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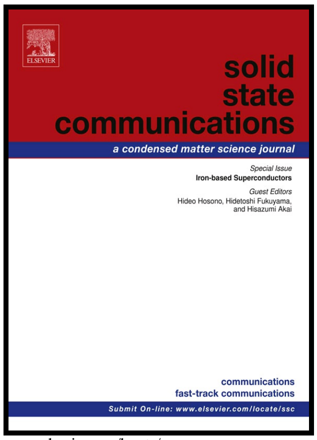

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ACCEPTED MANUSCRIPT

INFLUENCE OF ELECTRIC FIELD ON THE QUANTUM OSCILLATIONS IN THE WEYL SEMIMETALS

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Investigation of Weyl semimetals (WSMs) is one of the most important and hot topics of modern condensed matter physics. In this paper, we investigated the Landau band and quantum oscillations in the WSMs under crossed magnetic and electric fields (CMEFs). We obtained an expression for the energy spectrum of such system using an algebraic and quasi-classical approaches. We have shown that the electric field leads to a cardinal change the Landau bands. When an electric field is equal to $\upsilon_F H/c$, the collapse of the Landau levels occurs, and the motion becomes completely linear. It will lead to fundamental change of the character of the surface states, called the Fermi arcs. The electric field influences on the character of the quantum oscillations. The density of states has a singularity at $E=\upsilon_F H/c$. We have shown that such a result is due to the continuous model. In the lattice model this singularity disappears. Finally, we investigated the density of states of tilted WSMs. We shown that the phase transition between I and II phases of WSM can be induced by electric field.

Keywords: Landau levels; Density of states; Crossed fields; A. Weyl semimetals.
PACS: 71.70.Di

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1. Introduction

At present time, the study of topological Dirac materials is one of the main directions of condensed matter physics [1, 2]. Due to their unique properties, these materials are considered as promising objects for future nanoelectronics. A topological insulators [3, 4] and WSMs [1, 2, 5-10] are of particular interest. In the WSMs, unlike graphene and topological insulators, three-dimensional chiral Dirac carriers are realized in the vicinity of the so-called Weyl points. Chirality and the linear spectrum of carriers lead to unique transport properties of WSM, such as negative magnetoresistance, anomalous Hall effect, chiral magnetic effect, etc. [11-14].

In addition to volume states, charge carriers in WSM exhibit gapless surface states. Various boundary effects for charge carriers in WSM have been considered in recent papers [15, 16]. The presence of exotic surface states, called Fermi arcs, is the hallmark of WSM. Such states lead to strong transport nonlocality in thin-layer samples [11, 17, 18] and anomalous quantum oscillations [13]. Surface states in the form of Fermi arcs are a unique property of WSM, associated exclusively with chirality of carriers.

In the present paper we investigate quantum oscillations in Weyl and Dirac semimetals in crossed magnetic and electric fields (CMEFs). Such research in graphene performed in [19-24]. Under crossed fields, Dirac materials exhibits interesting features, which have exclusively relativistic origin. The energy spectrum in non-relativistic materials is parabolic and the cyclotron mass is independent of energy. Indeed, the cyclotron mass is defined as

$$m_c(\varepsilon) = (2\pi)^{-1} d\mathcal{S}/d\varepsilon\,, \qquad (1)$$

where $\mathcal{S}(\varepsilon)$ is the area of the iso-energy trajectory $\varepsilon(\boldsymbol{p}) = \varepsilon$ in momentum space. The non-relativistic spectrum $\varepsilon(\boldsymbol{p}) = p^2/2m^*$ gives $m_c = m^*$. Consequently, the applied electric field will not be effect on the cyclotron frequency. In the Dirac materials, the energy

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