CEA/CADARACHE
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INSTITUT DE RECHERCHE SUR LA FUSION PAR CONFINEMENT MAGNETIQUE (IRFM)
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PhD PROPOSAL 2009

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Research team :
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CEA/DSM/IRFM/SCCP/GIDEA

Title: **Study of the magnetic resonances in negative ion beam photodetachement with a high finesse optical cavity for future fusion reactors.**

Summary :
The ignition of fusion reactions in the ITER Tokamak shall be performed by injecting 34 MW of high energy (1 MèV) D° neutral atoms into the plasma core. These atoms are produced in a system called « Neutral Beam Injectors ». It accommodates an acceleration stage in which intense negative ion beam are accelerated to 1 MeV, followed by a neutralisation stage where negative ions are neutralised by stripping reactions ($D^- + D_2 \rightarrow D° + \ldots$) on a gaseous target.
Although simple and reliable, this process presents some important drawbacks. In fact, its neutralisation efficiency doesn't exceed 60%. Moreover, important negative ion losses (~25%) occur in the acceleration cavity due to particles diffusion coming from the neutraliser vessel.
Negative ions photodetachement neutralisation could be a very seducing candidate for future fusion reactor since its neutralisation efficiency could reach 100% without generating any further perturbations.
Nevertheless, the photodetachement cross section is so low that the laser power required for a full neutralisation of the ITER negative ion beam is in several tens of MW range.
Recently, conceptual studies have shown that this problem could be resolved by using a refolded resonant optical cavity, which matches with the ITER geometry.
The topic of the PhD thesis is a continuation of these studies. It deals with the establishment of an experimental device which aims to:

- demonstrate the feasibility of neutralising an H^- negative ion beam using a high finesse Fabry-Perot cavity. A 150 µA H- beam shall be optimised and the cavity shall be settled using an Innolight laser (Byer NonPlanarRingOscillator model) the frequency of which shall be stabilised.
- conduct more fundamental studies on the photodetachement cross section aiming at identifying the experimental conditions in which the intracavity laser power could be reduced : studying the magnetic resonances due to Landau levels and highlighting the potential Feschbach resonance just below a Landau level. This study will require an accurate measurement of the hydrogen electron affinity, which shall be conducted in parallel with the photodetachment microscope and an OPO laser.

The thesis will be supervised by the photodetachement microscopy group in Laboratoire Aimé-Cotton (LAC) in Orsay University. This project will be carried out in the context of a collaboration including LAC, CEA de Cadarache and ARTEMIS Laboratory.

The host team at LAC has a long experience in photodetachament, matter-light interaction physics and stabilised lasers. This project belongs to a more general research program aiming at the development of a photo-neutraliser and conducted under the supervision of « la Fédération de Recherche CEA-CNRS sur la fusion ».

Skills: Atomic physics, Optics and laser…