Filamentation of IR and UV double femtosecond laser pulses

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Abstract—An influence of plasma channel created by a filament of focused femtosecond laser pulse with wavelength \( \lambda = 248 \text{ nm or } 740 \text{ nm} \) on characteristics of other plasma channel formed by a femtosecond pulse at the same wavelength following the first one with varied time delay was experimentally studied.

Keywords—filamentation; ultrashort laser pulses; plasma channels; double pulses (key words)

Propagation of an intense femtosecond laser pulse through transparent medium results in beam self-focusing and plasma channels formation – process of filamentation [1]. Plasma density in filament is important parameter for controlling high-voltage electric discharge. In reference [2] initiation of the discharge was shown to be more effective when using train of UV pulses instead of smooth pulse with the same duration. In present work filamentation of two sequential femtosecond laser pulses (i.e. a double pulse) is studied. Experiment was carried out by using a Ti-sapphire laser system. Laser pulses of 100 fs pulse duration (FWHM) at the wavelengths of 744 nm (IR) and third harmonic of one - 248 nm (UV) were used. The pulse energy was 1 mJ for IR and 35 µJ for UV laser radiation. The time delay between pulses was introduced by difference of optical paths of the ones. The pulses were focused by a concave mirror with 1 m focal length to the gap between spherical electrodes. When the laser pulse went through the electrodes gap, its capacity was changed by arising laser plasma and voltage corresponding to the capacitor recharge current was measured by an oscilloscope. Thereby this voltage is proportional to the linear density of the plasma channel.

The distribution of linear plasma density along the filament is shown on fig.1, 2. Experimental results showed that for UV pulses if the delay is less than 5 ns, significant decrease of linear plasma density formed by second pulse is observed, otherwise the difference is slight. Approximately two times less decrease of the peak linear plasma density took place in case of double IR pulses for all explored delays.

The explanation of such a difference is the existence of resonant process with characteristic time of a few nanoseconds, for example, oxygen ions \( O_2^+ \) formed by the first laser pulse can be excited by 5 eV quantum (248 nm) resonantly [3]. Therefore, in the conditions of a single filament the use of a train of UV ultrashort pulses with a period less than 5 ns does not look practical for sustaining plasma in the channel. In case of multifilament mode short time delays can resulted in the second filament can appear outside the filaments zone of the previous pulse, which can lead to more uniform filling of the "thick" laser plasma channel.

REFERENCES

