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Lamb shift and measurement of static and fluctuating electric fields in plasmas

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Electric field is a parameter of special relevance in plasma physics. Indeed, static electric field is at the root of Debye Shielding and electric field fluctuations are responsible for different macroscopic phenomena such as anomalous transport in fusion plasmas or Hall plasma thrusters.

Answering to a long-standing challenge, we offer a new method to locally and non-intrusively measure weak electric field and its fluctuations in plasmas from an atomic hydrogen beam.

The technique is based on the injection of metastable species which radiate at the Lyman-alpha line (121,6 nm) in the presence of an external electric field. Oscillations can be probed up to the GHz range.

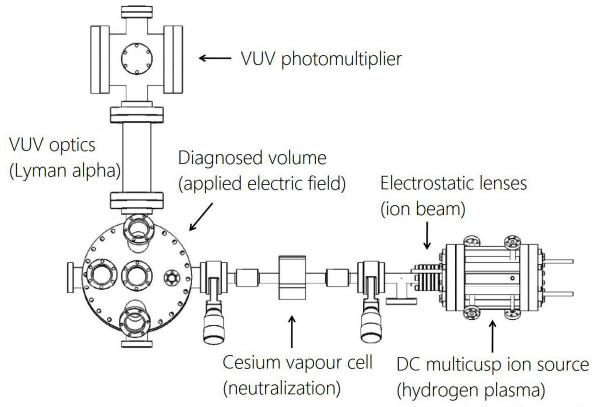

Fig.1: Sketch of the experiment

The measured induced radiation (resulting from the so-called quenching of metastability) originates in the Stark mixing of the $2s_{1/2}$ (metastable) and $2p_{1/2}$ (radiative) states. The lifting of the degeneracy between these two levels, which is due to the Lamb-shift [1], gives access to the micro-fluctuations of the electric field around the corresponding resonance, at f_0 = 1056 MHz, with a high sensitivity.

Fig.1 gives a sketch of the experiment: an H^+ beam is extracted through a system of electrostatic lenses from a hydrogen plasma created in a multicusp ion source. It is neutralized in a Cesium vapour cell before entering the diagnosed plasma chamber. The emitted Lyman-alpha light is collected in a direction perpendicular to the probe atomic beam[2].

We introduce measurements of the electric field performed from an ion and an atomic beam in vacuum and in a plasma where Debye shielding is measured [3,4].

For the first time, we used the Lamb-shift resonance to measure oscillating electric fields and observed the strong enhancement of the Lyman alpha signal around 1 GHz [3,5].

The measurement is both direct and non-intrusive, which allows probing extreme and difficult to access environments, and measuring fluctuations of the electric field at scales not yet experimentally reached [6].

References

[1] Lamb W.E Jr 1951, Anomalous fine structure of hydrogen and singly ionized helium, **Rep. Prog. Phys. 14**, 19-63

[2] Chérigier-Kovacic L, Ström P, Lejeune A and Doveil F 2015, Electric field induced Lyman-alpha emission of a hydrogen beam for electric field measurements, **Rev. Sci. Instrum. 86**, 063504

[3] Lejeune A, Chérigier-Kovacic L, and Doveil F 2011, Lyman-alpha radiation of a metastable hydrogen beam to measure electric fields, **Appl. Phys. Lett. 99**, 181502

[4] Lejeune A, Chérigier-Kovacic L, and Doveil F 2013, Lyman-alpha radiation of a probe atomic beam to explore the electric field in plasma sheaths, **Eur. Phys. Lett. 104**, 35001

[5] Doveil F, Lejeune A and Chérigier-Kovacic L 2013, Lyman-alpha radiation of a probing metastable hydrogen beam to measure electric fields in diluted fluids and plasmas, **Phys. Plasmas 20,** 055701

[6] Doveil F, Chérigier-Kovacic L and Ström P 2017, Lamb-shift and electric field measurements in plasmas, **Plasma Phys. Control. Fusion 59**, 014020