Absorption ^{87}Rb Cells with Anti-Relaxation Wall Coating with the Ultimately Low TFC Near to the Zero Value for Supporting a High Long-Term Stability of Frequency Standards

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In resent years the interest was revived with respect to creating the Rb cells (^{87}Rb) of small dimensions with anti-relaxation wall (ARW) coating for using those in frequency standards [1]. There is an evident advantage of absorption ^{87}Rb cells with ARW coating compared to the cells with buffer gases - higher (5÷8 times) SNR and lower (5÷8 times) width of $\Delta\nu_{0\text{-}0}$ resonance line [2,3]. For supporting a high long-term frequency stability of frequency standards, the cells are required with a low value of the temperature-frequency coefficient (TFC). When selection an optical regime for ^{87}Rb cells with ARW coating, one can detect a temperature region with the ultimately low TFC near to the zero value.

The following investigation results are presented in this work.

I. ^{87}Rb-cells with ARW-coating (dotriacontan, $C_{32}H_{66}$), cylindrical [20x20 (Ø,ℓ) mm], investigated temperature range is 40°÷68°C.

1.1 The lowest resonance line width, $\Delta\nu_{0\text{-}0}$, was ~ 60 Hz within a temperature range t^0 ~ 60°C.

1.2 The dependence of the resonance frequency on the cell temperature change, $\nu_{0\text{-}0}$ (t°C), has shown that, with increasing a temperature over a range of 40°÷56°C, a resonance frequency, $\nu_{0\text{-}0}$, increased linearly. With further temperature increase, an extremum (point of inflection) is observed over a non-linear segment of $\nu_{0\text{-}0}$ (t°C) dependence in the vicinity of t°~ 61(+1)°C. The $\nu_{0\text{-}0}$ value in the inflection point was 6 834 682 410 Hz ($|\nu_{0\text{-}0}|$ = 6 834 682 610,9 Hz). When the temperature increase exceeded ~ 62°C, the resonance frequency, $\nu_{0\text{-}0}$, decreased.

1.3 The length of the inflection region is estimated at the $\Delta t°$ ~ 0.5 t°C level. TFC within this ($\Delta t°$~ 0.5 t°C) region is ultimately low and can be fully realized technically at the level of $< 2\cdot10^{-13}$/grad in the vicinity of t* ~ 61°C temperature.

II. The ^{87}Rb cells with ARW coating of 25x25- dimensions and minimum width resonance have shown the analogous inflection in a temperature region of t° ~ 59 (+1) °C, in which vicinity the analogous inflection took place on $\nu_{0\text{-}0}$ (t°C).

III. When adding a buffer gas (^{20}Ne, ^{40}Ar,..) with a pressure of order of Torr units into a cell with ARW coating, a decrease in the inflection point temperature is observed compared to the cell without the buffer gas. The creation of ^{87}Rb cells with two anti-relaxation heterogeneous components (coating + buffer gas) needs careful investigations which are currently performed.

CONCLUSIONS

^{87}Rb cells with ARW coating have an operating temperature region with the ultimately low TFC near to the zero value and allow, using this parameter, to support a high long-term frequency stability of atomic standards and quantum magnetometers.

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