L.9: A novel high precision technique for pin-hole alignment of a spatial filter

Low frequency pass spatial filter is an important subsystem of any high energy, high power laser chain. As it is kept inside a vacuum vessel to avoid air breakdown, it is commonly known as vacuum spatial filter. A spatial filters basically removes spatial irregularities i.e. spikes or dips in an otherwise smooth intensity profile of the laser beam before they (irregularities) grow to a significant intensity gradient level to cause filamentation of the laser beam, thereby causing permanent damage to the lasing medium. In general, a spatial filter consists of two positive lenses in Keplerian telescope configuration with a metal or glass based pin-hole of optimum shape and size, placed in the common focal plane. Despite its utility and simplicity, an aperture-based spatial filter has some practical challenges such as precise positioning of the aperture of appropriate size at the common focal plane of the two lenses. For example, any misalignment of the pin-hole may cause truncation of the main laser beam, leading to undesired optical beam quality at the output of the spatial filter. In addition, the misalignment may enhance the severity of the edge damage and lead to the closure of the pin-hole due to plasma formation, causing undesired spatial beam quality and back-reflection of the laser radiation.

Our technique for alignment of the pin-hole of a spatial filter uses a simple intensity mask, consisting of a black dot, placed in front of the first lens L1 and the spatial profile of the beam is observed at a non-image-relayed point, as shown in Fig. L.9.1a. The intensity distribution of the diffraction pattern due to the intensity mask is strongly affected by the location of the pin-hole and is used as a high precision visual indicator for pin-hole misalignment, as the diffraction pattern of the mask becomes asymmetric for misaligned pin-hole. Fig. L.9.b and c show the theoretically calculated and experimentally observed beam spatial profiles, respectively, for different spatial positions of the pin-hole. It has been demonstrated that a pin-hole can be visually aligned with an accuracy of ~5% of the pin-hole diameter. The accuracy of the pin-hole alignment can be further improved using a computer based image processing algorithm. In a practical system, one may not require a dedicated mask, as presence of surface or bulk damage or a dust particle serves as a diffraction centre. [For details please see : A. K. Sharma et al, Applied Optics, Vol. 52, p 2546 (2013)]

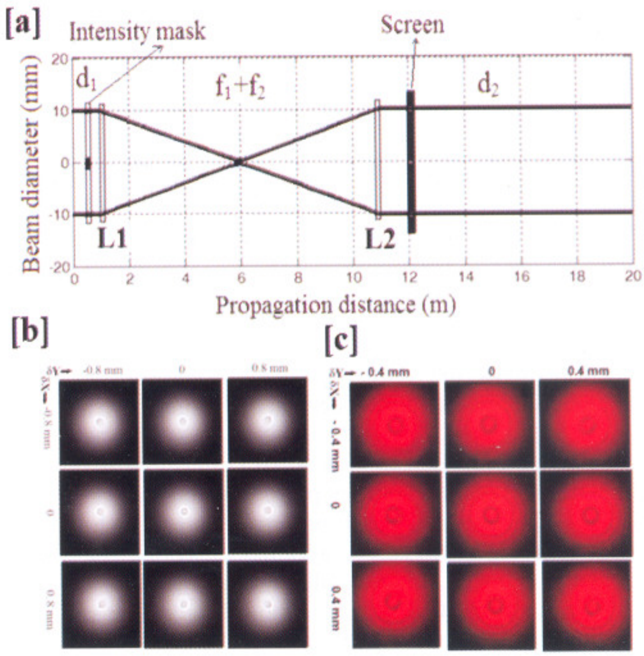

Fig.L.9.1: a) A typical setup, b) Theoretically calculated spatial beam profiles at screen location for pin-hole with diameter of 4 mm and black dot mask of 2 mm diameter; and c) Experimental beam profiles for pin-hole of 2.25 mm diameter and mask causing diffraction having 0.2 mm diameter. The horizontal and vertical misalignments X and Y are marked on the top and left side for each column and row.

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