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Microwave Cavity Resonance Spectroscopy of Ultracold Plasmas

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Ultracold plasmas (UCPs) form a new exotic category of plasmas that can be produced by photo-ionizing laser-cooled atoms in a magneto-optical trap (MOT) near-threshold. With densities up to 10^{18} m^{-3}, temperatures as low as $\sim$100 μK for the ions, and $\sim$1 K for the electrons, they are the ideal model plasmas to study fundamental processes in plasma physics, such as (the competition between) three-body recombination, disorder-induced heating, and collisional and collisionless microwave heating.

To study these plasmas, conventional diagnostics such as Langmuir probes are not suitable, and tools from the field of atomic and particle physics are employed instead: charged particle diagnostics for electrons and ions, and laser-induced fluorescence and absorption imaging for ions. However, these diagnostics are limited by the charged particle's time-of-flight to the detector or require optical transitions available to lasers and cameras, such as present in alkaline earth metals, to work.

At TU/e, we recently developed a novel diagnostic that combines some of the advantages provided by the previous diagnostics. The diagnostic is based on a 5 GHz resonant microwave cavity and uses the shift in the resonance frequency of the cavity, induced by the UCP, to determine the electron dynamics of the plasma. This diagnostic allows us to study the dynamics simultaneously non-destructively, very fast (ns temporal resolution), with high sensitivity, and is a potentially interesting device for other types of plasmas as well, such as plasmas induced by extreme ultraviolet irradiation.

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