reveal about the broader landscape of fusion and astrophysics.