Kr-N_2: a low-shift buffer-gas mixture for Rb vapor-cell clocks

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In the field of vapor-cell clocks a buffer gas is added to increase the coherence time of the alkali's hyperfine clock transition. Unfortunately, the buffer gas introduces a mean shift on the transition that is a function of temperature, thus increasing the environmental sensitivity of the clock. A mixture of Ar-N_2 is commonly used for Rb clocks to null the linear temperature coefficient, mitigating this effect. However, a large absolute shift of a few kHz is still present, resulting in large sensitivity to environmental-pressure and temperature-gradients fluctuations. To tackle this issue, we investigated a mixture of Kr and N_2. Given the properties of these two atomic species, it is possible to find a pressure ratio that nulls both the linear temperature coefficient and the absolute shift on the clock transition, around the temperature of operation (about 330 K). This is demonstrated in Fig. 1.
The effects of this novel mixture in terms of clock performances is experimentally analyzed on our Pulsed Optically Pumped (POP) clock testbed [1,2]. Possible improvements on the buffer-gas mixture are also discussed.

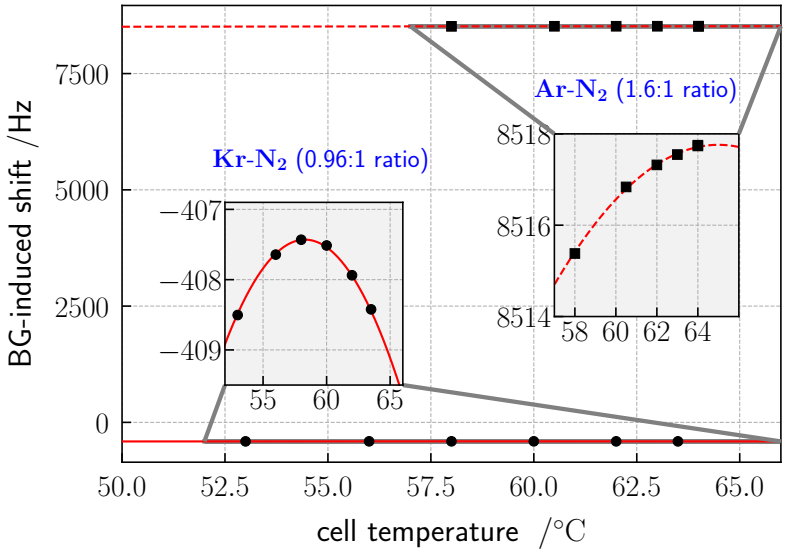

Figure 1. Absolute frequency shift induced by the buffer gas with respect to the unperturbed ^{87}Rb clock transition for the two buffer gas mixtures described in the text. The insets show a zoom of the frequency measurement around the inversion point, highlighting the quadratic behavior.

[1] M. Gozzelino, S. Micalizio, C. E. Calosso, A. Godone, and F. Levi, "Kr-based buffer gas for Rb vapor-cell clocks," IEEE Trans. Ultrason., Ferroelectr., Freq. Control (2020).
[2] S. Micalizio, C. E. Calosso, A. Godone, and F. Levi, "Metrological characterization of the pulsed Rb clock with optical detection," Metrologia, **49**(4), 425 (2012).