Solid State Physics
Lecture 56
Issues with the Classical Theory of Diamagnetism

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Now, there is a problem, first of all the magnetism is not a classical phenomenon it is a quantum phenomenon, but where does this Langevin theory go wrong. If we consider the precession of electrons of course, there is a current, but if one electron processes like this here and another electron processes like this here then at the junction the current is equal and opposite. Similarly, you will find that at every point the current is equal and opposites so there would be no current and hence no diamagnetism. This is what we meant by saying that there is no classical origin of magnetism. Therefore, we must go to the quantum theory and see if the result obtained that is the magnitude of the susceptibility obtained from Langevin theory is correct or not. (Refer Slide Time: 01:21)

When we discuss the quantum theory we have to write down the Hamiltonian first. So, the Hamiltonian, first let us consider the electronic Hamiltonian in an atom and then add the magnetic field part in the Hamiltonian as a perturbation. So, here we are writing only the magnetic field part of the Hamiltonian that is given as in CGS unit of course, $H = \frac{ie\hbar}{2mc}(\overrightarrow{\bigtriangledown} \cdot \overrightarrow{A} + \overrightarrow{A} \cdot \overrightarrow{\bigtriangledown}) + \frac{e^2}{2mc^2}A^2$. This is the part of the Hamiltonian that comes due to the magnetic field for an atomic electron these terms may usually be treated as a small perturbation.