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Optical excitation of molecules for Spin-Polarized Nuclear Fusion

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It is known theoretically and from scattering experiments that nuclear spin polarization increases the cross sections of the D-T and D-3He reactions by 50%, while also spatially aligning the recoil directions of the reactions products, which can be used to improve the efficiency of reactors [1]. However, the lack of a sufficiently intense source of spin-polarized deuterium (SPD) has not yet allowed the observation of spin-polarized fusion in a plasma, which has left three important questions unanswered [1]:
(1) Does nuclear spin-polarization survive long enough in the plasma to benefit fusion?
(2) What is the effect of spin-polarization on the D-D reaction (which occurs as a side reaction in both D-T and D-3He), as numerous theoretical predictions range from prediction of enhancement to suppression?
(3) Can a source of SPD be found with a production rate of 10^22 SPD/s, necessary for a nuclear reactor, such as ITER (as traditional methods, e.g. Stern-Gerlach spin separation or spin-exchange optical pumping, have production rates about 4-5 orders lower)?
We describe two novel methods that we have developed, for the production of spin-polarized hydrogen isotopes through the UV and IR optical excitation of molecules [2-6]. We describe how the UV photodissociation method gives spin-polarized D nuclei at densities of at least 10^19 SPD/cm3, which is sufficient for the observation of inertial-confinement polarized fusion using kJ-MJ pulsed lasers [3]. In addition, we discuss some details of how the IR excitation method may be able to produce beams of 10^22 SPD/s, needed for polarized magnetic-confinement fusion, and, therefore, how the three fundamental questions of polarized fusion may be answered.

References

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