On the disorder-driven transition in d=3 semimetals

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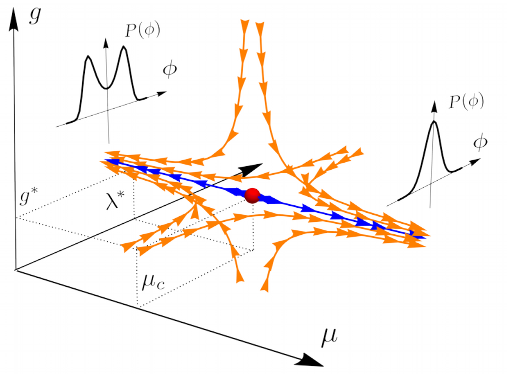
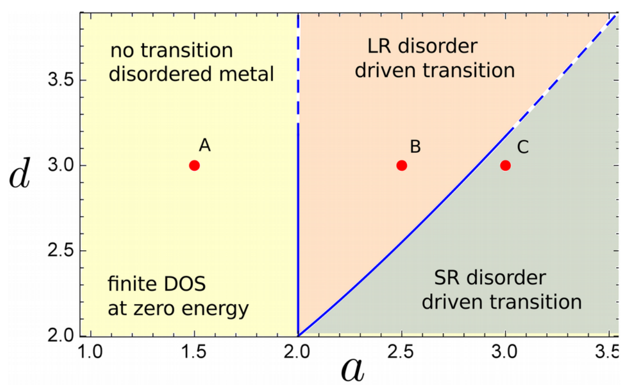
After discovering graphene the materials with relativistic-like spectrum of electronic excitations have become a popular subject which currently drives several hot topics in physics. Among them there are three dimensional materials which have been recently identified as Weyl semimetals and which provide a new universality class of phase transitions. The Weyl semimetallic phase is topologically protected against small perturbations such as presence of disorder. For a weak disorder, the system remains in a semimetallic phase: the density of states vanishes linearly at the band crossing, where electronic transport is pseudoballistic. However, for a critical disorder strength a transition occurs towards a diffusive metallic phase, characterized by a finite density of states at the nodal point [1]. This transition has been studied numerically and using renormalization group in d = 2 + eps [2] without consensus on the values of the critical exponents.
We reconsider this problem in view of relevance of disorder correlations and rare events. We find that the renormalization flow generates new terms in d = 2 + eps and propose an alternative route based on 4 - epsilon expansion [3]. Our method allows one to calculate the critical exponents in a systematic way opening an interesting perspective on several issues related to the transition. Besides, we show that in three dimensions, three scenarios are possible depending on the disorder correlations [4]. While the same transition is recovered for short range correlations, for disorder decaying slower than 1/r 2 , the Weyl semimetal is unstable to any weak disorder and no transition persists. In between, a new phase transition occurs. This transition still separates a disordered metal from a semi-metal, but with a new critical behavior that we analyze to two-loop order.





Left: RG flow diagram of the 4-eps expansion. Right: phase diagram depending on dimension and disorder correlations.

References

[1] E. Fradkin, Phys. Rev. B **33** (1986)
[2] P. Goswami and S. Chakravarty, Phys. Rev. Lett. **107**, 196803 (2011)
[2] T. Louvet, D. Carpentier and A. A. Fedorenko, arXiv:1605.02009
[3] T. Louvet, D. Carpentier and A. A. Fedorenko, arXiv:1609.08368