Laser-Plasma Calorimeter

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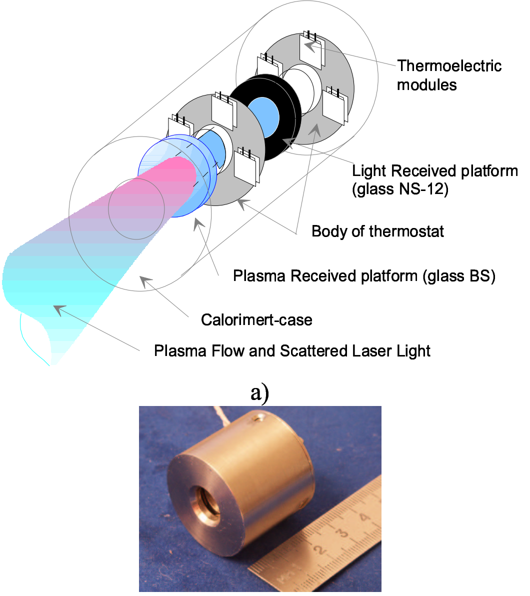
One of the basic aims in laser plasma interaction experiments is to study conversion of laser radiation into the plasma kinetic energy. Such studies are also of interest for laser-fusion research.

In such experiments the calorimetric method is often used for measuring of the scattered laser light and the energy released from the plasma.

The absorbed energy of x-rays and fast particles is usually measured directly by an array of plasma calorimeters located around the target. This provides the information about a spatial distribution of the plasma energy and scattered laser light. Integrating over the space gives the total amount of the radiated and dissipated energy.

For measuring angular distributions of plasma flow and scattered laser light a laser-plasma calorimeter has been developed [1]. The calorimeter is of small size (∅30x25мм). Fig. 1 presentes the calorimeter principle scheme and its view.



a)

b)

Fig. 1 The scheme of the plasma-light calorimeter for plasma and light measurements (a) and its view (b). A calorimeter allows measuring plasma flows and scattered light under one viewing angle to the target.

Plasma and light calorimeters are placed one by one in general steel metal casings. An entrance diaphragm with a diameter of 9.5 mm on the receiving platforms of the plasma calorimeter transmits particles and x-ray`s and prevents the laser light to be reflected and dissipated by plasma. A receiving platform is a disk made of glass K 8 of 1 μm thickness. It has a very low absorption coefficient (κ = 0.001mm^{-1}) in the wavelength range of λ=0.6÷1.315μm. Therefore heating of the absorber is caused practically only by energetic particles and short-wave (λ<0.2 μm) plasma radiation. Laser light reflected and dissipated by the plasma passes through this glass receiver and comes to the receiving platform of the light calorimeter (glass NS12 1 mm thick with absorption coefficient κ=1.2 mm^{-1}). Such receiving platform is an unselective absorber for λ=0.5÷1.8 μm spectral interval. It works with intensities up to $3\cdot10^6$ W/cm^2 at a nanosecond laser pulse duration.An increases of receiving platforms temperatures are registered by the semiconducting thermoelement TEMO-8, fixed on massive thermostats. The thermostats are isolated from the calorimeter body.

The calibration of the calorimeters was performed by comparison with a standard light calorimeter. For a light calorimeter the λ=1.06 μm laser was used, and laser with λ=10.6 μm was used for calibration of the plasma calorimeter. The calorimeters' sensitivities achieve ξ≈3 mV/J. The error in calibrating the calorimeters is ± 15 %.

Fig.2 show the results of the measured angular distribution of the plasma flow and scattered laser light in one of the experiments on the ISKRA-4 laser facility [2].

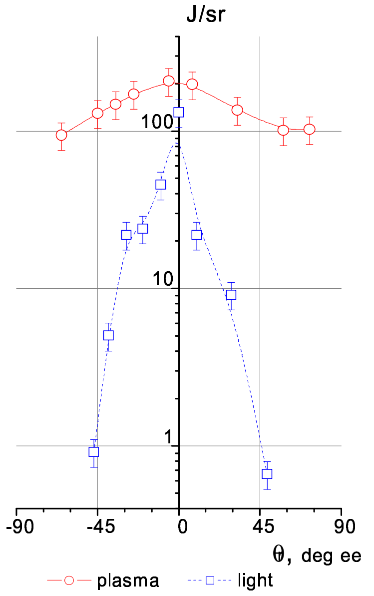


Fig. 2 Angular distribution of the plasma flow and scattered laser light, registered at the irradiation of the flat Al target (λ=1.315 μм,7q $3\cdot10^{12}$W/cm^2).

Al-disks have been irradiated at λ=1.315 μм with the energy 250 J and a pulse duration $\tau_{0,5=}$0.6 ns. Spot The averaged intensity in the laser spot was 7q= $3\cdot10^{12}$W/cm^2. The absorption coefficient Kp=85% was calculated by integrating overthe plasma angular distribution.

References

[1] A.V.Bessarab, V.A.Gaidash, G.V.Dolgoleva et al. JETF v.102, N6 (12), p.1800, (1992)

[2] S.A.Bel'kov, A.V.Bessarab, G.V.Dolgoleva et al. Czechoslovak Journal of physics,Vol.42, №10 p.969 (1992)