Investigation of negative ions in detached fusion plasmas in the York Linear Plasma device

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Studies on tokamak divertors and operating scenarios almost unanimously conclude that plasma detachment is necessary for stable and continuous operation of large, power plant scale tokamak devices. That is to say cooling of the plasma exhaust from the hot core is essential to preserve plasma facing components. This is usually achieved via the puffing of neutral gas into the target area encouraging recombination and redistribution of energy. At lower temperatures relevant to a detached tokamak divertor, around 1eV, the main process of neutralization of species is molecular activated recombination (MAR) [1]. This process is subdivided into two mechanisms whose relative contributions to detachment are not fully understood. Both mechanisms involve the interaction between exited molecules with ions. One involves interaction with an electron yielding a H^- which goes on to interact with H^+ becoming H + H. The second involves interaction with H^+, creating a $H_2{}^+$ which goes on to collide with an electron and divide into H + H. The York Linear Device is a magnetised plasma device capable of producing plasma conditions relevant to tokamak divertors. The diagnostic accessibility of this device is far better than a standard tokamak, making it an ideal device for the study of the fundamentals of detachment.

In this experiment we use laser photo-detachment to measure the density of negative ions using a custom Langmuir probe and YAG laser [2, 3]. The probe geometry is different to standard straight-wire probes by including a right angled bend, bringing the axis of the wire along that of the YAG beam. This diagnostic technique assesses the population of Hydride (H^-) ions which are involved in one of the two MAR chains. The linear device is also equipped with Thomson scattering and Raman scattering diagnostics to analyze the same plasma. The electron temperatures and molecular rotational temperatures may thus be studied in the same plasma under the same conditions as those used in the photodetachment experiments. This gives a full overview of the physics behind detachment which may be extrapolated to larger machines.

References

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