Apparatus for Studying Heavy Ion Beam Pumped Recombination Laser Schemes ◇

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Recombination laser schemes [1] are studied in gas targets excited by heavy ion beams. These experiments require plasmas with high electron densities and low electron temperatures. In hydrogen-like He^+, for example, population inversion is studied for the 164 nm transition (n=3 → n=2) at an electron density of $10^{14} - 10^{15} \frac{1}{cm^3}$ and an electron temperature of less than 0.1 eV [2]. In order to obtain these plasma parameters two beam pulses from the Munich van de Graaff Tandem accelerator are stopped in a He gas target ($p_{He} \approx 300mb$). The first pulse is used to preionize the target gas. With a delay of typically 100 ns an electrical high voltage pulse (16 kV) is applied to two electrodes causing a discharge. The second beam pulse is stopped in this plasma to produce He^{2+} ions. Recombination of these ions is studied.

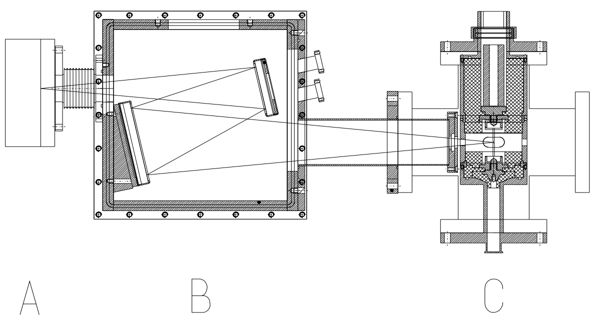

Fig. 1: Experimental setup:
The entrance slit assembly of the monochromator is indicated by A. The imaging optics is shown in B. The target cell in which the ion beam interacts with the discharge plasma is also shown (C).

Heavy ion beam induced processes in the discharge plasma are analysed by time resolved optical spectroscopy. Electron density and temperature can be changed by varying the time interval between the beam pulses and the electrical discharge.

An imaging optics has been designed and built which focuses light emitted from the target region onto the entrance slit of a VUV monochromator (fig.1). It consists of a spherical and a flat mirror. Both mirrors are mounted in a vacuum cell allowing VUV spectroscopy and can be adjusted from outside the vacuum. The optics was optimized using both commercially available and home made raytracing codes. The astigmatism caused by the curved mirror is minimized by using an almost normal incidence geometry and a magnification factor of 1. Both size and position of the two mirrors were choosen to match the effective aperture of the monochromator ($d : f = 1 : 5$).

A fast (≈ 10 ns) high voltage pulse is applied to the two electrodes by an electrical circuit adapted from a Nitrogen laser. For this purpose the cavity of the Nitrogen laser has been removed and a coaxial cable (RS 213) guides the high voltage pulse to the discharge cell. The length of the coaxial cable and capacity of the discharge cell are matched with the capacity of the former configuration of the nitrogen laser (≈ 1 nF). The electrical circuit can be triggered by standard TTL-pulses at a rate up to 100 Hz. The discharge unit fits into a 100 mm diameter double-cross shaped vacuum cell which can be evacuated to about 10^{-6} mbar. The electrical power supply line inside the vacuum is built in a coaxial geometry with an impedance of 50 Ω to avoid reflexions of the high voltage pulse. The pulse is applied to the lower electrode (fig.1). The upper electrode is connected to ground potential via a 50 Ω resistor, absorbing energy which flows across the electrodes while they are connected by the discharge plasma. The electrodes consist of two 4 mm long steel tubes (∅= 4mm), separated about 5 mm from each other. The heavy ion beam passes through the axes of the tubes. Other electrode configurations, like blades and spikes can also be used. The electrical properties of the discharge plasma are observed by 2 fast capacitive coaxial voltage dividers, who measure the voltage drop across the discharge region [3]. A fast rogowski coil is used to monitor the electrical current in the discharge circuit which reach approximately 600 A. The time integral of voltage drop across the discharge region times current determines the energy put in the plasma. The electron density can be estimated using this value.

In first experiments using the complete setup the timing between beam pulses and discharge has been successfully tested. Reproducibility is 10 ns or better.

References

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