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Study of Differential Pumping System for Beam-Pumped Laser by TIT Heavy-Ion RFQ Linac

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Abstract

3.1MeV $^4He^+$ beam from V.d.G. was used to pump He-Ar gas Laser with a differential pumping system. In our experiments, Laser action of the 1.27μm line could not have been observed above the threshold of 33W beam power input. One of the reasons is that the differential pumping system does not have the orifices aligned. For the experiments of Beam-Pumped Laser by using 0.88MeV $^4He^+$ beam from TIT Heavy-Ion RFQ Linac, I designed a differential pumping system with the orifices which are able to be aligned easily.

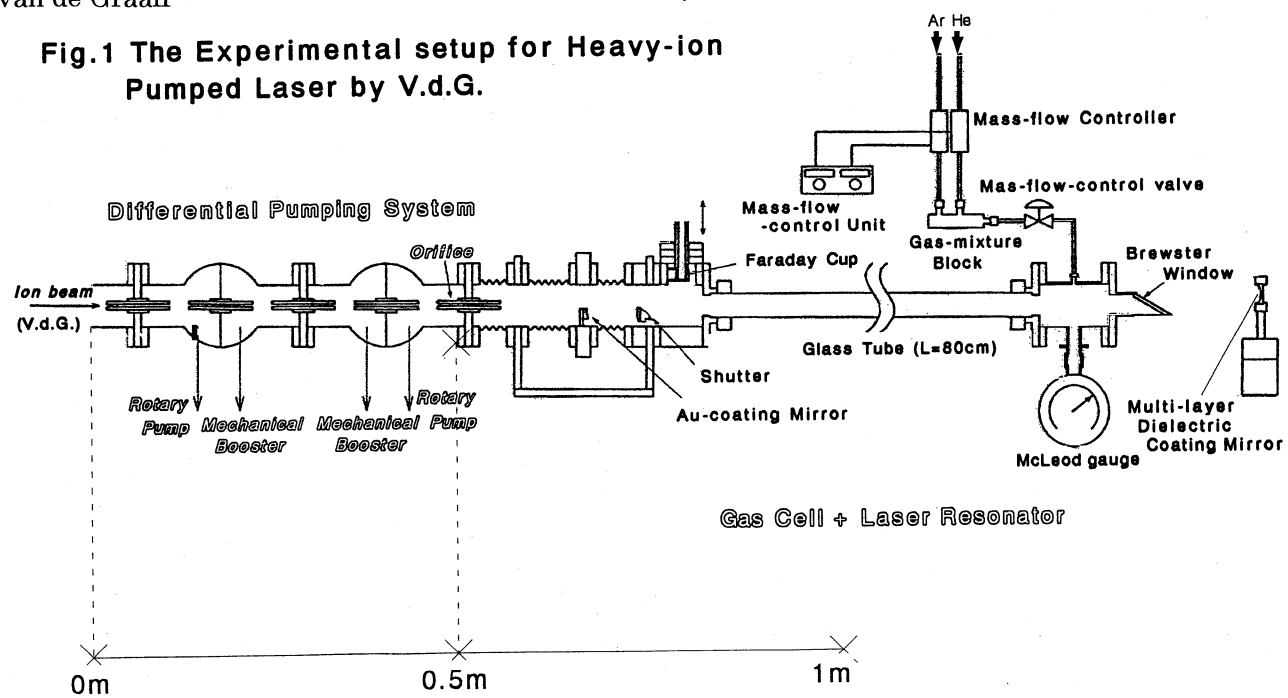
1.Introduction

Heavy ion beam-pumping is a method to produce the population inversion of a medium through projectiling heavy ions into the medium.

Experiments to study lasers pumped by heavy-ion beams in Munich were initiated by P. Kienle in 1979, and optical gain and laser effect were first observed in 1982-1983. A low threshold pumping power of 33 W was found in rare gas mixtures lasing in the near infrared in experiments performed at the Munich Tandem van de Graaff accelerator (Ulrich et al. 1983). This work had been stimulated by results of nuclear-pumped laser experiments in the Soviet Union and the United States that had been published in the 1970s, and most of the laser lines observed by ion beam pumping appear also on the list of nuclear-pumped lasers (Fitaire 1978). This immediately indicated that ion beam-pumped lasers can be used as model systems for nuclear-pumped lasers. A practical advantage of working with accelerators is that there is access to the target area, often also during operation of the laser. Continuous or quasicontinuous operation allows experimental parameters such as gas mixtures and the alignment of the optical cavity to be optimized rapidly.

Heavy-ion accelerators are widely used in atomic physics, especially to study few-electron atoms and inner-shell excitation process. The possibility of obtaining well-focused beams of particles with a high energy loss -dE/dx in the target material has stimulated the idea of using heavy-ion accelerators as drivers for inertial confinement fusion experiments. On the basis of similar arguments we have started a program to explore the possibility of short-wavelength lasers pumped by heavy-ion beams.

Fig.1 The Experimental setup for Heavy-ion Pumped Laser by V.d.G.



2.Experiment

In our research program, at first we make experiment for 1.27μm(ArI) laser action of He-Ar gas mixture with 50μA, 3.1MeV $^4He^+$ beam by TIT Van de Graaff.Then we are going to make experiment for 1.79μm laser action with 0.88MeV $^4He^+$ beam by TIT Heavy-Ion RFQ Linac.

The program of the experiments with V.d.G. (Fig.1) is as follows;

(1)Designing for the experiment setup

(2)Detecting the spontaneous emission from He-Ar gas target with spectroscope to examine the population inversion

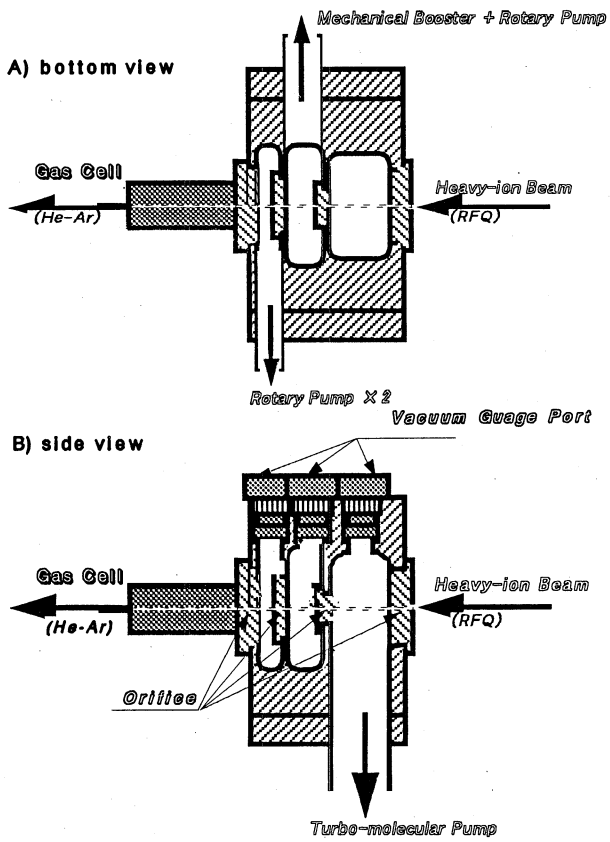
(3)Testing infrared laser action

(4)In the case of no laser action, improving the systems

In this paper, I report the result of the experiments and some improvements of this setup.

Laser action is a phenomenon which has a threshold. Therefore, on the development of laser systems, it is hard to make clear what is going on in the whole system. For the method to check the possibility on the laser action, I used plasma spectroscopy to measure the population inversion.

Fig.2 Compact Differential Pumping System



3.Experimental Result and Improvement

We could not observe He-Ar, 1.27μm laser action in our experimental setup.

The cause of unsuccessful result of the laser action is probably as follows;

(1) The laser resonator is not aligned, or the laser gain is less than laser resonator loss.

(2) This experimental setup needs a differential pumping system to keep the pressure difference between the accelerator and the gas cell. It consists of 4 stages which are pumped independently. In this system fine alignments of the beam axis obtained by means of orifice-shaft nuts shimming.Thus the orifices are not stable on the wall between the stages. It makes hard to align the optic axis. Moreover it is almost impossible to develop the study with it, because this system can not have any reproducibility.

For the improvement of such a system, I made a compact differential pumping system (Fig.2) which is machined from one brass block. As the loss of beam power was great in the differential pumping system, the distance along beam axis of the new compact differential pumping system is made five times shorter than that of the ex-differential pumping system. I prepared 4 kinds of diameters of the orifices. They are 1.6mm, 2.0mm, 2.5mm, and 3.0mm. Every orifice is screwed to be self-aligned, when they are screwed directly into walls of the main body of compact differential system.

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