L.2 Generation of flattened Gaussian beams from Gaussian mirror resonator

Laser beams of flat top spatial intensity profiles, are attractive for many applications like non-linear optics, holography, lithography, material processing, optical data storage and spectroscopy etc. Several techniques to generate flat top or uniform intensity beam profiles external to the cavity are reported in the literatures. However, in this case there is a substantial loss of energy compared to the original beam energy. In an active resonator configuration, super Gaussian beams (SGB) of flat top intensity profile can be generated by using super Gaussian mirrors. Flattened Gaussian beams (FGB) are another class of beams, which also exhibit uniform intensity profile. Though SGB and FGB look alike and are experimentally difficult to distinguish, mathematically they are quite different. Theory for FGB was first proposed in 1994, and the beams with such profiles were demonstrated external to the cavity. Practical realization of FGB in an intra-cavity setup was not reported. Generation of FGB in an active resonator configuration using a variable reflectivity mirror (VRM) with Gaussian reflectivity profile has been recently demonstrated at the Solid State Laser Division of RRCAT. The system was an electro-optically Q-switched Nd:YAG laser in positive branch unstable resonator configuration.

Generally VRMs are fabricated based on three important parameters. These are : Gaussian order, peak reflectivity and coating spot size. Once these parameters are decided then the resonator magnification is fixed to yield a Gaussian output profile. Therefore such a VRM mirror can be used only in a particular resonator. The transmission profile of such a VRM is given by

$$I_{out}(r) = \left\{1 - R_0 \exp\left[-2(M^2-1)\left(\frac{r}{\omega_i}\right)^2\right]\right\} I_0 \exp\left[-2\left(\frac{r}{\omega_i}\right)^2\right]$$

where M is resonator magnification and r is the radial co-ordinate, w_i the incident spot size and n the Gaussian order. In the present case n = 2 (Gaussian). R_0 is the peak reflectivity. From the above equation one can see that, the output profile will be flattened when the resonator magnification M value is changed from the designed value calculated for a Gaussian profile. This is shown in the Fig.L.2.1.

Experiments were conducted using a 2m convex VRM mirror with Gaussian reflectivity profile coating. The spot size of the coating was 1.8 mm and peak reflectivity of 30%. The rear mirror was 3 m concave and separation between the mirrors was 0.5 m. This results in a resonator magnification of 1.5 for which the output is of Gaussian spatial profile, which is shown in (Fig.L.2.2). The resonator magnification was changed by changing the mirror curvature and resonator length. Output spatial profiles were generated for magnifications 1.5, 1.8 and 2. Generated profiles were fitted with FGB equation [See for details: R.Sundar, K.Ranganathan, and S.M.Oak Applied Optics 47, 2, 147, 2008]. FGBs of order 3 and 4 were generated by changing the resonator magnification as shown in Fig.L.2.3. The output energy had a marginal drop as the reflectivity and hence output coupling was not optimum for different resonator configurations. However, the pulse width did not change appreciably. This technique has an advantage of generating various spatial profiles which include Gaussian, flat Gaussian of different orders and annular like profiles using a single VRM Gaussian mirror.

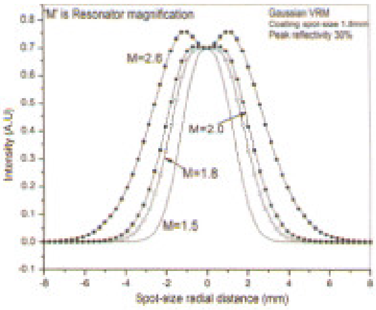

Fig.L.2.1: Theoretical transmitted profile from Gaussian mirror for various resonator magnifications.

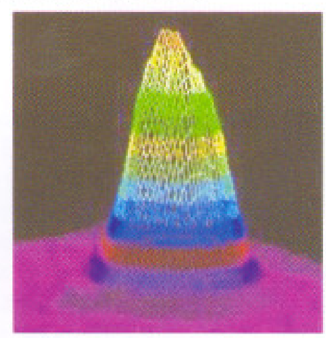

Fig.L.2.2: Gaussian output spatial profile generated from resonator magnification M = 1.5.

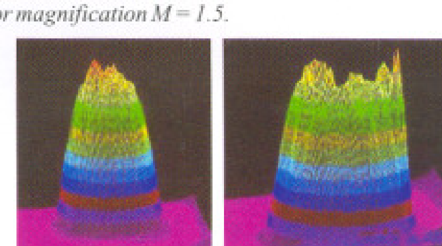

Fig.L.2.3: Output spatial profile of FGB order 3 generated from resonator magnification M = 1.8 and FGB order 4 for magnification M = 2 respectively.

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