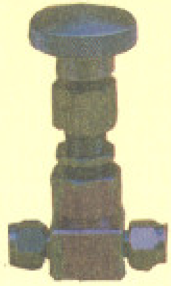
monohydrate). Although the largest KDP crystals grown at present at CAT are of size 4.5 x 4.5 x 19 cm^3, still larger crystals can be grown, if required. Process parameters such as the pH value of the solution, and the speed of rotation of the seed crystal during crystallisation have to be optimized for obtaining inclusion-free crystals of desired dimensions and quality. The level of trivalent impurities in the aqueous solution has also to be kept under control for ensuring that the crystals do not acquire a "tapered" growth habit, and do not have unacceptably high anomalous biaxiality.

KDP crystals grown have been used to fabricate the following devices: Type I and Type II second-harmonic generation (SHG) cells, phase-matched for Nd-YAG laser radiation; Type I SHG cell for Ar-ion laser radiation, with quartz windows; and electro-optic modulator (Pockels cell).

The efficiency of these KDP crystals for converting 1064 nm radiation to its second harmonic was measured, at Burdawan University, using a laser beam of pulse energy 17.7 mJ and a pulse width of 8 ns. For an effective crystal length of 3.39 cm and using a focussed beam of diameter 0.06 cm, the conversion efficiency was found to be 50%, against the theoretically expected value of 58%.

Gas Flow Metering Valve

A union bonnet metering valve rated for a pressure of 30,000 KPa (at 25°C) for applications in Laser systems has been developed. The flow coefficient can be varied from 0.002 for one turn of the stem to a maximum of 0.04 after ten turns (fully open). This valve of 1.6 mm diameter orifice and swage lock type connectors at the inlet and outlet gives a precision control of gas flow. The maximum allowable stem seal leak rate is 0.1 std cc/min.



Gas flow metering valve

SQUID based Magnetometer

A commercial SQUID based magnetometer was installed and commissioned in February 1993. This highly sensitive instrument can measure magnetic moments with a sensitivity of 10^{-8} e.m.u. Furthermore, measurements can be performed in a temperature range of 2 K to 400 K with magnetic field in the range of - 5.5 Tesla to 5.5 Tesla. The high sensitivity allows accurate study of magnetisation decay in hard superconductors, from which one can infer the flux-flow resistivity. The importance and relevance of such measurements can be gauged from the example of superconducting magnets for which this resistivity is below 10^{-12} ohm cm, and cannot be measured easily by transport methods. The high sensitivity also permits detailed studies on superconducting crystals of small sizes (<0.1 mm^3), and on weakly magnetic samples. This instrument is presently being used for such measurements. It requires about fifty litres of liquid helium every week which is being supplied regularly by the liquid helium plant at CAT.

Gravitational Wave Detector - CAT Participation

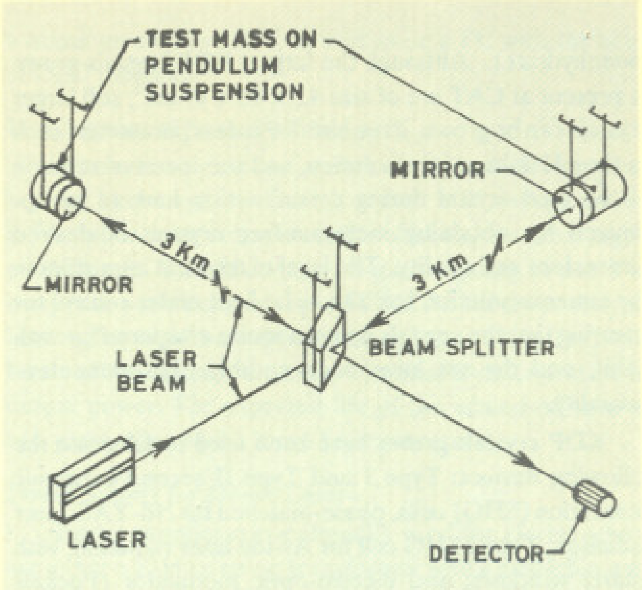
A direct detection of gravitational waves (GW) is one of the most challenging tasks in experimental physics today. The maximum strain amplitude ($\delta L/L$) of GW expected from astrophysical events in our galaxy is $\sim 10^{-18}$ and that too only once every decade or so, while the maximum amplitude expected from extragalactic events that might occur a few times per year is $\sim 10^{-21}$. With such small strains the distance between two test bodies separated by 1 km would change by only 10^{-18} m. For the detection of GW these small changes in the separation of test masses have to be measured against a background of other perturbing influences.

One of the most promising earth-based detection schemes is to use a Michelson Interferometer arrangement. The GW induced path difference between the two arms will lead to a fringe shift. The optimum optical length of the arm for GW detection is around 150 km. Such large optical path lengths can be achieved by having multiple reflection in the arms of the interferometer. Refractive index fluctuations in the residual gas can cause path length changes in the two arms, and thus the detector has to be housed in ultra high vacuum (10^{-8} mbar). The large optical path lengths in the two arms lead to large beam sizes, necessitating large diameter vacuum pipes.

Sustained effort over the last four decades to detect GW has led to rather impressive advances and what previously appeared a fantasy has now turned into an expectation. Prototype multi pass laser interferometric detectors with arm length ranging from 1 to 40 m have already been operated at several laboratories and strain sensitivity of few parts in 10^{-18} has been achieved. With increase in path length and use of some recent ideas it is felt that it is feasible to make interferometeric detections with sensitivity levels of upto 10^{-22}. Then there is a significant chance of detecting gravitational waves.

Because of this realization several such detectors have been planned. In USA a pair of 4 km arm length detectors are planned. Groups in UK and Germany are planning a 3 km arm length detector and groups in France and Italy are also working on similar plans. Australia is planning to set up an International Gravitational Observatory (AIGO) near Perth jointly with India and Argentina. The Indian participation in the project, the construction for which is expected to commence in 1996 will be in two areas, viz. i) data processing where Inter University Centre for Astronomy and Astrophysics (IUCAA), Pune will collaborate; and ii) in the design, fabrication and installation of the vacuum system, where CAT will participate. The UHV vacuum system will involve fabrication of two 3 km long and 1.22 m diameter vacuum tubes with minimum demountable joints and a large vacuum tank holding beam splitter etc.. The vacuum system is expected to cost nearly 20 million Australian dollars which is roughly one fifth of the estimated cost of the project.

An international workshop on 'New Technologies for Gravitional Astronomy' was organised by University of Western Australia, at Perth, from April 26-29, 1993 to review the construction of AIGO and exchange ideas. Shri A S Raja Rao from CAT was invited to the workshop and presented the details of a vacuum system configuration for AIGO.



Schematic of Interferometric GW Detector

Copper Vapour Laser Developed at CAT

Introduction

Copper vapour laser (CVL) emits light in the visible part of the spectrum at wavelengths 511 & 578 nm, and is the most efficient laser in this part of the spectrum. In this laser, first demonstrated by Walter et al in 1966, transient inversion is achieved by excitation of a resonance upper laser level from ground state level. Of the many metal vapour lasers that have been operated covering wavelengths from ultra-violet to infra-red, CVL has received the maximum attention because of its potential use in laser isotope separation. CVL is used for pumping high repetition rate tunable dye lasers which are ultimately used for selective excitation and ionization of desired isotopic species.

The lasing medium is copper in the atomic form. Vapours of copper are generated either by heating metallic copper to high temperature (1400-1600 °C) or by using salts of copper so that operating temperature is brought down considerably (400-600°C). There has been a considerable technological development, and average power of a single CVL has increased from 20 mW in 1966 to more than 100 W in 1993. Further increase in average power has been achieved by arranging these single lasers in master oscillator-power amplifier configuration. In this scheme the master oscillator is suitably improvised to provide a low power, good quality beam, and the power of the laser beam is increased by subsequent passage through a series of amplifiers in a specified time sequence. We discuss here some technological problems in the development of CVL and summarise our efforts and successes in that direction.

The operating principle of CVL can be best understood with reference to Fig.1, which shows the low lying levels of copper atom. Ground state of copper atom $^2S_{1/2}$ has the configuration $3d^{10}\ 4s$. Promoting the outermost 4s elecron to higher orbitals i.e. 4p, 5p, etc. results in a series of ^2P levels which are connected to ground state by strong resonance transition. The first set of transitions from these resonance levels (with electron configuration $3d^{10}\ 4p$) have wavelength 325 and 328 nm. There exists a configuration $3d^9 4s^2$ which is 1.5 eV above the ground state and is below the first resonance level. This configuration ($3d^9 4s^2$) gives rise to $^2D_{5/2}$ and $^2D_{3/2}$ levels and these are metastable because the radiative transition is forbidden by the parity rule of electric dipole transition. The free copper atom in ^2P levels has a finite probability ($2\mathrm{x}10^6 \mathrm{sec}^{-1}$) for decay to ^2D levels. Because the lower laser levels ^2D are metastable levels and can decay to ground level only via non-radiative decay (which is a slow process), the lower levels population