Coherent Population Trapped Spectrum Based on External Cavity Diode Laser Chip

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Abstract:

This article reports a scheme for obtaining coherent population trapping (CPT) spectrum based on a chip-scale external cavity diode laser (CECDL). The CPT spectrum linewidth is 680Hz. Compared to the scheme using vertical cavity surface emitting laser (VCSEL), CECDL has a comparable small volume and higher laser power of 14mW and narrower linewidth of 270kHz. This is beneficial for improving the stability performance of CPT chip-scale atomic clocks.

Introduction

The coupling of two ground states to a common excited state by means of two coherent radiations leads to interference effects in the excitation process, a phenomenon that has been called coherent population trapping (CPT) [1]. The laser source commonly used in CPT chip-scale atomic clocks is VCSEL [2]. But its linewidth is wide, usually~several 10MHz. Compared to the VCSEL, the linewidth of external cavity diode lasers is usually narrower in the 100 kHz level. However, traditional external cavity lasers usually have large size and limited modulation bandwidth, making it difficult to be used for CPT chip-scale atomic clocks.

Experimental setup and results

For this experiment, we utilize a CECDL weighing 4.062g and having a volume of 0.896cm³, with a modulation bandwidth of 4.6GHz. ^{87}Rb atoms are filled into a cube vapor cell with a volume of 0.216cm³. Firstly, lock the wavelength at 794.977nm by adjusting the current and temperature of CECDL.Next, turn on the microwave signal scanning and apply microwave modulation to the CECDL through a bias-tee module. The frequency of microwave signal is 3.417GHz. By fine-tuning the microwave intensity and frequency, coherent population trapping (CPT) spectrum can be observed. We optimized the structure of temperature controler and magnetic field of the vapor cell. Finally, the obtained CPT linewidth is 680Hz. The compact external cavity laser we used in the experiment has a linewidth of 270kHz, which is two levels narrower than VCSEL. In the experiment, the laser beam was expanded to allow Rb atoms to fully interact with laser. The CPT spectrum are shown in Figure 1. Due to the measurement of data is in Alternating Current mode, the spectrum is asymmetric.

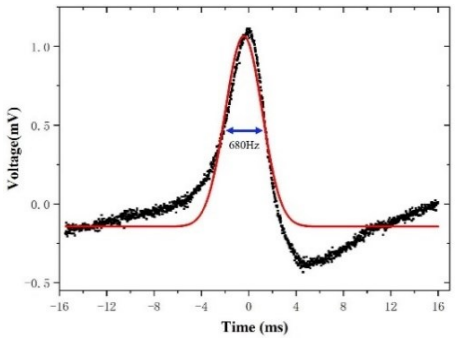

Fig. 1: Coherent population trapping spectrum obtained by chip-scale external cavity laser.

Conclusions

This article proposes a new scheme for obtaining CPT spectrum using a chip-scale external cavity diode laser. The linewidth of CPT spectrum is 680Hz, which is basically consistent with the test results by VCSEL. However, the linewidth of the external cavity laser is narrower, which is beneficial for increasing the signal to noise ratio of the CPT clock. The results of this experiment will contribute to achieve a more stable CPT chip-scale atomic clock.

References

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