



June 22<sup>nd</sup>, 2022

To the thesis committee,

I am writing to report my evaluation on Anna Grigoreva's Bachelor's thesis. In short, this is an excellent thesis with a very high quality.

Anna's thesis reports on the theoretical study of the cyclotron motion of the surface electrons in a Weyl semimetal (WSM) that hosts a charge density wave (CDW) phase. One of the most unique properties of Weyl semimetal is its exotic surface states, known as Fermi arcs. The Fermi arc connects the Weyl points with opposite chirality and enables a special cyclotron motion: when a magnetic field is applied perpendicular to the surface of a WSM, the electrons travel along the Fermi arc and tunnel into the bulk Weyl point at the end of the Fermi arc, then complete the travel on the other side of the crystals along the Fermi arc with opposite Fermi velocity. Evidence of such a "Weyl orbit" has been reported experimentally soon after the discovery of topological semimetals.

In this thesis, the author studies the effect of CDW formation on the Weyl orbits. They discovered that instead of tunneling into the bulk Weyl points, the electron is scattered off by the CDW. The author calculated the spectrum of surfaces in the presence of CDW and studied the period of the cyclotron motion in such surface states. They found that the main difference between the Weyl orbits with and without CDW is the time spent during the scattering by the CDW, which is inversely proportional to the CDW gap. This study is experimentally relevant, especially given the recent discussion of the CDW WSM candidates (TaSe<sub>4</sub>)<sub>2</sub>I and NbTe<sub>4</sub>.

I found this work is of very high quality. Anna made an important and unambiguous prediction of the cyclotron orbits in CDW WSM, which is derived from a series of non-trivial calculations. This type of works, i.e. a simple analytical result directly applicable to experiments, is rare nowadays. This thesis is also written in a logical and concise manner. The only weakness I can find in this thesis is that sometimes it is too concise. It will be very helpful to make the presentation more accessible to experimentalists. Nevertheless, given that the Anna has just started her academic career, I am sure this weakness will be overcome in no time.

Sincerely,

Jiun-Haw Chu

Associate Professor of Physics