Double-Polarized Fusion

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Since more than 50 years it is known that polarizing the fuel particles will change the total cross section of the nuclear fusion reactions. For the $d+^3He$ and the $d+t$ reaction it was expected and has been shown, that aligned spins will increase the fusion rate by a factor up to 1.5 [1] because both reactions have a $J^\pi = 3/2^+$ resonance at low energies. For the $d+d$ reactions no valid theoretical guidance exists. They require consideration of s, p, and d waves in 16 transition matrix elements [2]. The knowledge of the complete reaction matrix may allow to controll the neutron rate in a fusion reactor and, therefore, to optimize the energy transportation from the fusion plasma to the reactor walls. In addition, the lifetime of the reactor walls can be maximized, which will decrease the prize of the fusion energy. When both deuteron spins are alligned (quintet state) a huge list of different predictions [3-10] exist (Fig. 1), which partially describe a neutron reduction. In order to determine the quintet state suppression factor a direct spin-correlation cross section experiment at low energies is in preparation. In the framework of an ISTC (No. 3881) and a

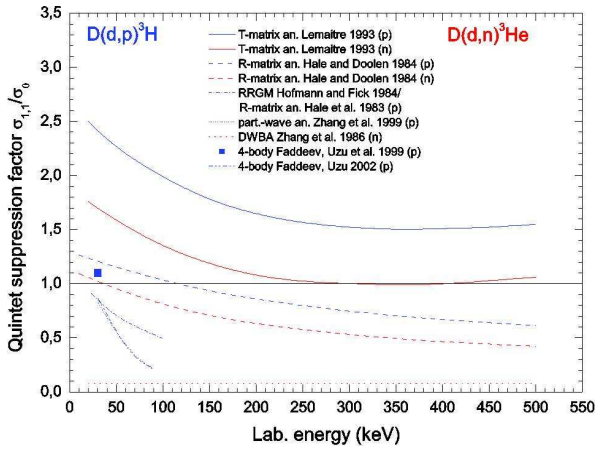

Fig. 1: The different predictions for the quintet suppression factor, which is the ratio of the total cross section for the double-polarized fusion reactions $d+d \rightarrow ^3He+n$ and $d+d \rightarrow t+p$ and the unpolarized total cross section.

DFG project (EN 902/1-1) a double polarized experiment is in preparation at PNPI, St. Petersburg, to measure the spin-correlation coefficients $C_{z,z}$ and $C_{zz,zz}$ of the reactions $dd \rightarrow ^3He+n$ and $d+d \rightarrow t+p$ to determine the quintet suppression factor for both reactions. To produce a polarized deuterium jet target the polarized atomic beam source (ABS) from the former SAPIS experiment [11] at the Institut für Kernphysik of the University of Cologne was dismounted and sent to Russia. In addition, the polarized ion source POLIS, which was in use at KVI, Groningen [12], will be sent there in spring 2010. The polarization of both sources will be determined with a Lamb-shift polarimeter (LSP) (Fig. 2). The expected target density of $\sim 2\times10^{11}$ atoms/cm^2 and an ion beam of ~ 20 μA will provide a luminosity of 3×10^{25} cm^{-1}s^{-1}. Therefore, it will take about two months of beam time to to measure the quintet suppression factor at 30 keV. With this setup additional spin-correlation coefficients can be measured at different energies to obtain futher information about the dd-fusion process. On the other hand the *astrophysical S-factor* can be investigated for different nucleus-electron spin-combinations.

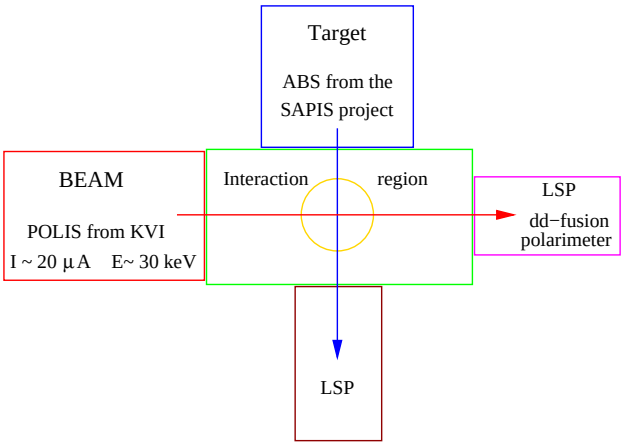

Fig. 2: Schematic setup of the experiment: The polarized deuteron beam will be produced by the POLIS source from KVI and the polarized deuterium jet target will be produced by the SAPIS ABS. The polarization of both, beam and target, will be measured with different Lamb-shift polarimeters. In addition, a nuclear-reaction polarimeter can be used for the ion beam.

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