Loop Amplitudes Induced by Tensor Fermionic Current in Constant Homogeneous Electromagnetic Fields

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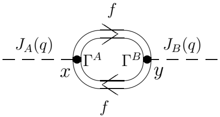
Introduction: General Case of Two-Point Correlator

- Lagrangian density of local fermion interaction

$$\mathcal{L}_{\rm int}(x) = \left[\bar{f}(x)\Gamma^A f(x)\right] J_A(x)$$

- J_A is the generalized current (photon, neutrino current, etc.)
- Γ_A is any of γ-matrices from the set $\{1,\ \gamma_5,\ \gamma_\mu,\ \gamma_\mu\gamma_5, \sigma_{\mu\nu} = i\left[\gamma_\mu, \gamma_\nu\right]/2\}$
- Interaction constants are included into the current J_A
- Two-point correlation function of general form

$$\Pi_{AB} = \int d^4X\, \mathrm{e}^{-i(qX)}\, \mathrm{Sp}\,\{S_{\rm F}(-X)\,\Gamma_A\, S_{\rm F}(X)\,\Gamma_B\}$$



- $X^\mu = x^\mu - y^\mu$ is the integration variable
- $S_{\rm F}(X)$ is the Lorentz-invariant part of exact fermion propagator
- Correlations of scalar, pseudoscalar, vector and axial-vector currents were studied by Borovkov et al. [Phys. At. Nucl. 62 (1999) 1601]
- Consider correlations of a tensor current with the other ones

Photon Polarization Operator

- Photon polarization operator $\mathcal{P}^{\mu\nu}(q)$ is related with $\gamma \to \gamma$ transition matrix element and, consequently, with the correlator of two vector currents

$$\mathcal{M}_{\gamma\to\gamma} = -i\, \varepsilon'^{*}_{\mu}(q)\, \mathcal{P}^{\mu\nu}(q)\, \varepsilon_{\nu}$$

- Photon dispersion relations follow from the equations

$$q^2 - \Pi^{(\lambda)}(q) = 0 \quad (\lambda = 1, 2, 3)$$

- $\Pi^{(\lambda)}(q)$ are eigenvalues of the photon polarization operator (electron loop is considered only)

$$\mathcal{P}_{\mu\nu}(q) = \sum_{\lambda=1}^{3} \frac{b_{\mu}^{(\lambda)} b_{\nu}^{(\lambda)}}{(b^{(\lambda)})^2}\, \Pi^{(\lambda)}(q)$$

- As in vacuum, there are two physical eigenmodes of $\mathcal{P}_{\mu\nu}(q)$ in an external constant homogeneous magnetic field

$$\varepsilon_{\mu}^{(1)} = b_{\mu}^{(1)} / \sqrt{q_{\perp}^2}, \quad \varepsilon_{\mu}^{(2)} = b_{\mu}^{(2)} / \sqrt{q_{\parallel}^2}$$

AMM Contribution to Photon Polarization Operator

- Field-induced part of $\Pi^{(\lambda)}(q)$ is modified

$$\Pi^{(\lambda)}(q) = -i\,\mathcal{P}(q^2) - \frac{\alpha}{\pi}\, Y_{VV}^{(\lambda)} + \frac{\alpha}{\pi}\, a_e\, Y_{VT}^{(\lambda)}$$

- The last term can be presented in the form of double integral

$$Y_{VT}^{(\lambda)} = \int_0^\infty \frac{dt}{t} \int_0^1 du \left\{ \frac{\beta t}{\sin(\beta t)}\, y_{VT}^{(\lambda)}\, e^{-i\Omega} - q^2\, e^{-i\Omega_0} \right\}$$

$$y_{VT}^{(1)} = y_{VT}^{(3)} = q^2 \cos(\beta t u), \quad y_{VT}^{(2)} = q_{\parallel}^2 \cos(\beta t u) - q_{\perp}^2 \cos(\beta t)$$

- Notations are from the book by A. Kuznetsov and N. Mikheev, Electroweak Processes in External Electromagnetic Fields (Springer, 2013)
- Part independent on the field is subtracted
- For the electron, $a_e \sim \alpha$ and the AMM correction is small
- This contribution can be enhanced when AMM is dominated by New Physics