Influence Of Magnetic-Field Gradient On The Magneto-Optical Resonance Signal Linewidth With Anti-relaxation-coated Cells

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I. ABSTRACT

In this work, we experimentally measure the broadened linewidth of magneto-optical resonance signal due to magnetic-field gradient with an alkali buffer-gas-free anti-relaxation-coated cell. We also study how the temperature of the atomic vapor cell affects the magneto-optical resonance signal linewidth under different magnetic-field gradients. Theoretical calculations show that the relaxation caused by magnetic-field gradient could be suppressed with increased temperature, which could be useful to optimize the working parameters for unshielded atomic magnetometer based on anti-relaxation-coated cells.

II. MOTIVATION

A dominant advantage of a buffer-gas-free anti-relaxation-coated cell is that the atomic polarization could collide with the cell walls for thousands of times without depolarization , and thus the effect of magnetic-field gradient should be averaged to some degree due to the motional narrowing. However, previous work shows that, for an anti-relaxation-coated atomic vapor cell, the magnetic-field gradient is still positively correlated to the relaxation . Based on this, our goal is to extend and develop this model, i.e., by considering the contributions which are neglected in this model, for example, the bias magnetic field and higher-order magnetic-field gradients, and experimentally verify the validity of our developed model. This could provide a general guidance on how to obtain the optimal parameters for an anti-relaxation-coated vapor cell and could be useful for applications of the atomic magnetometer in practical unshielded magnetic-field environments.

III. RESULT

Figure 1 compares the measured linewidth of the magneto-optical resonance signal under two conditions with different magnetic-field gradients. Under almost the same bias magnetic field, the linewidth measured with a larger magnetic-field gradient (top figure) is an order of magnitude larger than that measured with a smaller magnetic-field gradient (bottom figure). Such a broadening effect can be well explained with previous theoretical model. We notice that there still exist some additional broadening effects that are not included in this model and should be considered, in order to fully describe the magnetic-field gradient induced relaxation effect and improve the magnetic-field measurement sensitivity. A broadened linewidth in turn degrades the magnetic-field sensitivity of the atomic magnetometer, see Fig. 2. Besides, the factors such as the size of the cell, the temperature should as well be considered altogether. We plot the dependence of the magnetic-field gradient induced relaxation rate with different temperature, which is shown in Fig. 3. The temperature is one of the crucial parameters that determine the magnetic-field sensitivity of the alkali-metal atomic magnetometers. It is shown that, with increased temperature, the relaxation rate caused by magnetic-field gradient could be suppressed.

IV. FIGURES

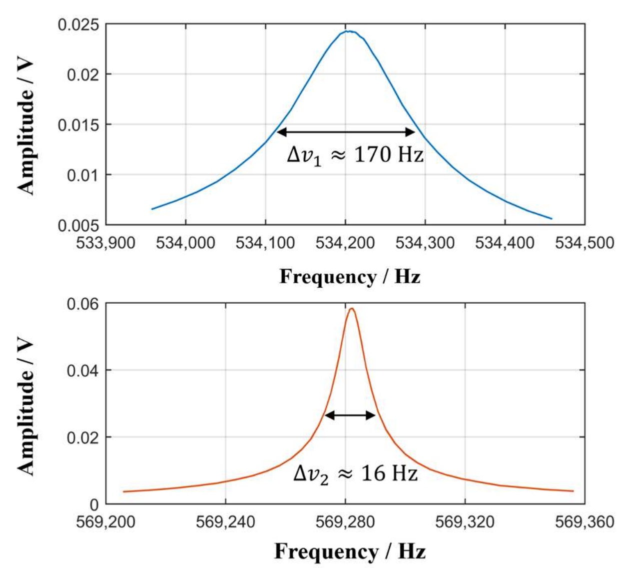

Fig.1. Magneto-optical resonance signals measured under large (top) and small (bottom) magnetic-field gradients.

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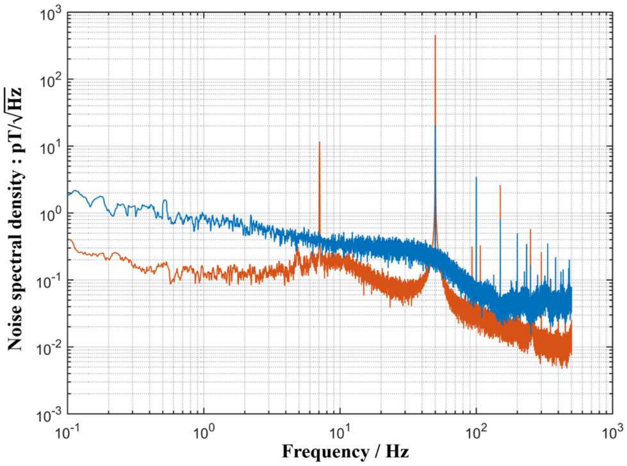

Fig.2. Magnetic-field noise floor measured under large (blue) and small (orange) magnetic-field gradients.

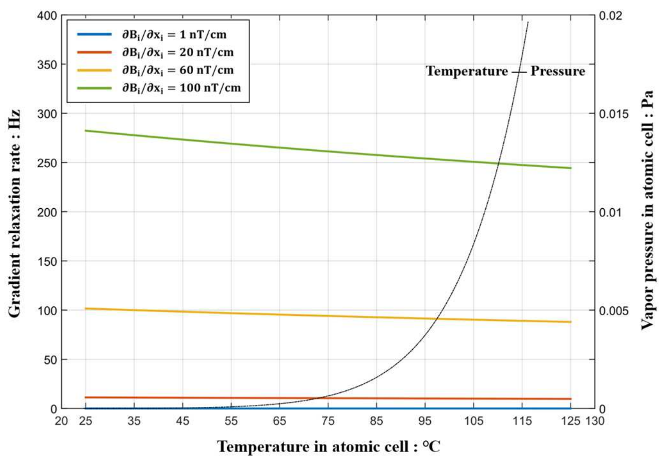

Fig.3. Theoretical calculations for the dependence of the magnetic-field gradient induced relaxation rate with different temperature.

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