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Helium plasma jet as a probe for the laser irradiance measurements

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The knowledge of the effective value of the laser power density in the arbitrary position is usually of importance for any experimental work. It has been shown that the non-resonant laser irradiation induces line shift through the dynamical Stark effect of the excited atoms (Dubreuil et al. 1978). The effect is shown to be of order of 4·10-3 nm/(MW·cm-2) for particular helium atom transition 43S - 23P at 471.3 nm. The work included theoretical calculations based on the second order perturbation theory and the experimental confirmation utilized by continuous wave CO2 laser irradiation of low-pressure discharge in helium.

In this work we present preliminary results of the measurements of the helium line shift caused by helium atmospheric pressure plasma jet irradiation by tunable energy (4 mJ maximum) femtosecond ytterbium doped fiber laser at 1030 nm (Pharos, Light Conversion). Atmospheric pressure plasma jets represent controllable plasma devices of simple construction that found broad applications in various fields, from material science to medicine. These devices emit spatially and temporally stabilized low electron density streamers through the helium gas stream that flows into the air (Lu et al. 2014). Thus, their construction enables generation of plasma in free space which candidates them as ideal plasma probes.

Helium atmospheric plasma jet based on the asymmetric dialectic barrier discharge was powered by 2.5 kV sinusoidal voltage at 30 kHz. The laser operated at the same frequency and its average power could be changed in range 0-20 W. The laser and the plasma jet were synchronized by means of delay generator in a manner that the laser light and the streamer appear at the same time at the same place. 1-m focal length spectrometer equipped with iCCD recorded helium emission at the particular wavelength. The laser intensity was kept bellow breakdown value. The recorded line profile and the line shift dependence on the applied power are given in Figure 1(a) and 1(b).

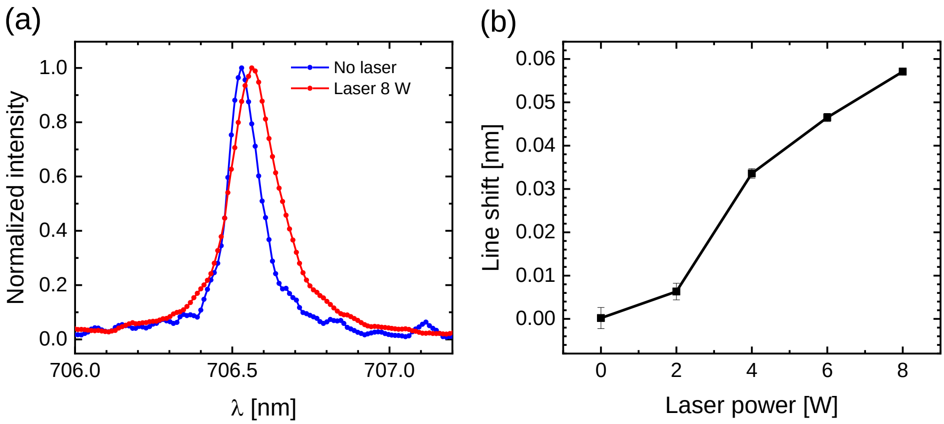

Fig. 1. (a) The examples of unshifted and shifted lines. (b) Line shift in dependece of laser power.

The preliminary results confirm the effect of the line shift induced by laser radiation. Further measurements should valorize these results and find the atomic emission line which is the best candidate for the use for the laser power density measurements.

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References

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