ABSOLUTE FREQUENCY MEASUREMENT OF THE CESIUM D_2 LINE

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Abstract

We describe a scheme of absolute frequency measurement of the cesium-stabilized diode laser at 852 nm based on the absolute frequency standard of ^{87}Rb at 780 nm and well stabilized CO_2 laser at 9.23 μm. The frequency of the CO_2 laser is stabilized to the center of the 4.3-μm saturated fluorescence with frequency instability of 5 kHz. Two diode lasers are stabilized to the center of D_2 saturated absorption line of Cs at 852nm and to the center of D_2 line of ^{87}Rb at 780nm with accuracy about 30 kHz, respectively. The sum frequency of the 852 nm and 9.23 μm radiation is beated against the 780 nm radiation to obtain the absolute frequency of the Cs D_2 line. The sum-frequency generation and beat frequency experiment will be finished in the near future and reported in the conference.

Background

Direct frequency measurement of the near infrared radiation is very useful in many applications, especially in the fields of precise spectroscopy and frequency calibration of the tunable difference frequency generation IR source. But only the $5S_{1/2}$-$5D_{3/2,5/2}$ two-photon absorption of ^{85}Rb at 778 nm [1], the D_2 lines of ^{87}Rb at 780 nm [2] and some I_2 hyperfine spectral lines near 790 nm [3] are the absolute frequency standards in the near infrared. By focusing a stabilized CO_2 laser radiation and a stabilized diode laser radiation at 852 nm into a nonlinear crystal such as $AgGaS_2$, a sum-frequency radiation near 780 nm can be obtained [4]. Therefore, the frequency of the 852 nm laser can be measured by heterodyning with a stabilized diode laser radiation at 780 nm. So the frequency of D_2 line of Cs at 852 nm can be measured precisely. And also the absolute frequencies of some iodine hyperfine lines in the range from 840nm to 860nm can be measured accurately.

Experimental Setup

The scheme of the absolute frequency measurement of the Cesium-stabilized diode laser is shown in Fig. 1. The frequency of CO_2 line is stabilized to the center of the 4.3-μm saturated fluorescence. Its frequency instability is less than 5 kHz. The diode laser 1 is stabilized to the center of D_2 saturated absorption line of Cs at 852 nm. The diode laser 2 is stabilized to the center of D_2 line of ^{87}Rb with an external cell at the ambient temperature. The output of the diode laser 1 focused by a BK7 lens and the output of CO_2 laser focused by a ZnSe lens are coupled by a Pyrex beam splitter. The nonlinear crystal $AgGaS_2$ is used with type I phase match at room temperature. In order to avoid damaging the avalanche photodiode, the residual CO_2 laser is absorbed by a sapphire plate and a bandpass interference filter at 780 nm is used to filter out the 852 nm radiation.

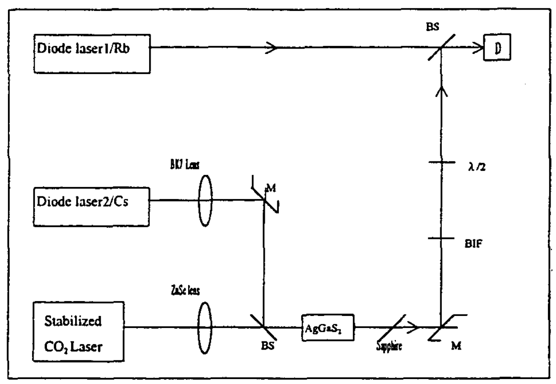

Fig.1 Experimental setup for the absolute frequency measurement of the Cs D_2 line at 852nm. BS: beam splitter; Here, M: mirror; BIF: bandpass interference filter; D: avalanche photodiode. The outputs of all lasers are linearly polarized vertically and the sum-frequency radiation is polarized horizontally.

Results

Both diode lasers are stabilized to the center of the saturated absorption spectrum using the third-harmonic demodulation method. The Rb cell is at the ambient temperature and Cs cell at 11 °C. The pump beam size is about 3.5 mm in diameter and the probe beam size is about 1.2 mm in diameter; the angle between these two beams is about 1 mrad. By the third harmonic technique we carefully studied the properties of the hyperfine lines

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of Cs and Rb vapors via pump power, probe power and modulation width. The signal strength and S/N ratio of the d-f crossover line and its modulation broadening for Rb atom are shown in Fig. 2 and Fig. 3.

For the cesium-stabilized and rubidium-stabilized diode lasers, the S/N ratio are about 2000 and about 800, respectively, and the frequency instabilities are less than 30 kHz for the d-f crossover line. The other lines such as b, b-d crossover, d, and b-f crossover lines are also studied carefully.

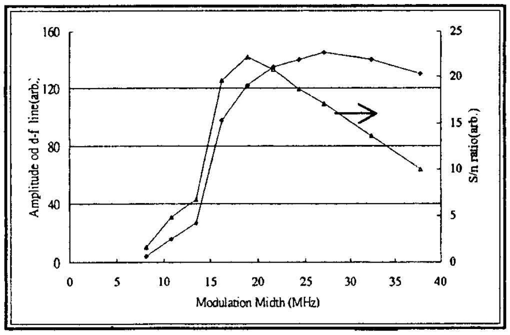

Fig. 2 Signal strength and S/N ratio of the d-f crossover line vs. modulation width. Here, pump power: 70 μW; probe power: 8 μW; temperature: 11 °C; modulation frequency: 9.8 kHz.

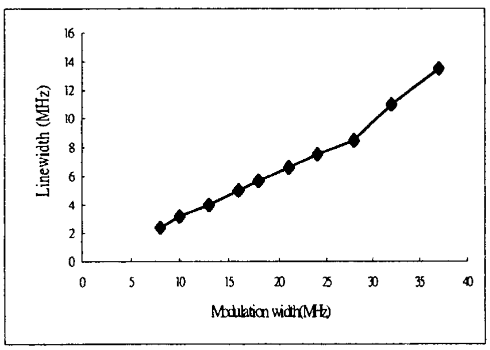

Fig. 3 Modulation broadening of the d-f crossover line. Here, pump power: 70 μW; probe power: 8 μW; temperature: 11 °C; modulation frequency: 9.8 kHz.

It is important to pay more attention to the frequency shift caused by the static magnetic field in the laboratory. To eliminate the Zeeman effect caused by the static magnetic field, both the Cs and Rb cells are carefully shielded with the mu-metal and the remained magnetic field is less than 0.002 Gauss.

The beat frequency experiment is now underway and the final results will be presented in this conference.

References

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