Improved Optical setup and electronic subsystems for reliable operation of NPLI-CsF1

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The NPLI-CsF1, designed and developed at CSIR-NPL, India [1] contributed towards calibration of the international Atomic Time (TAI) maintained by BIPM during its initial run in 2014-15[2]. It was not functional for many years due to various constraints. The fountain operation was revived recently and during its operation, it was found that the S/N of the clock needs improvement for better stability and long-term sustainable operation. With this goal, significant modifications have been made to the laser and optical configuration and various electronic subsystems such as microwave synthesizer, sequence controller, local oscillator and detection electronics. In this paper, modified optics and electronics schemes, preliminary Ramsey spectroscopy and stability results are presented.

The schematic of redesigned the optics setup is shown in Fig. 1. The cooling laser has an external cavity diode laser (ECDL) with tapered amplifier (TA). The seeding scheme of the TA has been changed to have better amplification and stable output power. For improving the output beam profile of the TA, a high-power optical fiber has been used to filter the TA output. Detection beams have been split right after TA output without any modulators/frequency shifters in their path in order to have stable detection powers. In addition, active power stabilization of detection beams has been implemented. For further improvement in stability of detection beams, liquid crystal-based modulators will be used to eliminate any remaining intensity noise.

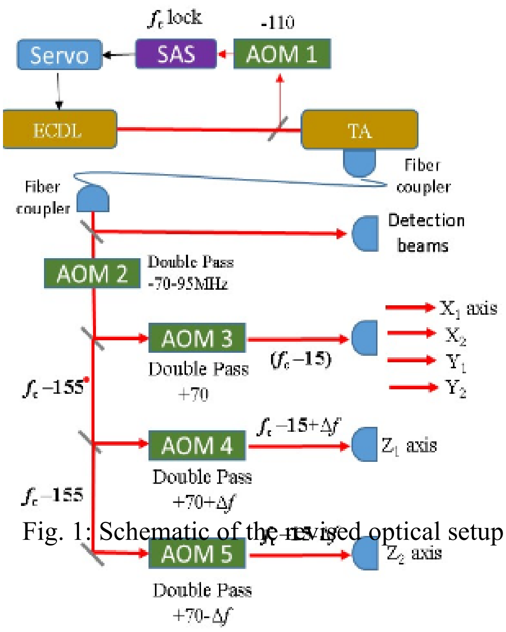

Fig. 1: Schematic of the revised optical setup

A precision microwave synthesizer is used to feed the microwaves to the Ramsey cavity and the state selection cavity. Frequency of 9.6 GHz YIG oscillator is divided to obtain 400 MHz which is mixed with 7.368230 MHz generated using a DDS. 9.6 GHz from YIG oscillator is mixed with 407.368230 in a microwave mixer board to obtain the Cs resonance frequency 9.192631770 GHz. The output is split into two for feeding the Ramsey as well as state selection cavity. During Ramsey spectroscopy, the DDS frequency is tuned to tune the microwave frequency. Since a single microwave mixer is used, the microwave to the state selection cavity also gets detuned which resulted in noise in the Ramsey spectroscopy signal al larger microwave frequency detuning. To improve the Ramsey spectroscopy, 407.368230 MHZ from an external synthesizer is being used to generate Cs resonance frequency for feeding the state-selection cavity resulting in a better Ramsey spectrum.

5 MHz from an OCXO is used as the external reference to the microwave synthesizer which is phase locked to an active Hydrogen maser (which is part of the Indian standard time generation chain). This is done to use the excellent low phase noise of oscilloquartz along with high stability of the AHM. The PLL circuit has been optimized to reduce the phase noise.

In addition to the reduction of the RF phase noise, the photodetector amplifier circuit used for atom fluorescence detection has been fine-tuned for lower dark current and the electronics assembly of the detection setup has been enclosed with a magnetic shield to avoid any 50 Hz noise pickup. Further, we are working to improve the schematic of the detection preamplifier circuits to remove any possible sources of noise in the detection electronics. With these improvisations we hope to have a reliable and sustainable operation of the fountain and relatively better S/N and the results of this exercise will be presented in this paper.

References:

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