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Quantum degenerate plasmas: particle-in-cell simulation method and the role to increase beam-target p-11B fusions

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It is becoming more appealing to collide intense laser beams or accelerated proton beams with a boron target to produce p-^{11}B reactions. The fusion yield of p-^{11}B reactions is closely related to proton beam parameters and boron target conditions such as density, temperature, and ingredients. Quantum degeneracy will increase fusion yields by reducing the stopping power of injected protons. In this talk, I would introduce how to simulate quantum degenerate plasmas via a particle-in-cell simulation method, and then suggest a scheme for beam-target p-^{11}B fusions via injecting a MeV proton beam into a highly compressed quantum degenerated boron target. Such a boron target can be achieved via quasi-isentropic compression of solid boron by using precisely shaped laser pulses. Our results indicate that for densities ranging from 1000 rho_s to 100000 rho_s, where rho_s is the density of solid boron, contributions of bound and free electrons electrons to the stopping of protons can be completely disregarded and dramatically reduced, respectively. The result is an increase in fusion yield by orders of magnitude. Furthermore, in order to achieve multiplication factor F greater than one, with F defined as the ratio of output fusion energy to the energy of injected protons, it is found there exists a minimum possible density of boron target, which is 180000 rho_s when the kinetic energy of injected protons is 880 keV.

References

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Figure 1: (a), (b) Diagram of a p-^{11}B fusion scheme, (c) p-^{11}B fusion cross section as a function of center-of-mass energy, where the data of the orange triangle is extracted from the work of Sikora and Weller, and (d) The ionization degree of the boron target as a function of temperature and density of the boron target; the data is calculated by Heltemes's code BADGER.