Radiation from the graphene in the presence of an external field: kinetic approach

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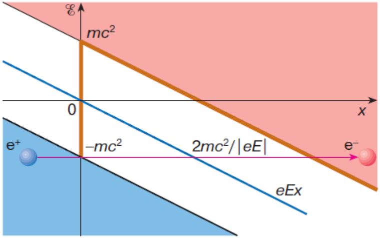
Outline

Motivation - I

The Schwinger effect



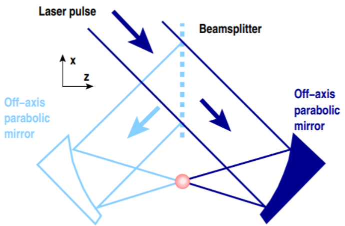
Sauter-Heisenberg-Euler-Schwinger formula

$$\varpi = \frac{ce^2E^2}{4\pi^3\hbar^2}\exp^{-\frac{E_{cr}}{E}}, \textit{where is } E_{cr} = \frac{\pi m^2 c^3}{e\hbar}$$

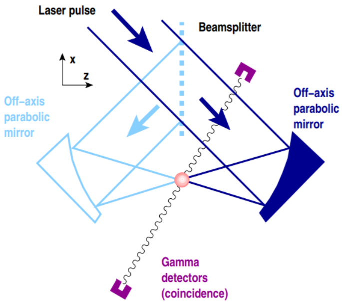
- Necessary value: $E_{cr} = \frac{m^2}{e} \backsimeq 1.3 \cdot 10^{16}\ \frac{V}{cm}$

Motivation - II

Possible way of observation



Heinzl, et al., Opt.Commun. 267, 318 (2006)



G.Gregori et al.(2008) at RAL Astra-Gemini Laser

Previous works - I

The basis

D.B. Blaschke, V.V. Dmitriev, G. Röpke, and S.A. Smolyansky, Phys. Rev. D 84, 085028 (2011).

BBGKY kinetic approach for an $e^- e^+ \gamma$-plasma created from the vacuum in a strong laser-generated electric field: The one-photon annihilation channel.

A. Fedotov, A. Panferov, S. Pirogov, and S. Smolyansky, LPHYS'18, Nottingham, July 16-20, 2018.

Self-consistent kinetic description ofthe $e^- e^+ \gamma$-plasma generated from vacuum by strong laser field.

Previous works - II

The basis

The Hamiltonian function:

$$\mathcal{H}(t) = \upsilon_F \int d^2x \Psi^+(\vec{x}, t)\hat{\vec{\mathcal{P}}}\vec{\sigma}\Psi(\vec{x}, t),$$

where $\hat{\mathcal{P}}_k = -i\hbar\nabla_k - (e/c)A_k(t)$ is the quasimomentum,
υ_F is the Fermi velocity,
σ_k are the Pauli matrices.

*)

A.D.Panferov, B.D.Blaschke, D.V. Churochkin, S.A.Smolyansky. Memory Conference of Ginzburg-100, 2007.

Nonperturbative kinetics in graphene

KE for the distribution function of the non-Markovian type:

$$\dot{f}(\vec{p},t) = 2\lambda(\vec{p},t)\int_{t_0}^{t} dt'\lambda(\vec{p},t')[1-2f(\vec{p},t')]cos\theta(t,t'),$$

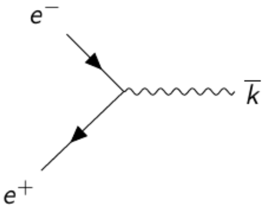
where $\lambda(\vec{p},t)$ is the amplitude of the transitions between states with the positive and negative energies.

KE in the form of equivalent system of ordinary differential equations:

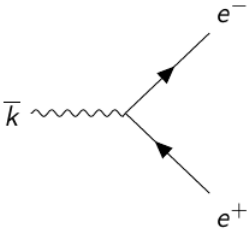
$$\dot{f} = 2\lambda u,\ \ \dot{u} = \lambda(1-2f) - \frac{2\epsilon}{\hbar}\upsilon,\ \ \dot{\upsilon} = \frac{2\epsilon}{\hbar}u,$$

where ϵ is the quasienergy,
υ and u describes polarization effects.

Kinetics of radiation from graphene (preliminary results)



a)$\sim f^- f^+ (F+1)$



b)$\sim -F(1-f^-)(1-f^+)$

Figure: a) "Ingoing" term; b) "Outgoing" term

KE for photons:

$$\dot{F}(\vec{k},t) = \int d^3p \int^t dt' K(\vec{p},\vec{k};t,t')\{f^-(\vec{p},t')f^+(\vec{p}-\vec{k},t')\cdot$$

$$\cdot[F(\vec{k},t')+1] - [1-f^-(\vec{p},t')][1-f^+(\vec{p}-\vec{k},t')]F(\vec{k},t')\}$$

Summary

- Obtained KE's belongs to the general class of the strong field theories described by the basic KE.
- The kinetic theory of the eh – excitations in graphene has been constructed in the frameworks of the low energy
- The kernel $K(\vec{p}, \vec{k}; t, t')$ is calculating now.

Thank you for attention.