Explaining Fermi Surfaces

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Abstract

The National High Magnetic Field Laboratory (NHMFL) spends a huge amount of time and tens of millions of taxpayer dollars to explore the properties of materials. Yet the public understands little about one of the main research areas of the Maglab, Fermi Surfaces. If asked, most people on the street would not have even heard the name. This project tried to somewhat remedy that by producing scripts and animations that explain what Fermi Surfaces are and how they determine the properties of materials.

Fermi Surface

The Fermi Surface of a metal, semimetal or semiconductor is the set of occupied highest energy electron states in momentum space. It determines the behavior of the most mobile electrons in a material, the charge carriers in a conductor. This determines most of the properties of the material, such as the electrical and thermal conductivity.

In theory the biggest stumbling block for the general public is that Fermi Surfaces are abstract surfaces in momentum space. The ways that they connect to the properties of the metals they describe are often mathematically intensive. This project tried to produce intuitive and nonmathematical examples of the importance of these abstract objects.

Animations

Several animations and scripts were made detailing different aspects of how Fermi Surfaces impact materials.

A video is currently being produced by Stephen Bilenky using a script written by the author of this poster defining what Fermi Surfaces are in a conceptual manner.

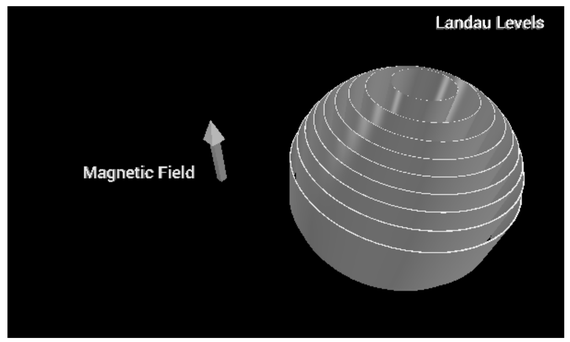

Fig. 1: A screenshot of an animation of Landau Levels in a changing magnetic field.

Using Visual Python, Landau Levels in an increasing magnetic field were animated. The accompanying script explains how Fermi Surfaces are measured using oscillations in a materials properties from Landau Levels leaving the Fermi Surface when magnetic field increases.

Finally, a script explaining how features of Fermi Surfaces cause orientation dependent conductance in crystals was written.

Hall Effect

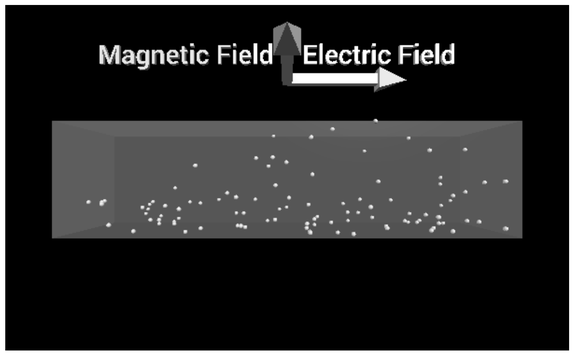

Fig. 2: A screenshot of a simulation of the Hall Effect using a Drude Model for the charge carriers.

As an aside, a simulation of the Hall Effect using a Drude Model was made and a corresponding script written explaining what the Hall Effect is.

Crystallography Database

Elemental crystallography data was gathered from crystallography.net into a database to be used in the future to make a Periodic Table of Fermi Surfaces.

Thanks

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