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The Potential For Retention of Spin Polarization To Raise Fusion Reactivity

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Spin Polarized Fusion (SPF), which increases the DT fusion cross section by 50% and is predicted to yield power gains of 75% in an ITER Q=10 plasma (without SPF), could be demonstrated in the DIII-D tokamak, using recent technological advances. The cross section (probability) for thermal DT fusion is not only temperature dependent, but also depends on the spin orientation of the nuclei, increasing the DT fusion cross section by up to 50%. A self consistent transport calculation predicts up to a 75% increase in fusion power in that ITER scenario. A test of the survivability of spin polarized DT fuel through to the fusion reaction can be obtained by injecting spin polarized D and ^{3}He pellets into the DIII-D tokamak. The DT fusion reaction D+T$\rightarrow$ α+n is isospin equivalent to the reaction D+^{3}He$\rightarrow$ α+p. Simulation synthetic diagnostic data of the resultant energetic proton fluxes, such as could be measured with a fast ion loss detector, calculated for polarized material with currently available levels of polarization, show that there can be up to a 30% change between the anti-parallel and parallel alignment configurations at several locations near the vessel walls. Spin polarized D is routinely produced in the nuclear physics community. The purity fraction is currently ˜40%. D-pellet polarization will have a depolarization decay time of about a year at liquid helium temperatures, which would be sufficient to produce the pellets in Virginia, USA, and then transport them to DIII-D for the proposed polarization survival experiment. We have recently shown that highly (˜65%) polarized ^{3}He can retain essentially all of its polarization during diffusion through a polymer shell to make a ^{3}He pellet for injection in the proposed polarization survival experiment. Because the depolarization time for these ^{3}He filled pellets at liquid nitrogen temperatures is only a few hours, a device for producing ^{3}He would be built onsite at DIII-D, and then the pellets filled shortly before injection into DIII-D. Polarization retention in the proposed D^{3}He experiment would be a breakthrough for fusion. This work was supported by General Atomics Internal Research and Development funds, a grant from the University of Virginia Research and Initiative Fund, and the US Department of Energy through grants DE-FC02-04ER54698 and DE-AC05-06OR23177.

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