Compton rotation in strong magnetic field in tree approximation

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The research is done according to the suggestion of V.G. Baryshevsky and V.V. Tikhomirov. Applying the method of [1] with tree approximation, we consider the angle of Compton rotation [2, p. 91] of photon's plane of polarization per unit path in totally polarized degenerate electron gas (m is the electron mass) on photon's energy $\hbar\omega$, electron density n_e, magnetic field strength $\vec{B}$. The angle between the wave vector of photon $\vec{k}$ and $\vec{B}$ is β. If $\hbar\omega < mc^2$, then the width Γ_n of resonance on n-th Landau level in R-diagram must be considered, but the resonance in S-diagram is absent. Averaging over electron momenta gives

$$\frac{d\varphi}{dx} = \frac{e^2 m\mu_B B cos\beta}{4\hbar^3\omega}\exp(-\frac{\phi}{2})\sum_{n=1}^{\infty}\phi^{n-1}\int_{-w_1}^{w_1}(R_n - S_n)dw, \phi = \frac{\hbar\omega^2\sin^2\beta}{2cBe},$$

$$w_1 = \frac{\pi^2(\hbar c)^3 n_e}{(mc^2)^2\mu_B B}, \Gamma_n \approx \frac{16(2n-1)(e\mu_B B)^2}{3m\hbar c^3}, Q_n = \frac{\hbar\omega}{mc^2}sin^2\beta - 4n\frac{\mu_B B}{\hbar\omega},$$

$$R_n = \frac{f_1(w)f_2(w)}{f_3(w)(f_1^2(w) + \frac{\Gamma_n^2}{\hbar^2\omega^2}(1 + 4n\frac{\mu_B B}{mc^2} + (w + \frac{\hbar\omega}{mc^2}cos\beta)^2))},$$

$$S_n = \frac{1}{f_3(w)} - \frac{Q_n}{f_3(w)(Q_n - f_2(w))}, f_1(w) = Q_n + f_2(w) + \frac{\Gamma_n^2}{4\hbar\omega mc^2},$$

$$f_2(w) = 2(\sqrt{1+w^2} - wcos\beta), mc^2 f_3(w) = mc^2\sqrt{1+w^2} + \hbar\omega (\text{IV..1})$$

The integrals are taken numerically (analytical expressions are very complicated). Here is a numerical example: if $n_e \sim 10^{23}$ cm^{-3}, $\hbar\omega \sim 0.1$ MeV (hard X-region), $B \sim 10^{13}$ G, then $d\varphi/dx \sim 10^2 - 10^3$ rad/cm at the resonance. It is not small in comparison with Faraday rotation and is important in some astrophysical problems. Besides: 1. Unlike Faraday rotation, Compton rotation can change its sign (like nuclear spin precession of neutrons [2, p. 54]), that's why the addition of two types of rotation can give zero at some ω, B. 2. The increase of β leads to decrease of the resonant frequency ω_R, but the increase of B leads to increase of ω_R; in both cases the value of $(d\varphi/dx)_R$ decreases.

[1] P.I. Fomin, R.I. Kholodov, J. Exp. Theor. Phys. **90**, Num 2 281-286 (2000).
[2] V.G. Baryshevskii, Yadernaya Optika Polarizovannykh Sred (Nuclear Optics of Polarized Media) [in Russian]: Moscow, Energoatomizdat (1995).