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Weyl States as Skyrmions Living in Magnetic Protectorates

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Electrons in conductors are basically free particles subject to residual collisions, according to the picture first proposed by Paul Drude in 1900 and later developed by Arnold Sommerfeld in 1927 with quantum concepts. Here I show that the same picture unfolds startling new results, such as the natural onset of Weyl states from parabolic bands provided that electrons are constrained to move in a layer. For this a Drude-Sommerfeld assumption must be reviewed, namely, the claim that in between any two residual collisions the electrons move freely. This is an approximation that ignores the magnetic field produced by the electrons, which although very small cannot be discarded in case of electronic motion along the layer, as shown here. The electric current creates a three-dimensional magnetic field around the layer which leads to topologically protected states independently of the strength of the field. This is because the magnetic field streamlines, created by the electronic motion form loops that pierce the layer twice and cannot be broken unless by a strong collision regime. The present results stem from the three term decomposition of the kinetic energy [1], from which it follows that the above mentioned magnetic field loops are a consequence that the electrons occupy Weyl states. The linear Dirac spectrum of such Weyl states arise in the limit of zero helicity and set up magnetic protectorates forbad to decay into the lowest energy states. Remarkably the residual magnetic interaction among electrons is shown to be attractive leading to the conjecture of the onset of a magnetic condensate. In summary the Drude-Sommerfeld scenario for layers turns the electrons into skyrmions made stable by virtue of their own magnetic field. I also report here their non zero Chern index and obtain the electrical and the thermal conductivity of such states and compare to the Wiedemann-Franz law.

[1] Mauro M. Doria and Andrea Perali, Europhys. Lett. 119 (2017) 21001