Magnetic ordering

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We learned about the diamagnetic response of all atoms to an externally applied field, and paramagnetic response for atoms that have a net magnetic moment. In this lecture we will study what happens if we bring atoms together. Under which conditions do we get a ferro-magnetic material?

Lecture topics:

1. Bound currents
2. Molecular field theory
    a. Heisenberg interaction model
    b. Curie Temperature
3. Exchange
    a. Localized electron model
    b. Delocalized electrons, Band model, super-exchange
    c. Combination, RKKY

Recommended reading:

[1] Feynman, Leighton, Sands "The Feynman lecture notes on physics" Chapter 36 (Ferromagnetism), 37 (Magnetic materials). Addison Wesley. Available online: http://www.feynmanlectures.caltech.edu
[2] Charles Kittel "Introduction to solid state physics" Chapter 11 Diamagnetism and Paramagnetism, Chapter 12 "Ferromagnetism and anti-ferromagnetism" John Wiley.
[3] Stephen Blundell "Magnetism in condensed matter" Chapter 4, 7

Additional instructions

In the lectures we will use Peer instruction as a lecture form. This means **there will be no presentation by a lecturer**. Instead, we expect you to come prepared. At the session, we will discuss the theory guided by concept questions. (This form or education is called Peer instruction https://en.wikipedia.org/wiki/Peer_instruction, it is not meant to relief the lecturer, but based on the idea that you only learn when you are active).

Pre-class Study

The Peer instruction format requires that you study before you attend the lecture. Below we give a list. We realize your backgrounds and preferred text differ. Therefore, we provide options. We use four different textbooks. The **Feynman** lecture notes on physics is better in insight. Feynman uses more explanation, and is not afraid to indicate where our understanding ends. You will like it if your background is more hands-on. **Kittel**'s solid state physics more precise and condensed. Kittel goes deeper into the theory, and will be more helpful if you continue into solid state problems. **Blundell** is more modern and very condensed, and rooted in quantum mechanics. You will like it if you studied physics. **Chikazumi** is from the dark ages, but very complete and pleasant to read.

For this session, we would like you to **study** the following. Depending on your interest and choice you make, it will be 15-25 pages. This will take you about 4 hours.

1. The H-field
Feynman Vol II Chapter 36.1 (Magnetisation currents) and 36.2 (The H-field). (There is no good Kittel chapter for that). 5 pages.

2. Spontaneous magnetism
a) Either continue Feynman: 36.6 (Spontaneous Magnetisation), 37.1 (Understanding Ferromagnetism). 9 pages
b) Or continue with Kittel Chapter 12 "Ferromagnetic Order" (page 323-330 in the 8th edition). 7 pages

3. Direct Exchange.
If you have a background in quantum mechanics, you want to read more about the interaction of two electrons. Either
a) Blundell chapter 4.1/2. 3 pages
b) Feynman Vol III Chapter 10.3. 2 pages

4. Super Exchange
Either
a) Chikazumi/Charap chapter 5.1, page 80-81 or Chikazumi/Graham chapter 7.1 page 135-137 2 pages
b) Blundell chapter 4.2.3. 2 pages

5. Conduction electrons
If you have a background in quantum mechanics: Blundell 7.1 and 7.2. 5 pages
If not: Kittel Chapter 11 “Paramagnetic Susceptibility of conduction electrons” page 315 in 8th edition. 2 pages
Than read Blundell 4.2.4 (0.5 page)