LASER PROGRAM

L.1 Efficient laser energy absorption in gas cluster plasmas irradiated by high intensity multi-picosecond laser pulses

Gas jet targets are commonly used in laser plasma interaction experiments with ultra-short pulse lasers. Such targets have the advantage of being a debris-free intense x-ray-VUV source, which can be operated at high repetition rate for applications in x-ray contact microscopy and VUV lithography. However, a major drawback of gas jet targets (compared to solid targets) is that the absorption of laser light in them is rather very small due to low gas density, which in turn, results in a poor x-ray conversion efficiency. This problem is overcome by converting gas jets into gas cluster jets, which, with sub-picosecond lasers, lead to high absorption of laser light. For multi-picosecond laser pulses, the laser energy absorption in clusters is expected to be small as the clusters break-up time is of the order of picosecond. Our experiments have shown for the first time that even for 25 picosecond laser pulses, clusters do lead to a high absorption of laser light.

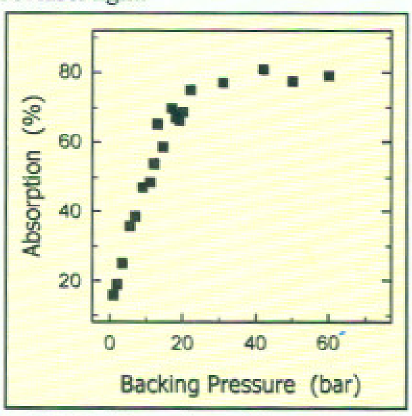

Fig. L.1.1 Absorption of laser energy v/s backing pressure for argon gas

Laser energy absorption measurements in gas jets of argon and nitrogen for 25ps laser pulses from the 100GW Nd: glass laser chain, were carried out. Peak absorption of ≥ 75% was obtained at an intensity $\sim 10^{15}$ W/cm^2, for a backing pressure of ≥ 25 atmospheres in both the cases (fig. L.1.1). Under these conditions, both these gases form clusters. It was observed that in the case of helium gas, where clustering does not take place, the laser light absorption was negligibly small. The results on high absorption are explained in terms of high-density plasma formation due to initial cluster heating and break-up, followed by large absorption of the remaining laser pulse energy in this preformed plasma.

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L.2 Enhancement of soft x-ray conversion in laser produced plasma of gold-copper mix-Z targets

Efficient conversion of laser energy into soft x-ray radiation is one of the main pre-requisites for success of indirect approach of laser driven inertial confinement fusion. High-Z materials like gold are used for such applications because, firstly, a high-Z plasma is an intense x-ray emitter, and secondly, a high-Z target offers high opacity to x-ray radiation penetrating into the target. A higher opacity reduces the radiation conduction loss into the target, which in turn, increases the x-ray conversion efficiency. It has been theoretically shown that a mixture of two or more high-Z elements with some optimum-mixing ratio can provide significantly higher Rosseland opacity than those of individual elements. This occurs when the frequency regions of small opacity of one element coincide with the absorption peaks of another element in the same photon energy band.

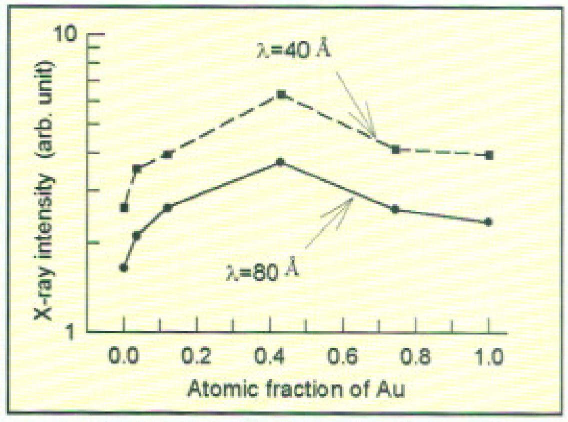

Fig.L.2.1 Variation of x-ray intensity with atomic composition

Experiments were carried out on x-ray generation from Au-Cu mix-Z planar targets of different atomic compositions. Plasma was produced by second harmonic of Nd: glass laser at an intensity of $\sim 10^{13}$ W/cm^2. X-ray intensity in the spectral region ~ 15 – 150Å and integrated x-ray yield for mix-Z target was observed to be higher than that for either of the individual elements. Variation of x-ray intensity at two representative wavelengths λ = 40Å and 80Å with atomic composition is depicted in fig.L.2.1. The maximum conversion occurred for an atomic composition of Au 0. 43 – Cu 0.57. These observations are consistent with the variation of Rosseland opacity with atomic composition calculated using a screened hydrogenic average atom model.

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