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# The preliminary evaluation of the new fountain clock NIM6

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In this paper, we introduce the design of our new fountain clock NIM6. Besides some improvements on the vacuum system, Ramsey cavity to reduce the Type B uncertainty, NIM6 collects atoms from a MOT loading optical molasses to get a better signal to noise ratio. The atom density will be more uniform compared to a 2D MOT loading optical molasses, and the diameter of the cloud can be adjusted by the intensity and detuning of lights during the post cooling after MOT to keep the collisional shift low. Cs atoms are collected in the lower MOT chamber for 0.5 second, and then the MOT magnetic field is turned down. Atoms are accelerated for 1 ms in a moving molasses, and further cooled for another 1.5 ms by adiabatically reducing the cooling beam intensities and red offsetting the frequencies.

NIM6 is running at high and low densities against the H850 H-maser alternatively. Since a good short term instability of this H-maser, a 100 MHz signal from a crystal oscillator locked to the H850 with a time constant of about 10 ms. Typical relative frequency instabilities are shown in figure 1. The black squares and red dots denote the instabilities of NIM6 operated at high and low densities respectively. It shows that the relative frequency instabilities are $1.0\times10^{-13}\,(\tau/s)^{-1/2}$ and $1.1\times10^{-13}\,(\tau/s)^{-1/2}$ for the high and low densities, respectively for averaging time less than 1000 seconds.

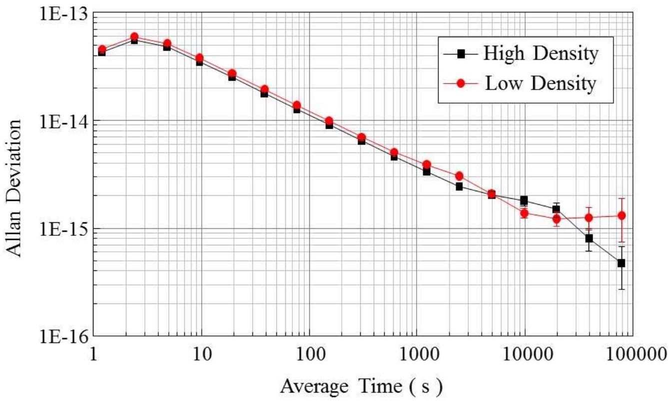


**Figure 1.** Standard Allan deviation $\sigma y(\tau)$ of NIM6 measured against the H850 H-maser over the period from Sep. 17th – 25th, 2018. The black squares and red dots denote stabilities at high and low atom densities respectively.

The uncertainties due to 2nd-order Zeeman shift and Black body radiations are reduced to less than $1\times10^{-16}$ because of a more stable and uniform C-field distribution and temperature distribution. The cold atom collisional frequency shift is reduced to $1\times10^{-16}$ due to a higher atomic number ratio between high and low densities. The microwave power related frequency shifts are under evaluating and will be finished soon. A new cryogenic sapphire oscillator (CSO) based frequency synthesizer [1] and ultra-stable microwave generated from ultra-stable laser [2] are also under developing to reduce the phase noise in order to reach the quantum projection noise, thus leading to a lower Type A uncertainty of this new fountain.

1. J. G. Hartnett, C. R. Locke, E. N. Ivanov, and et al, "Cryogenic sapphire oscillator with exceptionally high long-term frequency stability", *Appl. Phys. Lett.* **89**, 2006, 203513, https://doi.org/10.1063/1.2387969.

2. S. Dai, F. Fang, S. Cao, and et al, "The ultra-stable microwave based on ultra-stable laser", *SPIE/CIOP,* 2018, 10964-133, to be published.