Comparison between Two Ytterbium Optical Lattice Clocks

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Extended Abstract

At present, both instability and uncertainty of the optical lattice clocks are better than that of the cesium fountain clocks which represent the definition of the second [1-3]. Among them, the ytterbium optical lattice clock seems to be one of promising candidates for the next-generation frequency standards. Therefore, the two ytterbium optical lattice clocks have been developed in the East China Normal University, China. The experimental procedures are described as following. At first, the ytterbium atomic beam is collimated by two-dimensional laser cooling in transvers directions. Then the collimated atomic beam is decelerated along the longitudinal direction. After the slowed atoms move into the region of the magneto-optical traps (MOTs), the ytterbium atoms are cooled continuously by using the cooling lasers of 399 nm and 556 nm respectively. At the end, the temperature of the cold ^{171}Yb atoms in the 556-nm MOT is about 10 μK, and the number of atoms is about a few millions. After finishing the cooling stage, the cold ^{171}Yb atoms are loaded into a one-dimensional optical lattice constructed by the laser with the magic wavelength of 759 nm. When the cold ^{171}Yb atoms are trapped in the lattice, they are excited by the 578-nm clock laser, then they are detected by the 399-nm laser with the help of two pumping lasers of 649 nm and 770 nm. After optimizing all experimental parameters, the linewidth of the clock-transition spectrum of the ^{171}Yb atoms is reduced down to about 6 Hz [4]. Then the frequency of the 578-nm clock laser is locked in this narrow-linewidth clock transition. In order to eliminate the first-order Zeeman shift, the 578-nm clock laser can be locked by using two-peak locking method. In this case, the ^{171}Yb atoms are excited by the π-polarization 578-nm clock laser with a magnetic field applied along the polarization direction of the 578-nm laser. By comparing the frequencies of two ^{171}Yb optical clocks, the instability of the ^{171}Yb clock is measured experimentally. The results show that the clock's instability is at level of E-17 for the averaging time of a few thousands of seconds [5], which is limited by the clock laser in this moment. Currently, the experiments on both evaluating uncertainty of the ^{171}Yb optical lattice clock and developing the new clock lasers are going on.

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