Dirac fields in curved graphene

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ABSTRACT

From the perspective of high energy physics, graphene can provide us a real framework to study what is believed to be (as close as possible) a quantum field in a curved space-time. The peculiar structure of a graphene sheet determines in fact a natural description of its properties in terms of relativistic Dirac pseudoparticles. The charge carriers' behaviour at Dirac points in curved graphene can be thus obtained exploiting a Dirac spectrum description for particles living in a curved bidimensional background, in the large wavelength approximation [1].
The study of particular curved configurations, together with the quantization of some physical quantities due to the particular geometry of the manifold, can lead to characteristic observable effects. In particular, some optical responses of the graphene sheet can be obtained in peculiar ranges of energy including the visible light energy spectrum [2].

A more generic, geometrical top-down approach to realize the physics of graphene charge carriers can be obtained exploiting the holographic principle, where the 1+2 dimensional theory for graphene is realized as the boundary theory of a four-dimensional gravity model in Anti de Sitter (AdS) spacetime. The result is achieved through suitable boundary conditions for the D=4 fields, and an effective model for spin-1/2 fields on a curved background is obtained [3]. The unconventional symmetry of the boundary model allows to introduce suitable internal degrees of freedom, which can provide an application of the model to the description of general graphene-like 2D materials at the Dirac points K,K'. In particular, the two valleys correspond to the two independent sectors of the boundary model, connected by a parity transformation. The fermion masses entering the corresponding Dirac equations are related to the torsion parameters of the substrate in the three-dimensional model: the parity-even and odd components of the corresponding masses are identified with Semenoff and Haldane-type mass contributions, respectively [3].

REFERENCES

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[2] A. Gallerati, Eur. Phys. J. Plus 134 (2019) 202.
[3] Andrianopoli, Cerchiai, D'Auria, Gallerati, Noris, Trigiante, Zanelli, JHEP 01 (2020) 084.

FIGURES

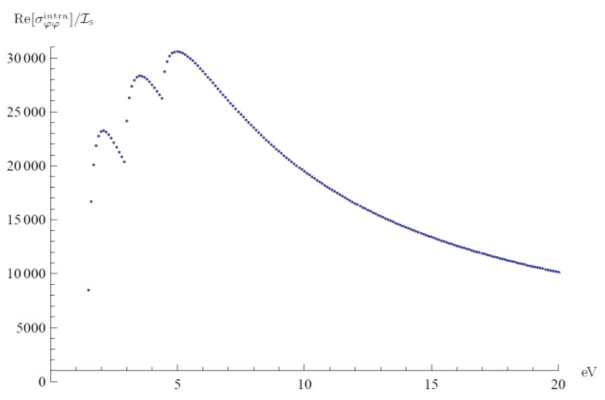

Fig.1: Optical conductivity for graphene nanoscroll

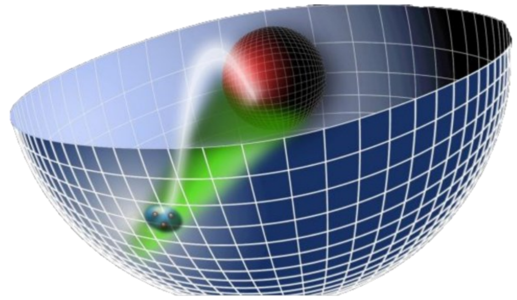

Fig.2: Holographic correspondence