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Laser Thomson scattering diagnostics of low-temperature plasmas

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Laser Thomson scattering (LTS) is the light scattering by free electrons and one can derive electron density and energy distribution from the intensity and profile of a light scattering spectrum. To apply LTS technique to diagnostics of low-temperature plasmas, one needs to detect narrow (∼a few nm) and extremely weak light scattering spectra against orders-of-magnitude stronger background stray scattering. This difficulty has been overcome by the development of a triple grating spectrograph [1], which produces a light scattering spectrum on its output focal plane with the stray component highly suppressed (10^{-6}) with the aid of an internal spatial filter. Imaging detection of the spectrum with a gated ICCD camera with photon-counting-level sensitivity enables one to carry out measurements within a reasonable time. The technique has been applied to a number of cases where a conventional Langmuir probe method is difficult to use, including measurements of EEDF near the plasma-dielectric interface in a surface wave plasma (where strong microwave field interferes with the probe), high spatial resolution measurements for atmospheric pressure microdischarge, etc. Other applications of the LTS measurement system could be negative ion density measurements (with the aid of laser photodetachment effect) and Raman scattering measurements, giving local gas temperature and local gas species concentration. To make reliable LTS measurements, one should be careful about electron production due to multiphoton ionization caused by strong laser field in the focal region. Direct measurements of multiphoton ionization yields for various gas species indicate that metastable rare-gas atoms are ionized with a high probability and even ground-state atoms and molecules are ionized with a probability exceeding the ionization degree of the plasma under study, depending on the gas species, plasma conditions, and laser focusing conditions, which should be controlled to minimize the laser perturbation.

[1] Kono and Nakatani, Rev. Sci. Instrum. 71 (2000) 2716.