Laser-Driven Proton-Boron Fusion and Applications

D. Margarone

Queen's University Belfast (UK) and ELI Beamlines Centre (CZ)

An overview of recent experimental achievements in the field of proton-boron nuclear fusion will be given with a focus on non-thermal approaches based on laser plasma acceleration [1-5]. High power laser systems with a broad range of parameters in terms of energy (10^{-2}-10^{3} J), pulse width (1-300 ps), and intensity (10^{16}-10^{19} W/cm^2) have been used to investigate the nuclear reaction yield, along with the energy spectrum of proton-boron fusion products (alpha-particles). Various targets with high concentration of B and H have been used to trigger the nuclear reaction in two main geometries, (i) direct irradiation (in-target pB fusion) and (ii) pitcher-catcher (beam-target fusion), with the goal to demonstrate the tunability of the produced alpha-particle source in terms of flux and energy. The generation of energetic alpha-particle beams using high-average-power table-top (~10 GW) laser systems will also be presented. Perspective schemes of interest for fundamental science and societal applications will be finally discussed.

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[2] D. Margarone, A. Picciotto, A. Velyhan et al., "Advanced scheme for high-yield laser driven nuclear reactions", Plasma Phys. Contr. Fusion 57 (2015) 014030

[3] L. Giuffrida, F. Belloni, D. Margarone et al., "High-current stream of energetic α particles from laser-driven proton-boron fusion", Phys. Rev. E 101 (2020) 013204

[4] D. Margarone, A. Morace, J. Bonvalet et al., "Generation of α-Particle Beams with a Multi-kJ, Peta-Watt Class Laser System" Front. Phys. 8 (2020) 343

[5] J. Bonvalet, P. Nicolai, D. Raffestin et al., "Energetic α-particle sources produced through proton-boron reactions by high-energy high-intensity laser beams", Phys. Rev. E 103 (2021) 053202