Modelling of an Ar-Cs Charge Transfer Laser ◇

T. Drobek , A. Ulrich , M. Salvermoser, and D. E. Murnick [a]
[a] Department of Physics, Rutgers University, Newark, NJ 07102, USA

In situ production of target ions in cold dense matter by heavy ion collisions and subsequent selective charge transfer may provide an effective pumping scheme for short wavelength lasers.

Charge transfer from Cesium to doubly charged Argon ions shows a selective population of several 4d-levels of Ar II, especially the 4d $^4D_{7/2}$ level [1]. The strong transition from 4d $^4D_{7/2}$ to 4p $^4P^o_{5/2}$ at 349.15 nm is studied as a possible laser transition.

Photoabsorption in the laser medium was measured as a process reducing net gain. Cesium has a hydrogen-like structure of absorption lines. One of these absorption lines (the transmission between 6s $^2S_{1/2}$ and 10p $^2P^o_{1/2}$) lies at 348.01 nm, near the laser line. There is absorption due to the wings of this van der Waals broadened line. The dominant contribution to the absorption in the laser medium at 349.15 nm is a weak absorption structure of Cs_2-molecules.

Photoabsorption has been measured in a mixture of 200 hPa Argon and various densities of Cesium ($1 \cdot 10^{15}\,\mathrm{cm}^{-3}$ to $5 \cdot 10^{16}\,\mathrm{cm}^{-3}$). Data for the laser wavelength of 349.15 nm are shown in Fig. 1. The measured values are fitted with a quadratic function in order to get an absorption coefficient for numeric modelling of the net gain. This absorption coefficient is

$$k(\lambda = 349.15\text{ nm}) = (1.54 \pm 0.2) \cdot 10^{-36}\text{ cm}^5 \cdot [\mathrm{Cs}]^2.$$

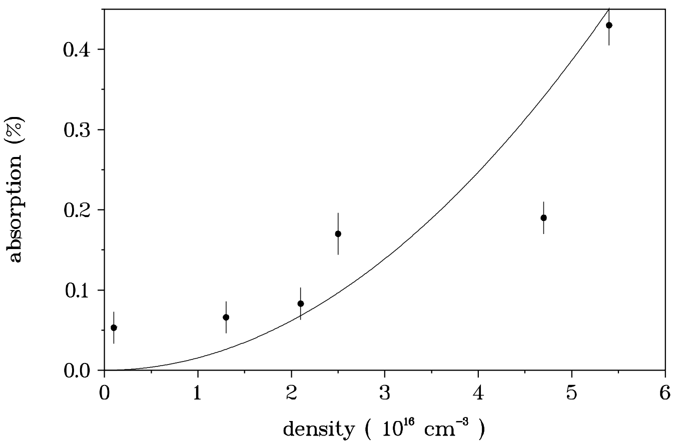

Fig. 1: Photoabsorption at 349.15 nm for a mixture of 200 hPa Argon and various Cesium densities. The error bars show the statistic error of the measurement. There is also a systematic error resulting from a limited reproducibility in preparing the cesium vapour.

As a cavity with optimized overlap between the pumped volume and the laser axis, a new setup for heavy ion beam pumped lasers has been developed. The ion beam was focussed to an elliptical beam spot. The laser axis was oriented along the long axis of the beam spot perpendicular to the ion beam axis. This geometry was successfully tested with a He-Ne-Ar laser [2] which was pumped by a 110 MeV ^{32}S beam from the Munich Tandem Accelerator.

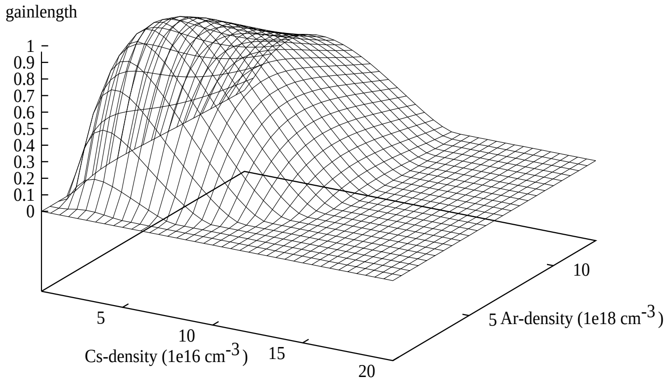

Fig. 2: Model calculation for the gainlength in Ar Cs pumped by 2 ns S-ion pulses (10^7 ions per pulse), as a function of Cs and Ar density.

A numerical model of the Ar Cs laser was developed using the measured absorption parameter of the Cs Ar mixture, rates of the charge transfer reactions, other kinetic reactions and transition possibilities. This model allows e.g. to determine the best mixing ratio of the two components and to estimate the gain in the laser medium. The gainlength of the Argon Cesium laser, pumped by 2ns-pulses of a Sulfur beam with 10^7 ions per pulse is shown in fig. 2. These conditions correspond to the conditions at the Munich Tandem Accelerator. With a newly preparated ion source, it should be possible to obtain a gainlength of 5 and to get above laser threshold.

References

[1] A. Ulrich, R. Gernhäuser, W. Krötz, J. Wieser, D. E. Murnick, Phys. Rev. **A50** (1994) 1931
[2] A.Ulrich, J. Wieser, A. Brunnhuber, W. Krötz, Appl. Phys. Lett. **64** (1994) 1902

◇This work was funded by BMBF: 06TM365/TP5 and NATO