We have developed a new reflecting element, all-metal axicon mirror, and demonstrated its use to generate hollow conic beam. The axicon mirror has a base angle of ~3 degree and is made of copper. It was fabricated in Laser Workshop of RRCAT, polished on a diamond turning machine in Machine Dynamics Division of BARC and gold coated in the Optical Workshop of RRCAT. Using this axicon mirror, a good quality hollow conic beam has been generated with a power conversion efficiency of ~ 85% for transformation of a Gaussian beam into a hollow conic beam. Focusing of the hollow beam by a lens was investigated and it was found that it is possible to have a region of length several cm over which the hollow beam diameter is few mm. This is suitable for guiding of cold atoms by using a suitably detuned laser beam.

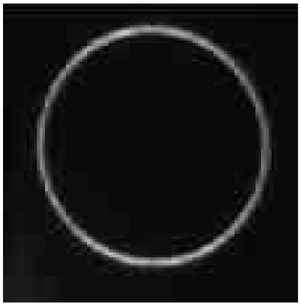

Fig. L.6.1 *CCD image of the hollow beam generated by axicon mirror.*

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L.7 Development of near 100 watt kinetically enhanced copper vapor laser

Kinetically enhanced copper vapor lasers are the advanced CVL systems with high efficiency 1.2-1.5% and increased output power (2-3 times) as compared to standard CVLs, where efficiencies are normally less than 1%. The carefully optimized HCl component of the buffer gas controls the electron density in the discharge medium by the process of dissociative attachment (DA), thus ensuring most favorable excitation conditions in the CVL. We have recently demonstrated a high power KE-CVL which was capable of generating about 94watt output power at ~ 10 kHz repetition rate using special buffer gas mixture in the discharge medium. The KE-CVL was based on 58mm bore and 1450mm length discharge tube. Alumina bulk fibre was used as thermal insulation around the discharge tube. Two water-cooled electrode assemblies were supported at two ends of the discharge tube with suitable end mounting flanges. HCl component of the buffer gas was prepared online by using a carefully optimized quartz cell containing high purity zirconium cloride as the source material. The total input power required was about 7kW. The overall wall plug efficiency was about 1.4 % which is highest so far achieved in our laboratory and very close to maximum value of 1.49% reported so far in KE-CVLs in the literature. The laser require about one hour to reach maximum output power after threshold lasing. The laser pulse durations are typically of about 50ns FWHM. The near field pattern of the beam cross-section is Hat Top type with higher intensity at the center.

Fig. L.7.1 *94 watt CVL beam being coupled out from laser window.*

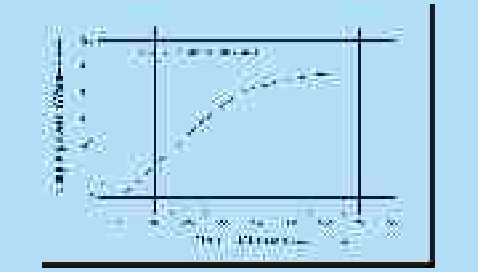

Fig. L.7.2 *Laser power buildup with time.*

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L.8 Generation of 120 watt CVL beam from single stage oscillator amplifier configuration

The kinetically enhanced (KE) CVLs offer high wall plug efficiency (1.2-1.5 %) and increased output power (2-3 times) capabilities as compared to standard CVLs by favorably enhancing the inter-pulse discharge kinetics using special buffer gas mixtures and other operating parameters [*B. Singh, V.V. Subramaniam, S.R. Daultabad, A. Chakraborty, Review of Scientific Instruments 126104, Dec 2005*]. These individual KE-CVL units can be grouped into oscillator amplifier configurations (fig. L.8.1) to generate single high power CVL beam. We have recently demonstrated a single stage oscillator-amplifier configuration using two KE-CVLs which was capable of generating output power in excess of 120watt with over all wall plug efficiency of about 1.4 %. Both the CVL units were optically aligned, electronically synchronized and optimized to achieve about 125watt total output power from this oscillatoramplifier configuration. The beam of KE-CVL oscillator with output power of about 20watt was folded and fed into the KE-CVL amplifier to achieve 125watt output power from the system. The tuning curve of amplifier (fig. L.8.2) was 150ns broad with FWHM of about 100ns . This is about 30 % more in comparison to that of standard CVLs. The amplifier contribution was about 105watt and hence the electro-optical efficiency of the KE-CVL amplifier was about ~ 1.6 %. The total input power to the oscillator and amplifier (both) units was about 9kW with total laser output power of ~ 125watt (maximum). The over all wall plug efficiency of the configuration was about 1.4 %.

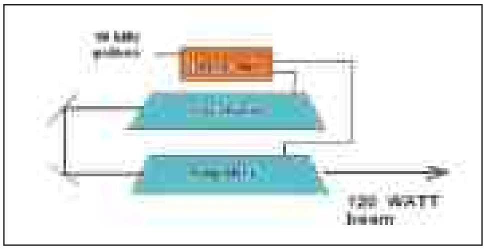

Fig. L.8.1 *Schematic of oscillator amplifier configuration.*

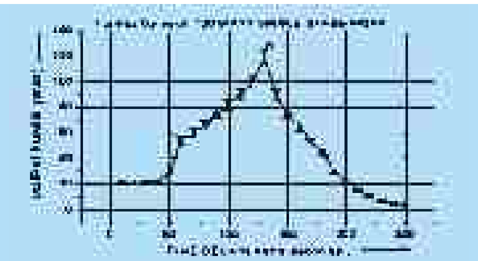

Fig. L.8.2 *Tuning of the oscillator amplifier.*

Fig. L.8.3 *Experimental layout of the KE-CVLs in oscillator-amplifier configuration.*

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L.9 Cation size effect on the Hyper-Rayleigh scattering and continuum generation of salt induced aggregates of silver nanoparticles

Research has been initiated on the use of nanomaterials for various bio-medical applications at Laser Biomedical Applications & Instrumentation Division. We have started preparing and characterizing metallic nanoparticles (NPs) of silver and gold because of their interesting size-dependent optical and electronic properties. One such nonlinear optical property of these metallic NPs is hyper-Rayleigh scattering (HRS). This is due to incoherent second harmonic generation (SHG) from the nanoparticle-solution interface.

HRS can be used as a sensitive tool to probe the salt induced aggregation of the metallic NPs as their aggregates show an order of magnitude increase in the HRS intensities. Addition of salts reduces the thickness of the electrical double layer (EDL) surrounding a NP, thereby reducing the electrostatic repulsion, which results in increased rate of aggregation. According to Gouy-Chapman model, for a 1:1 electrolyte the thickness of the EDL around a colloidal particle is dependent only on the ionic concentration and not on the ionic size. However, we have found that the effect of cation size (Li^+, Na^+ and K^+; chloride counterion) plays a profound role on the aggregation behavior of silver NPs (AgNPs). The AgNPs prepared had a SPR (surface plasmon resonance) band centered at 400nm having a size distribution of 20±5nm. The effect of addition of salts on the HRS intensities is observed to depend markedly upon the size of the cation (fig. L.9.1). For larger cations, Na^+ and K^+ the HRS intensities increase considerably (50 times) as the electrolyte concentration is increased beyond ~50mM. However for Li^+ this increase is only nominal (~ 4 times). Continuum generation was also observed upon addition of NaCl or KCl, but not in presence of LiCl. Fig. L.9. 2 shows the continuum spectra along with the transmission curve of the bandpass filter used to record the continuum and HRS signals. It is evident that the transmission properties of the filter used restrict the measured spectral extent of the observed continuum towards red. Although all the three cations have same charge, Li^+ has the smallest size, which means it has the highest charge density. These observations suggest that smaller size and hence higher ionic charge density of the Li^+ ion is not conducive to the formation of aggregates. Our observation can be related to the "Hofmeister effect", which describes the relative effectiveness of anions or cations, on a wide range of phenomena including colloidal aggregation. Further studies are in progress to understand the nonlinear optical properties of these salt induced aggregates.

[For further details, see K. Das, A. Uppal, P. K. Gupta, Chemical Physics. Letters, Volume 426, page 155, 2006]