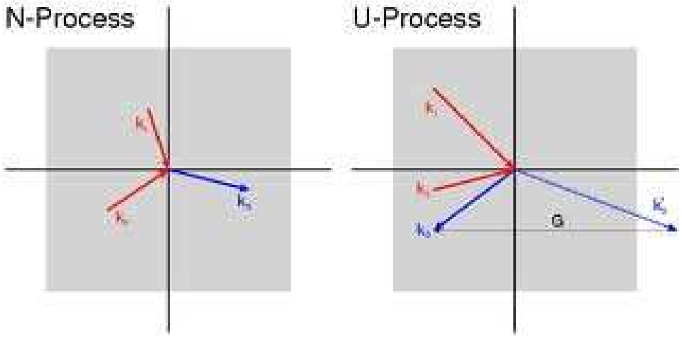
I. PROBLEM SESSION 9

A. 9.1



Umklapp scattering is a scattering/transformation of a wave vector to another Brillouin zone. Such that for an Umklapp process, crystal momentum is not conserved (when specified in the primitive cell). For electrons, this is the major contribution to resistivity when the concentration of defects or impurities are low. Umklapp processes are also important in superconductivity, where they contribute to the phonons responsible for the Cooper mechanism.

We now consider resistance in metals due to phonon scattering of electrons. Show, using a sketch that when the Fermi surface lies entirely inside the first Brillouin zone, there is restrictions on which phonon wavevectors q_0 that can contribute to scattering. Next, consider a simple 2D square lattice. Find an explicit expression for q_0 given by the fermi temperature T.

Now use your expression to find out what happens at low temperatures. Is Umklapp processes still important at very low temperatures?

B. Problem 9.2

Drude model for electrical/thermal conductivity:

a) Show that the Wiedemann-Franz coefficient in the Drude model is given by $\frac{3k_b^2}{2e^2}$. How is the coefficient modified when considering the FEFG model? b) Show (calculate) that the Drude model provides reasonable values of electrical resistivity at room temperature, ρ_0 at T_0. Further, it is know experimentally that the temperature dependence of the resistivity is given by $\rho(T) = \rho_0(1 + \alpha(T - T_0))$ where α is so called thermal resistance coefficient. Show that the Drude model is in qualitative disagreement with the observation. Please discuss if the application of FEFG model improves the situation.

C. Problem 9.3

The Hall effect is today has a large variety of industrial application, especcially in sensors. The most straightforward application is Hall probes, that are used in magnetometers. The quantum hall effect (that is a qualitatively different effect) is today a large subject of research, and is responsible behind some of the worlds most accurate measuring devices.

How does a magnetic field modify the dynamics of electrons? Explain the mechanism behind the Hall effect. Can you think of any other ways the introduction of a magnetic field alter the properties of the electron gas? Can the Hall effect be explained in terms of Drude/FEFG models? What is the core problem?