A loop-gap cavity with side-apertures for symmetric loading of a vapor cell in optically pumped Rb frequency standards

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A vapor cell based on glass-blowing technology naturally comes with a stem, which is a remaining part of a tubing sealed after injection of metals and buffer gas. Since it can also work as a cold reservoir for metallic source of Alkali vapor, the stem is often exposed out of the microwave cavity[1]. In most cases, the stem sticks out through one of the apertures along the longitudinal direction which leads to asymmetric loading of the vapor cell[2].

Recently we demonstrated a loop-gap cavity which is carefully designed to allow apertures on the side for laser cooling while maintaining a reasonable level of quality factor[3]. Here we introduce a similar approach to build a vapor cell atomic clock with a symmetrically loaded Rb cell in the cavity. We designed a cavity with side-apertures of 7 mm in diameter, and the measured quality factor exceeds 100 while a vapor cell with straight stems is loaded at the center of the cavity. A clock system using this cavity has been built in the continuous-optical-pumping configuration and a double-resonance spectrum with 271 Hz of linewidth was observed.

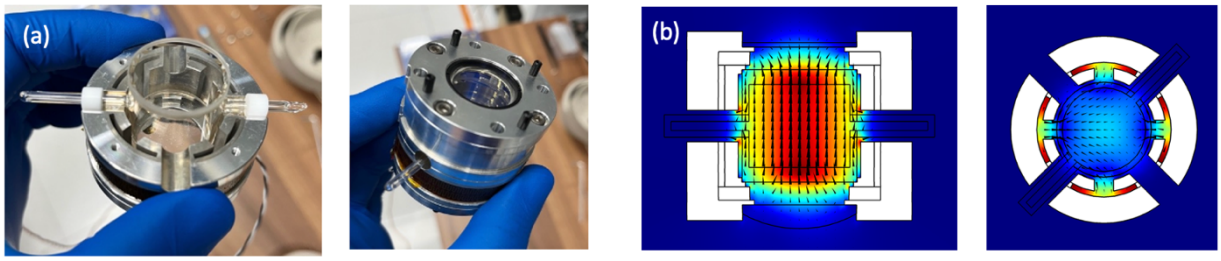

Fig. 1: (a) A microwave cavity holding a vapor cell with two straight stems. The cavity has four apertures on the side and is comprised of two aluminum parts encompassing a vapor cell. (b) The field distribution of resonant microwave mode calculated numerically by a finite element method.

[1] C. Stefanucci et al., "Compact microwave cavity for high performance rubidium frequency standards", Rev. Sci. Instrum., vol. 83, p. 104706, 2012.

[2] M. Gozzelino et al., "Loaded Microwave Cavity for Compact Vapor-Cell Clocks", IEEE Trans. Ultrason. Ferroelectr. Freq. Control, vol. 68, p. 872-879, 2021.

[3] S. Lee et al., "A compact cold-atom clock based on a loop-gap cavity", Appl. Phys. Lett., vol. 119, p. 064002, 2021.