Efficiency of Laser-Induced HB11 Fusion Reaction Under Varying Methods of Kilotesla Magnetic Confinement

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Finding new and more efficient forms of clean energy is necessary for humanity to survive the coming centuries, and although current methods of nuclear fusion are promising, they also produce high-energy neutrons which can damage the reactor and create radioactive waste. The use of the aneutronic H-B11 fusion reaction has been extensively studied in hopes of sidestepping these engineering challenges, and in 2017, a group of researchers proposed a concept reactor which would fuse H-B11 with a theoretical reactivity as high as that of traditional D-T fusion using high-contrast CPA lasers and a kilotesla-order magnetic confinement system. The papers outlining this reactor’s design introduce the need for simulation studies to examine how to optimize the operation of this magnetic field, so in this study, a three-dimensional, electromagnetic PIC simulation is developed and used to narrow down an optimal field strength for the confinement system and identify whether tapering the magnetic field strength over time may improve the energy efficiency of the reactor. The program models Coulomb collisions, calculates fusion reaction rate each pass of the code, and employs leapfrog and Lorentz-invariant methods of updating field values and particle kinetics. The results of these models suggest that 10kT fields may be up to 10 times more energy-efficient than 4.5kT fields when the effects of quantum tunneling and the strong force are taken into account and suggest that field tapering may indeed be a viable technique to further improve reactor efficiency. These results were found using cell sizes and time steps too large for the finite difference approximations to be sufficiently accurate, so higher-resolution versions of these models should be run to verify these results.

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Third Award of $1,000