Double-Polarized Fusion

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In a collaboration between IKP, FZ Jülich, PNPI and ITMO, St. Petersburg, the influence of nuclear polarized projectiles on the differential and total cross section will be investigated for the *dd*-fusion reactions at low energies. For the $^3He(d,p)^4He$ and the $t(d,n)^4He$ 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 energies below 100 keV. For the $d+d$ reactions no valid theoretical guidance exists [2]. The knowledge of the complete reaction matrix may allow to control the neutron rate in a fusion reactor and, therefore, to optimize the energy transport from the fusion plasma to the reactor walls. In addition, the lifetime of the reactor walls can be maximized, which will decrease the cost of investments for fusion energy.

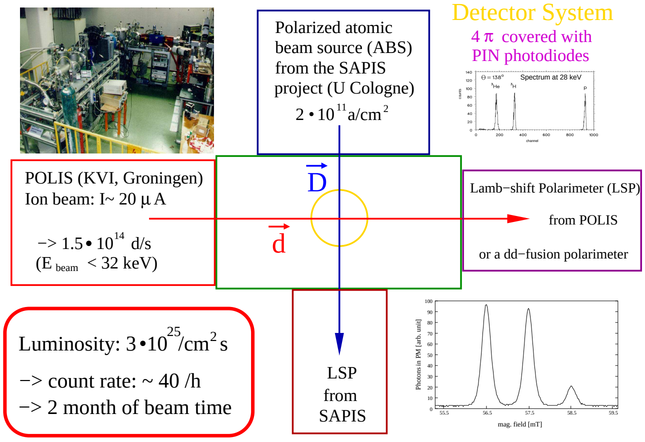

Fig. 1: Schematic setup of the experiment: The polarized deuteron beam will be produced by the POLIS source from KVI and the polarized deuterium jet target will be produced by the SAPIS ABS. The polarization of both, beam and target, will be measured with different Lamb-shift polarimeters. In addition, a nuclear-reaction polarimeter can be used for the ion beam.

In the framework of an ISTC (No. 3881) and a 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 $d(d,n)^3He$ and $d(d,p)t$ to determine the so-called 'quintet suppression factor' [2] for both reactions. To produce a polarized deuterium jet target the polarized atomic beam source (ABS) from the former SAPIS experiment [3] at the Institut für Kernphysik of the University of Cologne was dismounted and sent to Russia in 2009. In addition, the polarized ion source POLIS, which was in use at KVI, Groningen [4], was dismounted in spring and transported to Gatchina in summer of 2010. After some modification of the infrastructure at PNPI the ion source POLIS will be rebuilt in spring of 2011.

The polarization of both sources will be determined with a Lamb-shift polarimeter (LSP). In addition, a nuclear reaction polarimeter for the ion beam, based on the dd-reactions and the known analysing powers, was built and tested [5]. During this measurements it could be shown in Jülich, that photodiodes from Hamamatsu [6] are a cheap solution to detect the ejectiles (^{3}He, t and p) at energies between 0.8 and 3 MeV due to the large Q values of the reactions with a reasonable energy resolution. First tests with an α source showed an energy resolution of 28 keV. During the realistic tests with a deuteron beam on a CD_2 target an energy resolution of about 100 keV was reached due to the straggling in the thick target. Therefore, the necessary 4π detector around the interaction region of deuteron beam and target can be assembled from about 300 of these simple detectors.
The expected target density of $\sim 2 \times 10^{11}$ 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 measure the quintet suppression factor at 30 keV where a future fusion reactor will operate. With this setup additional spin-correlation coefficients can be measured at different energies to obtain futher information about the not well understood dd-fusion process.
On the other hand the astrophysical S-factor [7] can be investigated for different nucleus-electron spin-combinations. An ABS is able to produce a beam of deuteron atoms in different hyperfine states. Therefore, not only the nucleon spin can be changed but the electron spin, too. At energies below 10 keV the screening effect of the electron increases the total cross sections of the *dd* reactions due to the modified Coulomb barrier of the target atom. The influence of the electron spin in this case in completely unknown.

References:

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