MCNP Fusion Modeling of Electron-Screened Ions

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Abstract

Modeling nuclear reactions at kinetic energies below 1 MeV is critical to terrestrial fusion research and astrophysical nucleosynthesis but is currently incomplete. The Monte-Carlo N Particle (MCNP) modeling code has been used to model various nuclear reactions for decades. The National Aeronautics and Space Administration (NASA) Glenn Research Center (GRC) AEC Project [1] and the Department of Energy's (DoE) Lawrence Berkeley National Laboratory (LBNL) [2] independently published papers on novel means to drive nuclear fusion reactions in deuterated metal lattices deemed *Lattice Confinement Fusion (LCF)* which they each observed during recent experiments. The NASA GRC AEC Project has used the MCNP [3] code in their nuclear fusion research. However, neither NASA nor LBNL could model nuclear reactions at ion kinetic energies of interest since MCNP cannot handle ion energies below 1 MeV.

Although multi-MeV fusion reaction products are produced in a nuclear fusion MCNP model, once the scattered ion kinetic energies are < 1 MeV, their elastic and inelastic nuclear reactions are not calculated (Figure 1). Simulating fusion neutron interactions requires 2.45 MeV and 14.1 MeV fusion energy neutrons as input for diagnostic response functions, shielding modeling, and hybrid fusion-fission studies [4]. In addition, both AEC and LBNL projects attributed enhanced nuclear reaction rates to the effects of electron screening [5] which aren't modeled within MCNP either. Consequently, we have been unable to completely model the complex interactions necessary for gain and scaling through neutron and ion elastic and inelastic scattering and fusion reactions.

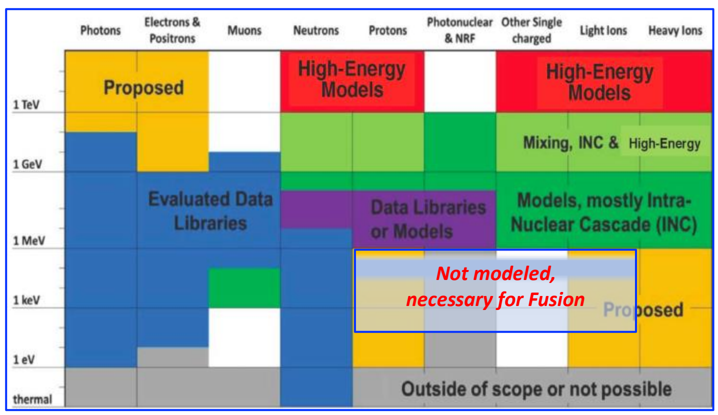

Figure 1: MCNP Particle Interactions [3]

We will present our plan for augmenting the MCNP code with existing SRIM/TRIM-based [6] ion interaction code routines developed to support the International Thermonuclear Experimental Reactor (ITER) [7] and electron screening theory [8] developed under the NASA GRC AEC Project. We plan to enhance MCNP with the ITER routines developed for 10 – 50 keV DD fusion generators [7] and the MCNP code can be extended below 10 keV by the addition of electron screening models [8].

Previously, MCNP additions have been made with the University of Michigan's PoliMi [9] neutron scintillator response functions and the LLNL Fission Reaction Event Yield Algorithm [10,11] codes. The AEC project used the PoliMi code for its Eljen EJ-309 scintillator response functions. The LBNL project used the same EJ-309 liquid scintillator allowing cross-comparisons of data and Pulse Shape Discrimination and neutron energy unfolding codes. This data from electron-screened observed fusion reactions can be used to validate the MCNP modifications over a range of experimental deuteron energies within a screened lattice.

Summary

Both NASA and DoE would benefit from modeling nuclear reactions of interest, including terrestrial and space-based fusion reactor technology. Augmenting MCNP with ion scattering and electron screening will enable the full nucleonic modeling of nuclear reactions from 1 keV to 50+ keV. The MCNP code can be vetted by modeling the LBNL and AEC center-of-mass results < 6 keV and < 32 keV, respectively. This new capability has both astrophysical and terrestrial fusion energy research significance.

Presenting this plan at the MCNP Symposium will alert the MCNP development team of enhancements that can be incorporated into existing versions of MCNP and potentially expand the operating envelope of the code to include modeling of nuclear fusion reactions currently unavailable.

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