Study on variation of light intensity spatial distribution of the rubidium spectral lamp

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The rubidium (Rb) spectral lamp (or rf-discharge lamp) used for optical pumping is a crucial component for the rubidium atomic frequency standard (RAFS). The pumping light creates the unavoidable ac-Stark shift (or light shift) [1]during the double-resonance interrogation, the variation of which is one of the major factors affecting RAFS's long-term frequency performance [2,3]. Currently, most attention is paid on suppressing the lamp's intensity-induced light shift. The effective solution is to optimize the vapor cell's operating temperature to the zero light shift point[4], where RAFS's output frequency is insensitive to the light power fluctuation. However, another possibility is that the variation (including fluctuation and aging) of the lamp's light intensity spatial distribution would result in RAFS's output frequency instability and drift via the inhomogeneous light shift[5] effect. And this kind of mechanism for RAFS's long-term performance deterioration sourced from inhomogeneous light shift is often overlooked.

In order to verify our hypothesis, we measured the Rb lamp's light intensity spatial distribution. The experiment setup shown in fig.1 is composed of a rubidium spectral lamp and two photo detectors installed in an oven-controlled metal cavity. The two detectors monitor the intensities of lamp's light in two separated areas. The ratio of the two detected intensities is used for indicating the stability of light intensity spatial distribution. The preliminary results in Fig.2 a and b, clearly show that the intensity ratio is dependent on both the temperature of lamp's bulb and rf-excitation circuit parameters of the lamp, which might be a factor that affects the long-term frequency stability of the RAFS. Further investigation results will be presented on the meeting.

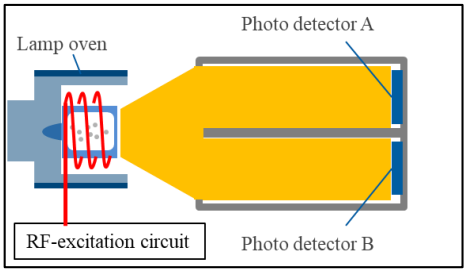

Fig.1 Schematic diagram of the experiment setup. The rubidium spectral lamp is a homemade one.

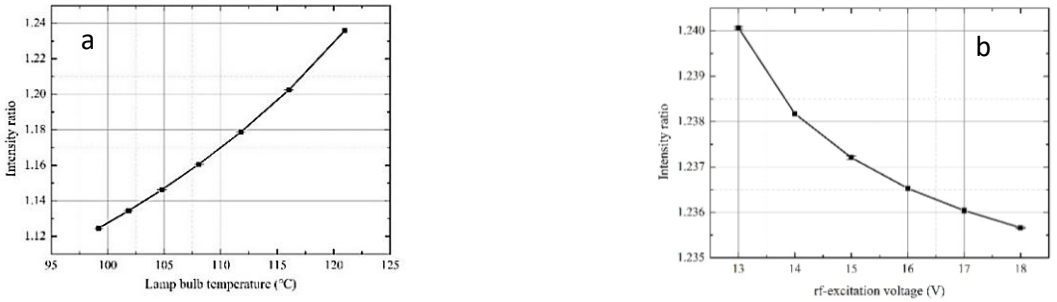

Fig.2 Intensity ratio as a function of lamp bulb temperature (a) and rf-excitation voltage (b).

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