Second Semiannual Status Report

July 1, 1966 - November 30, 1966

NASA Grant NGR 33-019-048

STUDY OF CW GASEOUS LASERS FOR SPACE COMMUNICATIONS

Responsible Investigator: Dr. Hideya Gamo
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SUMMARY

The principal objective of this research is to develop a CW gaseous laser which has potentialities for space communications. We have chosen the He-Xe 3.5 micron gaseous laser, since its line falls in one of the best atmospheric windows, and its gain is the highest known to date, 4 db/cm, although its output power is not very high. Excellent frequency stabilized Xenon laser is expected from the facts that the Doppler line width is narrow and the laser can oscillate in the low pressure where the pressure broadening is negligibly small. By applying the laser amplifier to the output of a frequency stabilized Xenon laser, we intend to obtain a relatively high power laser beam.

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Progress During the First Semiannual Period

December 1, 1965 - May 31, 1966

Some preliminary studies of pertinent subjects were performed by the responsible investigator with the assistance of graduate students. It should be noted that the principal investigator was not available during the period. A single mode, self-stabilized operation of Xenon 3.5 micron laser was theoretically shown to be realized effectively in the neighborhood of the oscillation threshold. A relatively long operational lifetime more than one hundred hours has become possible by saturating the plasma tube wall (Pyrex) with Xenon under the gas discharge.

Progress During the Second Semiannual Period

July 1, 1966 - November 30, 1966

During the summer, we studied 0.99 micron cascade transition ($6P_{22} \rightarrow 6S_{11}$) of the Xenon 3.5 micron laser in order to find out possibility of cascade pumping of the laser. Our conclusion was that the cascade pumping technique in the case of Xenon 0.99 micron line must be limited to the laser with very low pressure of the order of micron Hg or less. The effective lifetime of $6S_{11}$ level of Xenon under the normal gas pressure ($\sim$100 micron Hg) is longer than the lifetime of the upper level $6P_{22}$ due to the trapping of the resonance radiation 1469 Å.

Since September 1, 1966, Dr. T. Tako joined our group on leave from the National Research Laboratory of Metrology, Japan.

We have assembled a clean ultra-high vacuum system and have been testing it. The baking-up facility will be prepared soon. Several gas laser tubes to be filled by Xenon isotope were prepared including the DC tube. (Cf. Attached photograph)

The characteristic features of the new vacuum systems are as follows: 1) an ion pump is used in the clean section; 2) gas pressure can be measured by a capacitance manometer without contaminating the clean section; 3) an oil diffusion pump with a liquid nitrogen trap.

Plans for the Next Year

The output power of a single mode 3.5 micron Xenon laser as a function of cavity length, so-called Lamb dip, will be observed and analyzed. The half-width and asymmetry of the Lamb dip depends on the natural width of Xe^{136} atom to be used and atomic collision effects between Xe-Xe and He-Xe atoms. The Lamb dip of Xenon 3.5 micron line will be sharper and deeper than the Ne 1.15 μ line studied by Szöke and Javan. Since the Xe laser can oscillate in a wide pressure range, it will be possible to determine the frequency shift of the minimum of Lamb dip as the function of gas pressure. The result should be useful for determining the frequency shift of a stabilized laser from the atomic natural line center due to the pressure effect.

Characteristic features of plasma tubes under preparation are as follows:

1. Enriched Xe^{136} isotope (Xe^{136} 91.0%, Xe^{134} 8.5%, Xe^{132} 30.4%, Xe^{131} 0.1%)
2. RF and DC excitation (hot cathode or hollow cathode type).
3. Brewster windows under optical contact and welding.
4. The partial pressure of Xe will be controlled with the accuracy of 0.5-1 μ Hg by using a liquid nitrogen cryostat.

5. Internal mirror type laser will also be studied.

Experimental study of a self-stabilization of the 3.5 micron Xenon laser will be performed, based on our theoretical investigation performed during the last period. (See attached report). Design of such a frequency stabilized laser will require a spacer with low thermal expansion coefficient (Invar and Corning 7913 Vycor glass), temperature control and servo-control of optical resonator such as Spectra Physics 119 model.

The stability of these frequency stabilized laser, including amplitude, frequency fluctuations will be determined by means of various methods, such as intensity correlation interferometer, scanning Fabry-Perot interferometer and heterodyne detection (photomixing).

The output of a single-mode, frequency-stabilized Xenon laser will be amplified by the long amplifier tubes with infrared isolators. The infrared isolator using Yttrium Iron Garnet has been available under the support of AFCRL and NSF.

Graduate Students

Thomas J. Walter

worked for assembling of the vacuum system.

Shanti P. Chakravarty

0.99 micron cascade emission in Xenon laser.

Avinash R. Karnik

self-stabilization of a high gain laser.

Shih Shung Chuang

infrared isolator using Yttrium Iron Garnet.

Donald G. Lubnau

RF transmitter for gas laser.

Related Activities

1. Investigation of Operational Possibility of Laser Radiation in Partial Coherence Region.

   AFCRL AF 19 (628)4350

   September 1, 1964-August 30, 1967.

2. Intensity Correlation Inferferometry with Applications to Laser Beams

   NSF Research Grant

   November 1, 1966-October 31, 1968.

3. Modern Optics Equipment Grant

   ARPA DA - ARO - D - 31 - 124 - G693

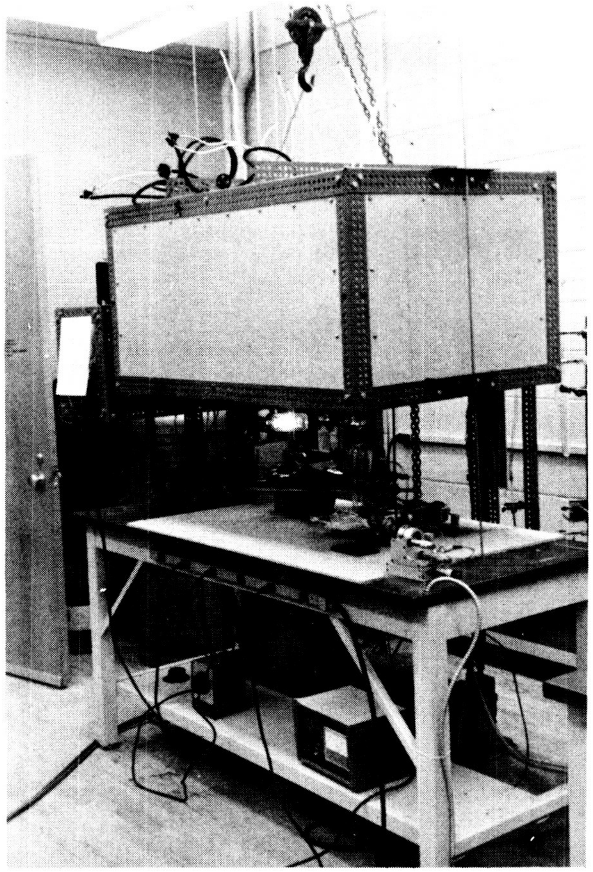
   June 1, 1965 - April 30, 1970.

Balance remaining in the Grant

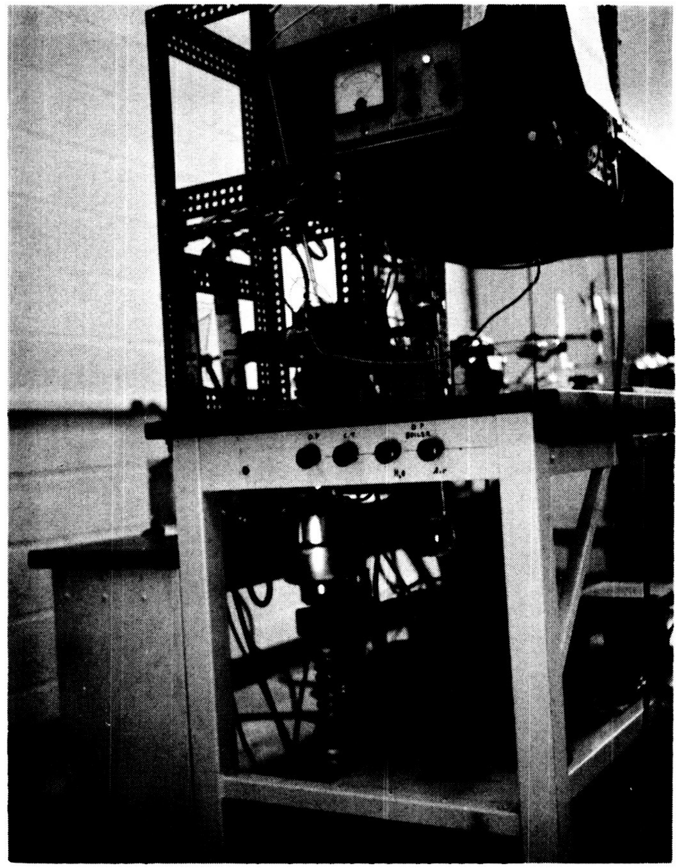
Account No. 554-2-301

by November 30, 1966 $ 13,090.10 CR

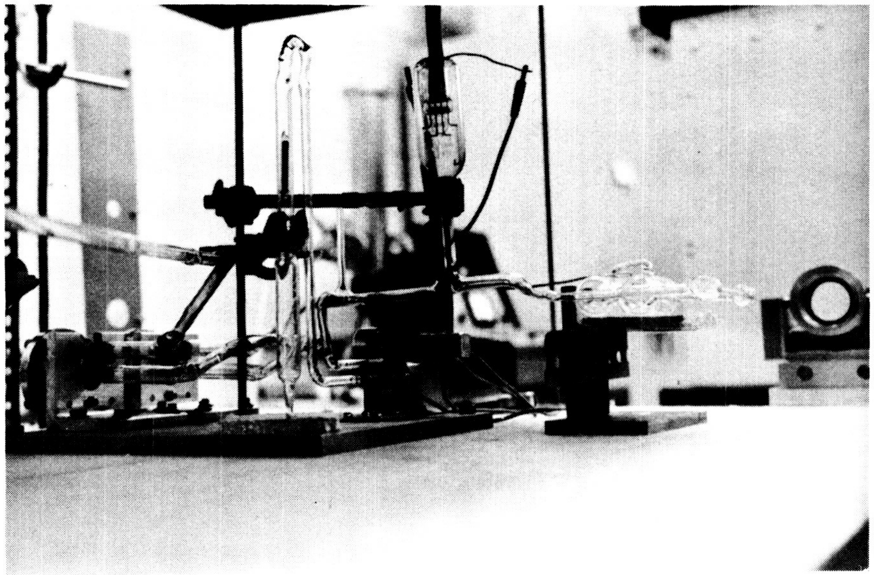
An ultra-high vacuum system has been assembled. Several optical components, such as mirror mounts, have been purchased.



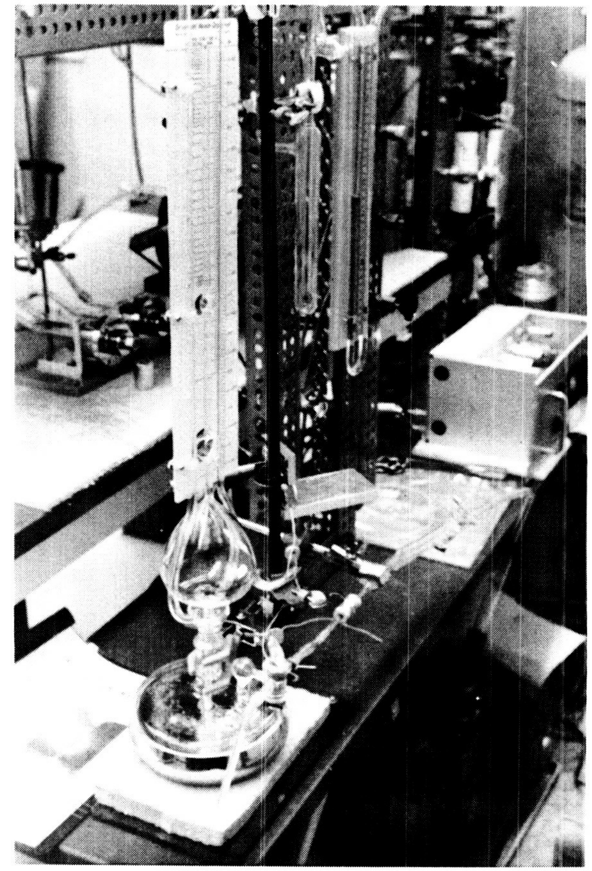
Vacuum System with Bakeout Oven



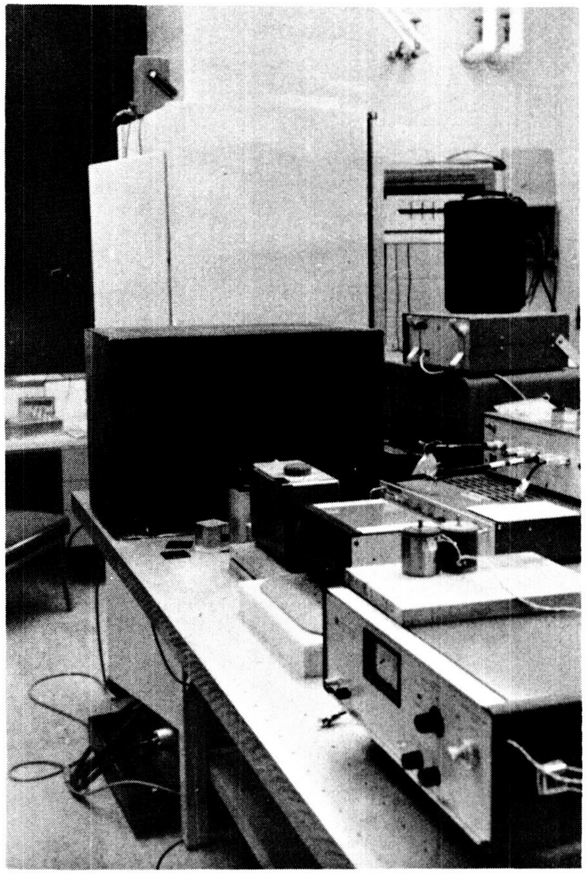
Front View of Vacuum System
(Oil Diffusion Pump with Liquid Nitrogen Trap)



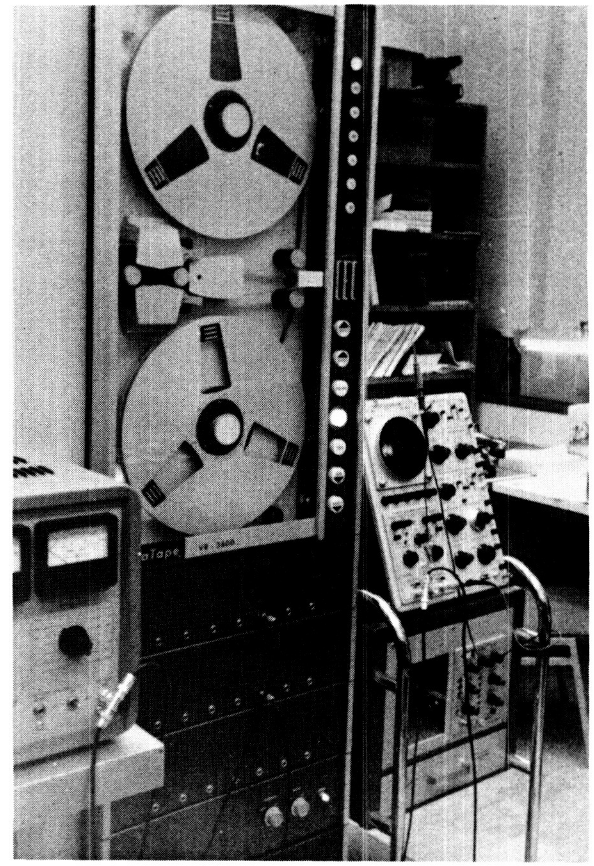
Plasma Tube with Isotope Filling System
(Bakable Valves and Ion pump)



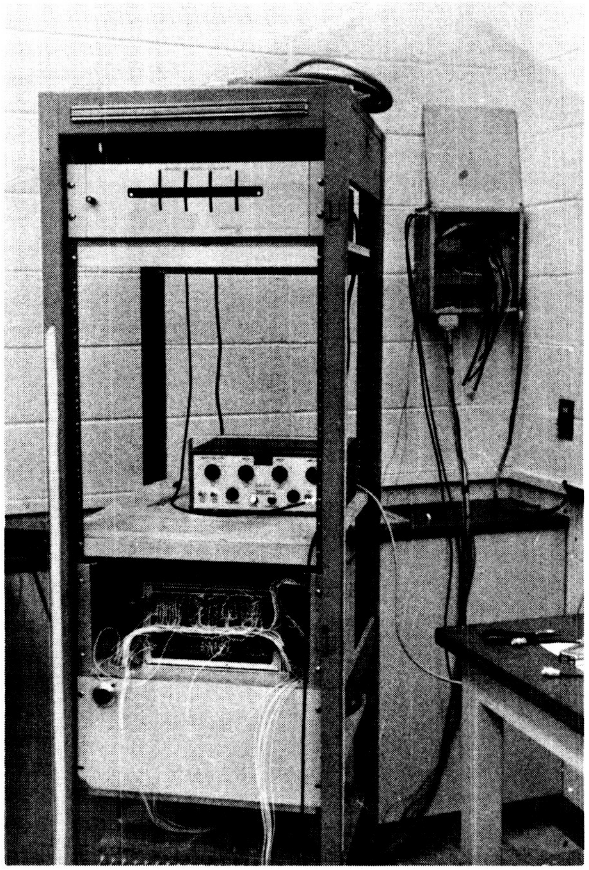
Pressure Measurement System
(Capacitance Manometer with McLeod Gauge)



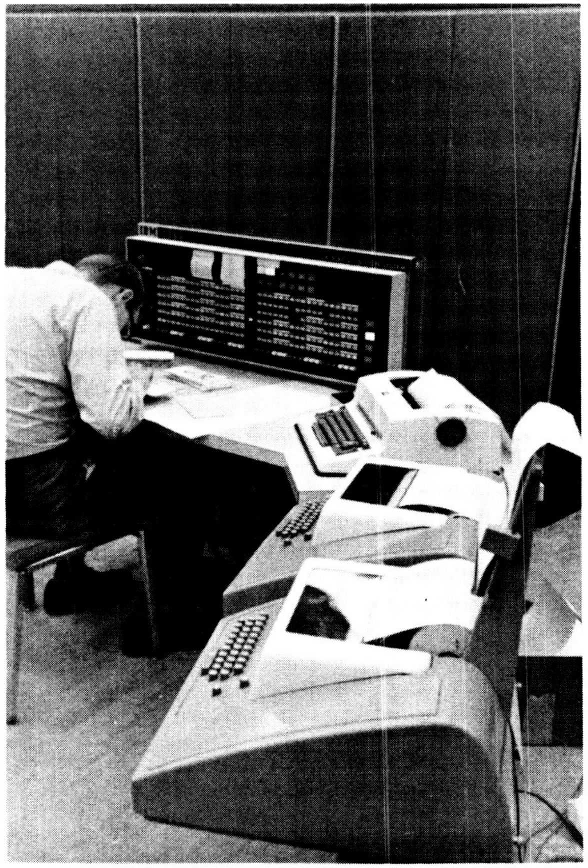
Intensity Fluctuations in a Single-Mode He-Ne Gaseous Laser



Instrumentation Recorder storing fluctuating Photocurrents (1.5 Mc AC and 500kc FM)



Analogue-to-Digital Converter and
Interface Unit for IBM 7700



IBM 7700 Data Acquisition System and
Teletype to be used in the Laboratory