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RESEARCH IN ROMANIA ON LASER INTERACTION WITH ALCALI ATOM ISOTOPES TO GENERATE THE UNIT OF TIME : A PROGRESS REPORT

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Abstract - **In context of the joining of Romania to the European Union, the practical realization of a national metrological system and its integration into the European metrological activity is becoming increasingly important. One of the goals of our research is the realization of an accurate time standard and the maintenance of a time scale compatible with the standards adopted internationally.**
Keywords **- atomic fountain, cold atoms, magneto-optical trap**

I. INTRODUCTION

An objective of the present project is the construction of an alkali atom fountain for the realization of the second. A first step towards this goal is the implementation of a laser-cooled magneto-optical trap, which will be used as the cold atom source for a future atomic fountain time standard. The paper describes the trap in some details and outlines our most recent results.
Medium-term objectives (4-6 years) are: Establish INFLPR as a modern Time/Frequency laboratory, equipped with a state-of-the-art frequency standard of its own construction and with the measuring equipment and techniques needed to compare it to standards in other countries.
Long-term objectives are: Contribution to the establishment of a modern metrological infrastructure in the key field of time and frequency.

II. MAGNETO-OPTICAL TRAP

This part includes the design and realization of a magneto-optical trap for cesium atoms (vacuum system, magnetic field compensation and magnetic gradient generation), preparation of optical parts to obtain the required six radiation beams (stabilized semi-conductor lasers, isolators, acousto-optic modulators and polarization control equipment). This implies in particular the realization of stable current source for the laser diode, realization of an extended-cavity for spectrum narrowing, and stabilization of the laser diodes that are used in cooling of the Cs atoms.
The schematic of our MOT is depicted in Fig.1 while a picture of the MOT is shown in Fig.2. The vacuum inside the trap is maintained by a 100 l/s ionic pump (HGZ100, Hochvakuum Dresden) and is of the order of 5 x 10^{-8} Torr (6.6 x 10^{-6} Pa). The MOT is realized by means of three orthogonal, retro-reflected, pairs of laser beams and of a uniform magnetic field gradient.

The cooling and detection laser beams pass into the MOT through the optical windows (1,2,3,4 in Fig.2). The source of Cs thermal atoms is realized in a so-called "cold finger" configuration and is attached to the MOT through a high vacuum valve.

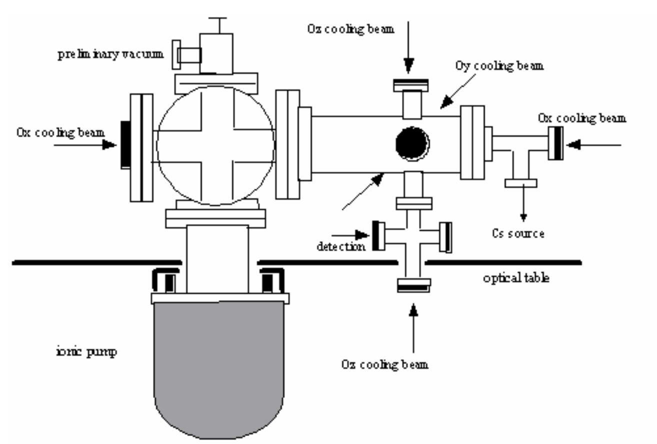

Fig.1 MOT design

Fig2 INFLPR MOT: (1,2,3)-cooling optical windows; (4)-detection optical windows; (5)-thermal atoms source

III. OPTICAL CONFIGURATON FOR LASER COOLING

The laser beams used in our MOT are prepared using an optical table whose schematic is shown in Fig.3. After passing through an acousto-optic modulator AOM, the radiation provided by the master laser is used to generate the detection beam and also the cooling beams, by injection in a slave laser. Another laser diode is used for generating the repuming beam. All the laser diodes are SDL type, at 852 nm, with a power of 150mW. The master and the repumping lasers are mounted in an extended cavity configuration. The lasers are stabilized by locking them to the appropriate frequency by means of the saturated absorption and Zeeman techniques. An acousto-optic modulator (at 80 MHz or 180 MHz) is used to shift the frequency to the appropriate resonances (Fig.3).

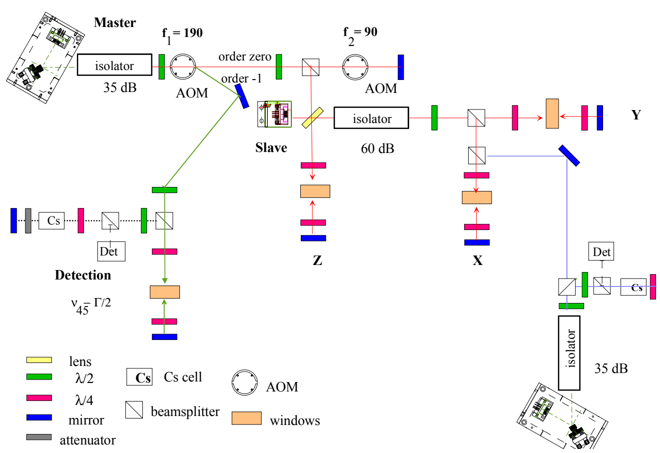

Fig. 3 Design of the optical table

The frequency of AOM are given by:

$$\nu_m = \nu_{45} - \frac{\Gamma}{2} + f_1$$

$$\nu_m + 2f_2 = \nu_{45} - 2.5\Gamma$$

where ν_m is master frequency, Γ is the detuning and f_1 and f_2 are the frequency of the AOM.
That give:

$f_1 = 90MHz$ and $f_2 = 190MHz$

IV. OPTICAL COMPONENT

All the optical parts were made in our laboratory. In the followings figures we show some of the components (extended cavity, mirror support, lens support, absorption cell).

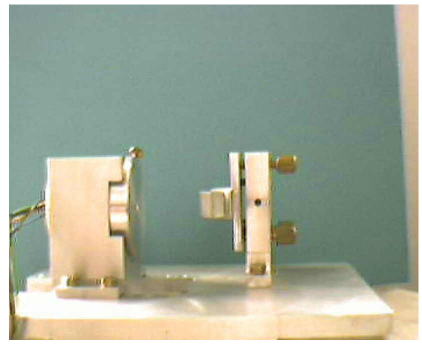

Fig. 4 Extended cavity

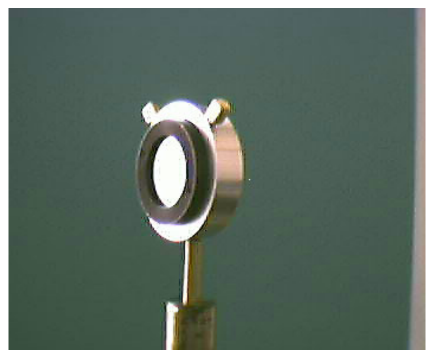

Fig.5 λ/2 (λ/4) support

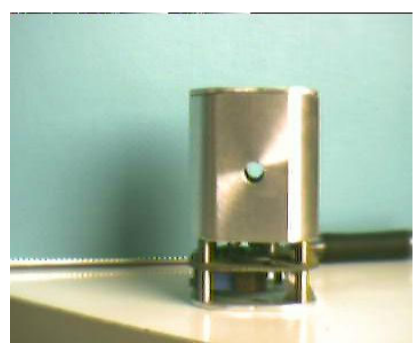

Fig.6 Absorption cell

The temperature of the cold atoms will be measured by means of the time of flight technique (TOF).

V. CONCLUSION

We have completed the first step of the construction of the cesium fountain. During the present year we intend to characterize the cold atom source (determination of the number of cold atoms and their temperature) and to start some studies in order to transform the MOT into an atomic fountain.

The realization of this program is made possible through a collaboration with the following institutions :

-Observatoire Cantonal de Neuchâtel, Switzerland

-Bureau National de Metrologie, SYRTE (formely Laboratoire Primaire du Temps et des Fréquences) Observatoire de Paris, France.

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