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Testing Fuel Polarization Survivability in a Tokamak Plasma

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The cross section of the primary reaction in a tokamak fusion reactor, $D + T \rightarrow \alpha + n$, would be increased by 50% if the fuels were fully polarized along the local magnetic field. In a large-scale fusion reactor such as **ITER**, the power gain could be as much as 75% due to increased alpha heating. Such a boost would be a significant step towards establishing a burning plasma. The realization of this significant gain is depending upon the survival of the fuel polarizations in the tokamak during the particle confinement time. The calculations in the 1980's predicted that the fuel polarizations would indeed survive long enough in a plasma. Benefiting from much improved polarized target technologies over the past decades, and recent prospects for potentially producing large quantity of fully polarized ***D*** and ***T*** with laser-driven sources, we are now ready to carry out the ***in situ*** test of polarization fuel survival in a tokamak plasma. In this test, the isospin-mirror reaction, $D + 3He \rightarrow \alpha + p$, would be used to avoid tritium handling issues. Optically pumped ***3He*** with ~65% polarization, and dynamically polarized ***LiD*** with ~70% ***D*** polarization or frozen-spin HD with ~40% ***D*** polarization can be injected into a plasma inside a research tokamak such as **DIII-D**. The spin relaxation times of both polarized ***3He*** and ***LiD/HD*** inside carrier pellets are much longer than the injection gun loading time, and such pellets can be fired into the plasma within a milli-second. The ~15 MeV proton signals would provide a "background-free"signature of ***D + 3He*** fusion. The expected yield ratio of yields with parallel spins and anti-parallel spins is 1.6 for ***LiD + 3He*** and 1.3 for ***HD + 3He***.

Category

New Applications

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