VNIIFTRI CESIUM FOUNTAIN

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1. ABSTRACT

The state of affairs with the development of the Russian cesium fountain is presented. Design of the physical parts, laser and optical system is briefly outlined. The features of the experimental equipment are as follows: The vacuum system has the melted windows, master and repumping laser are locked to the inverted picks and an alternative way of the F3 state is proposed. The very first results are MOT and molasses regime operation. The temperature is about 6 mK for MOT and 2 mK for molasses are reached.

2. INTRODUCTION

Russian State Time and Frequency Service relies on a group of H-masers and classical Cs-beam primary frequency standard. H-masers are used as time-keeper with a long term stability near 10^{-15}, while Cs standard is used for H-maser calibration and it has (2-3)*10^{-14} uncertainty.

We started our Cs fountain project in the spring 1999, minding to get uncertainty at least one order less.

3. EXPERIMENTAL LAYOUT

A layout of LPTF experimental set-up [1] was used to start a physical part design.

We have developed a titanium vacuum system, presented on Figure 1 a. There is a bottom section, consisting of two ion pumps, vacuum gauge and vacuum sleeve. It also has a window for the vertical laser beam. Ion pumps have 2 litre productivity. The vacuum sleeve is used for a baking-up the system with a powerful external vacuum pump.

The following two sections are molasses and detection zones. They are changeable and very similar in design, but molasses zone section has an additional vacuum flange for Cs reservoir.

The microwave cavity section and free flight section finish the vacuum chamber. All the windows are made of a fused silica. They have an antireflection coating and are melted into titanium. Graphite absorbers are inserted everywhere where it is possible. The photo of the assembled vacuum system is shown on Figure 1 b.

The vacuum system is surrounded by C-field coil, a permalloy screen, thermostat coil and another two magnetic screens. An optical mounting is placed around the whole system. The optical beams about 10 mm in diameter can be balanced and adjusted in polarization. These beams are formed by four telescopes. Single mode optical fiber is used to get a spatial filtering.

A laser system consists of the master and repumping laser and two injection ones. Master laser is frequency locked to an inverted pick in F4-F’5 transition [2] and the repumping one is locked to the inverted pick in F3-F’2 transition [2]. The inverted picks simplify the operation of an AFC and increase reliability.

AOM decrease the master laser frequency by 150-200 MHz and the frequency shifted signal is used to inject two slave lasers. Horizontal beams injected laser is shifted in frequency up by 140 MHz and vertical one by 140±d MHz, where d is determined by the height of atomic cloud flight. The frequency of the repumping laser before passing to the molasses region is shifted up by 152 MHz.

Frequency unshifted master and repumping laser beams are used to detect the states with F=4 and F=3 correspondingly.

To probe the microwave transition the specially designed H-maser is under development. It has enhanced storage bulb and it should have improved short-term stability. At present we have got 30 fold times increased output power of this H-maser.

All operation is computer controlled and operation software still in progress.

4. PRELIMINARY RESULTS

The vacuum system was baked a few days at temperature about 300°C. Then the cell with metallic Cs was broken and the system was pumped again at room temperature and cut off from a stationary vacuum post. After mounting the system on the optical table we opened a valve of Cs reservoir and baked the reservoir to a 70°C a few days. Only after this baking we had seen a fluorescence signal from a trapping area. The final vacuum in the pumping region is evaluated as 10^{-9} Torr.

We have started with the MOT. Temporary we put on coils on trapping area and we have got stable MOT operation with horizontal beam intensity from 1 till 0.2 mW/cm^2. The brightness of a cloud in the MOT was highest when laser frequency detuning from F4-F'5 transition was 7 MHz down and a gradient of a magnetic field was varied from 3 to about 0.7 G/cm.

Next step was to check operation in molasses mode. We put on one layer of the magnetic shield and we have got a molasses operation. Then we have made some experiments with measuring the temperature of the Cs cloud. To measure the temperature in case of the MOT we turned off the beam, then we turned off the coils and in the end we turned on postcooling beams for about 0.5 mS and turned the beams off. Time of flight and pulse width was measured and it is shown on Figure 2. The width of the pulse is the same for molasses and for the MOT. It means that the temperature in the MOT is evaluated as 6 mK and in the molasses the temperature is about 2 mK.

Now we should put the microwave cavity into the vacuum system.

5. CONCLUSION

We have got cold atoms, all system operates satisfactory and we hope to see microwave fringes by this winter. We relied on experience in PTB and LPTF. I had some advice and explanation from A.Clairon and I.Sortais from LPTF and I thank them a lot. I personally very thankful to all people from timing laboratory of PTB, especially to Drs A.Bauch, S.Weyer, when I spent a month to study their experience with the fountain.

G.A.Elkin – Physical part of fountain, probing signal, H-maser, A.V.Novoselov – Signal processing, computer control, software, fiber optics, L.N.Kopylov – All kinds of electronics, V.N.Baryshev – Laser and optical systems.

6. REFERENCES

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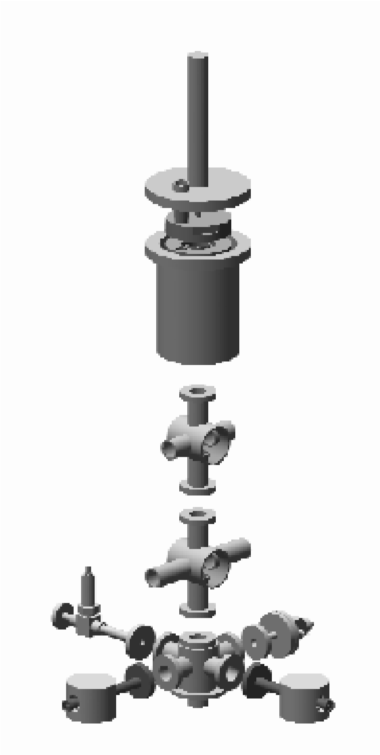
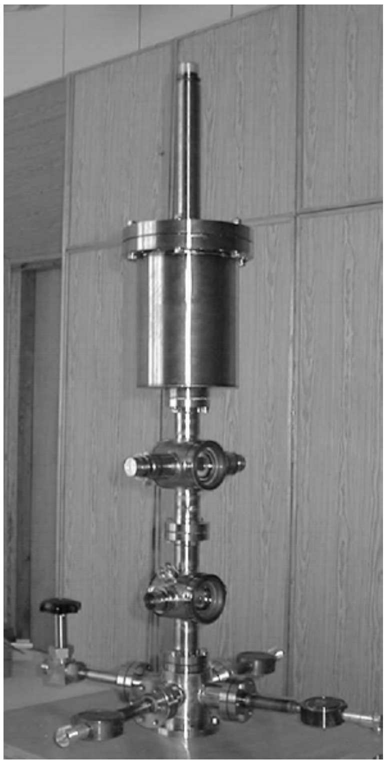


a



b

Figure 1.
Vacuum system.

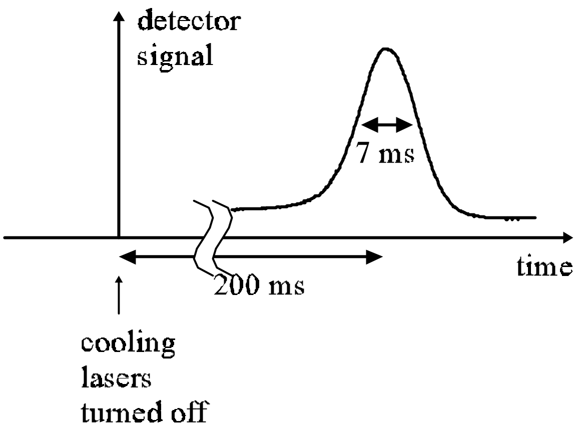


Figure 2.
TOF signal, atoms are cooled then dropped.