Title
Ion-driven fast ignition: Reducing heavy-ion fusion driver energy and cost, simplifying chamber design, target fab, tritium fueling, and power conversion

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Abstract

Ion fast ignition, like laser fast ignition, can potentially reduce driver energy for high target gain by an order of magnitude, while reducing fuel capsule implosion velocity, convergence ratio, and required precisions in target fabrication and illumination symmetry, all of which should further improve and simplify IFE power plants. From fast-ignition target requirements, we determine requirements for ion beam acceleration, pulse-compression, and final focus for advanced accelerators that must be developed for much shorter pulses and higher voltage gradients than today's accelerators, to deliver the petawatt peak powers and small focal spots (~100 μm) required. Although such peak powers and small focal spots are available today with lasers, development of such advanced accelerators is motivated by the greater likely efficiency of deep ion penetration and deposition into pre- compressed 1000x liquid density DT cores. Ion ignitor beam parameters for acceleration, pulse compression, and final focus are estimated for two examples based on a Dielectric Wall Accelerator; (1) a small target with $\rho r\sim 2\ g/cm^2$ for a small demo/pilot plant producing ~40 MJ of fusion yield per target, and (2) a large target with $\rho r\sim 10\ g/cm^2$ producing ~1 GJ yield for multi-unit electricity/hydrogen plants, allowing internal T-breeding with low T/D ratios, >75 % of the total fusion yield captured for plasma direct conversion, and simple liquid-protected chambers with gravity clearing. Key enabling development needs for ion fast ignition are found to be (1) "Close- coupled" target designs for single-ended illumination of both compressor and ignitor beams; (2) Development of high gradient (>25 MV/m) linacs with high charge-state (q ~26) ion sources for short (~5 ns) accelerator output pulses; (3) Small mm-scale laser-driven plasma lens of ~10 MG fields to provide steep focusing angles close-in to the target (built-in as part of each target); (4) beam space charge-neutralization during *both* drift compression and final focus to target. Except for (1) and (2), these critical issues may be explored on existing heavy-ion storage ring accelerator facilities.