“SUPPLEMENTAL MATERIAL to”

Study of cesium atomic transitions in strong magnetic fields with use of a half-wavelength-thick cell

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Hyperfine spectra of Cs D_2 line transitions for zero magnetic field consist of two groups shown in Fig.1: group of atomic transitions Fg=3→Fe=2,3,4 (with frequency separation 151 MHz and 201.5 MHz) and group of atomic transitions Fg=4→Fe=3,4,5 with frequency separation 201.5 MHz and 251 MHz). The Doppler broadening of each atomic transition is ≈400 MHz, that’s why inside absorption spectrum for a usual 0.1 - 3 cm-long Cs cell (at a room temperature) these transitions are not resolved .Use of the nanometric- thin cell (NTC) , with L=λ/2 thickness, due to the effect of the spectral narrowing allows one to resolve 6 hyperfine atomic transitions. The experimental profile of the absorption line is best approximated by the curve which is described by the “pseudo-Voigt” function (the “Origin-8” program).

When a strong magnetic field is applied to Cs NTC, there is splitting and shift of Cs D_2 line energy levels. That’s why new atomic transitions appeared. In Fig.2 absorption spectrum of the Cs NTC with L=λ/2, for circular σ^- laser excitation and B=6.1 kG is shown. In the case of hyperfine Paschen-Back (HPB) regime there are two groups and each group contains 8 atomic transitions: 1-st group transitions labeled 1′-8′ belongs to $6S_{1/2}$, m_J=-1/2 → $6P_{3/2}$, m_J =-3/2 transitions, while 2-nd group transitions 9′-16′ belongs to $6S_{1/2}$, m_J= +1/2 → $6P_{3/2}$, m_J =-1/2 (see Fig.3). The frequencies of all 16 transitions are below the frequency of F_g=4→F_e=3 transition.

It is well known that a radiation with linear polarization in the case of a longitudinal magnetic field could be considered as a sum of two radiations with circular σ^+ and σ^- polarizations. In Fig.4 absorption spectrum of the Cs NTC with L=λ/2, for linear polarization excitation and B=6.1 kG is shown. There are 16 atomic transitions both for σ^+ and σ^- excitations. It is interesting to note that from Fig.4 it is seen that the ratio of the amplitudes for atomic transitions in the case of σ^+ excitation A(*9-16*) / A(*1-8*) ≈3 , meanwhile in the case of σ^- excitation A(*1′-8′*) / A (*9′-16′*) ≈3 [for the groups *1-8* and *1′-8′* the initial level is (Fg=3) and for the groups *9-16* and *9′-16′* the initial level is (Fg=4)]. This is confirmed also by the theory.

Thus, λ/2-method is a convenient tool for quantitative study of atomic transitions in magnetic fields.

Figure Captions

Fig.1 Absorption spectra of Cs D_2 line obtained with NTC of L=λ/2. They consist of two groups: atomic transitions Fg=3→Fe=2,3,4 and atomic transitions Fg=4→Fe=3,4,5. All six transitions are partially resolved, meanwhile in a usual Cs cell of cm-size they are not resolved at all.

Fig.2 Absorption spectrum of the Cs NTC with L=λ/2, *B*=6.1 kG, for circular σ^- laser excitation. All sixteen atomic transitions are well resolved and are located below Fg=4→Fe=3 transition.

Fig.3. Diagram of the Cs D_2 line atomic transitions for σ^- laser excitation for the case of HPB regime. The selection rules for the atomic transitions are $\Delta m_J = -1$; $\Delta m_I = 0$. It should be 16 atomic transitions. Ground levels (Fg=3) and (Fg=4) for $B \gg B_0$ contain by 8 sublevels.

Fig.4 Absorption spectrum of Cs NTC with L=λ/2, *B*=6.1 kG, for linear laser excitation. All 32 atomic transitions are well resolved .16 transitions (for σ^+ excitation) are located above Fg=3→Fe=4 ,while another 16 transitions (for σ^- excitation) are located below Fg=4→Fe=3 transition.

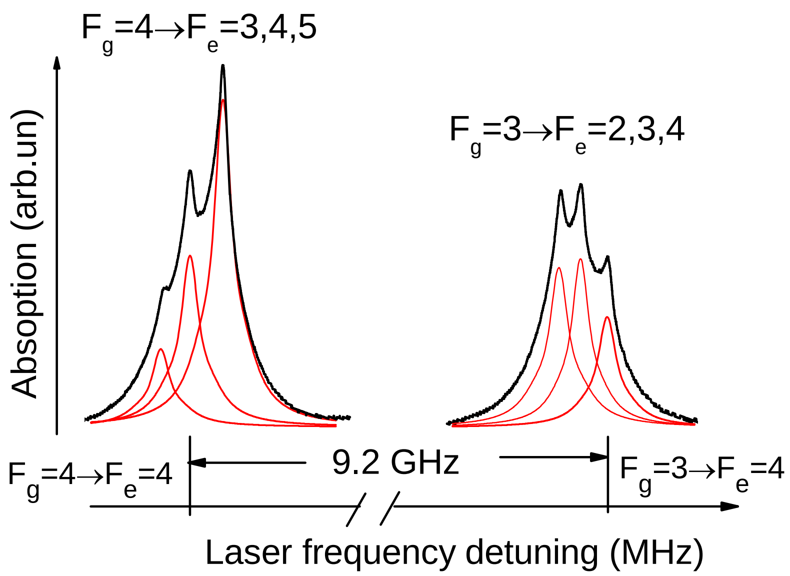

Fig.1 Supplementary

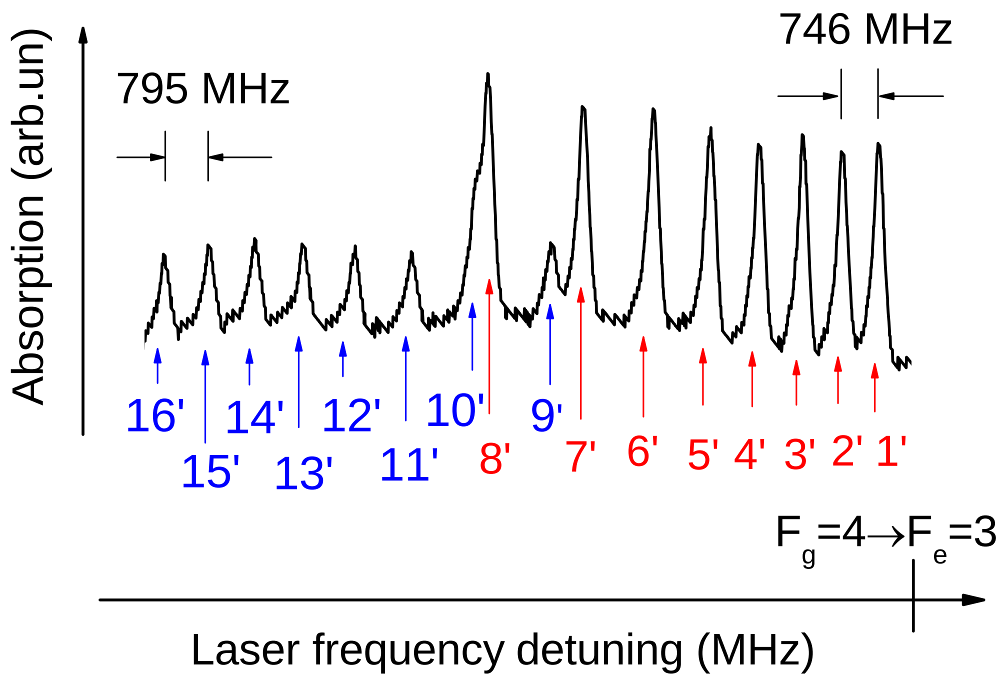

Fig.2 Supplementary

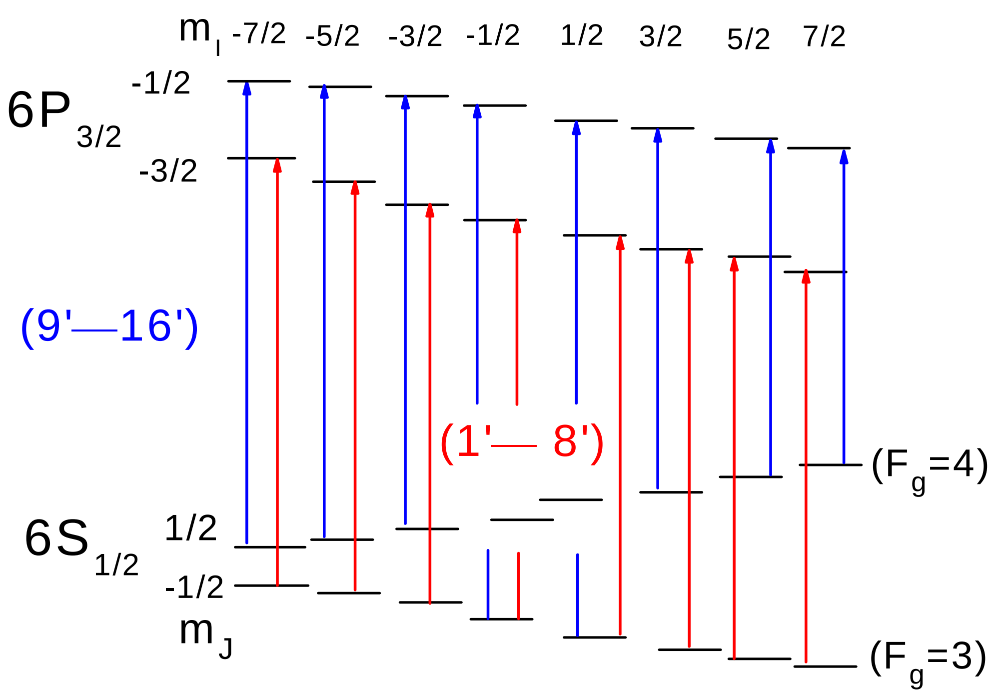

Fig.3 Supplementary

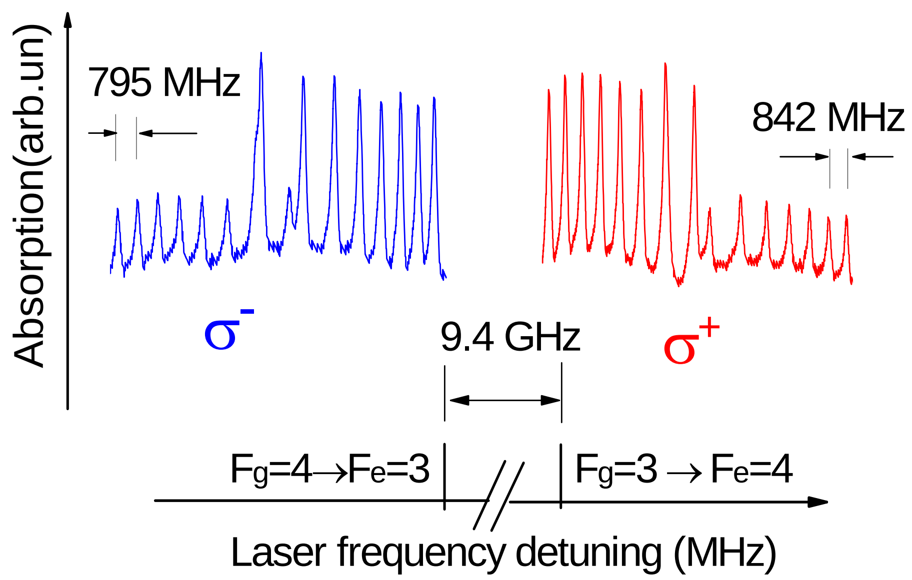

Fig.4 Supplementary