

## Diluted Magnetic Semiconductors

### Part. 1

#### 1. Introduction on magnetism.

- 1.1. Why diamagnetism in ordinary metals, where conduction electrons are not bound to atoms, is not a huge effect?
- 1.2. Where does the Brillouin function come from?
- 1.3. How would magnetization versus magnetic field curve look like at  $T = 0$ ?
- 1.4. Why the Van Vleck paramagnetism does not depend on temperature?
- 1.5. What is the difference between Curie and Curie – Weiss temperatures?
- 1.6. What is the origin of magnetic order?
- 1.7. When does the mean field approximation work well?
- 1.8. What type of magnetic order, if any, would you expect in a material where only direct exchange is present? Why?

#### 2. The beginnings

- 2.1. What are classical magnetic semiconductors?
- 2.2. Why the effort to study them undertaken in the sixties was stepped down?
- 2.3. Why Jacek Furdyna wanted to study semiconductors with magnetic ions?
- 2.4. What were the first DMS materials studied?
- 2.5. What effects attracted attention of physicists to DMS?

#### 3. Influence of magnetic ions on charge carriers (I)

- 3.1. What is the difference between Faraday rotation and natural optical activity?
- 3.2. What types of Faraday rotation can be distinguished depending on the parameter influenced by the magnetic field?
- 3.3. What type of singularity at the resonance frequency can one expect in (Zeeman type) Faraday rotation spectra for: (i) a single absorption line, (ii) an absorption threshold and (iii) a squareroot absorption edge?
- 3.4. What are the arguments for the interband character of the giant Faraday rotation in CdMnTe?
- 3.5. What is the most important influence of magnetic field on band structure of large gap DMS at low temperature? Is electron wavevector still a good quantum number?
- 3.6. How can one determine sp-d exchange integrals in large gap DMS of zincblende structure?
- 3.7. Is it possible to measure Zeeman splittings for optical transitions at the L point of the Brillouin zone? Are they comparable to those at the  $\Gamma$  point?
- 3.8. How can we explain the Zeeman splitting values of energy bands at L point?

### Part 2

#### 4. Ion-ion (d-d) interaction

- 4.1. What is the energetic structure of an ion-ion pair coupled by exchange interaction?
- 4.2. What experimental conditions must be chosen to observe ESR on antiferromagnetically coupled ion-ion pairs in a DMS?
- 4.3. How can one determine number of ion-ion pairs and their coupling constant from ESR measurements?
- 4.4. What information can be obtained from high temperature susceptibility?
- 4.5. What is the meaning of parameters of empirically modified Brillouin function?
- 4.6. How can ion-ion coupling be determined from specific heat measurements? What is the peculiar feature of  $\text{Fe}^{2+}$  ions influencing such studies?
- 4.7. Why steps are observed in magnetization vs magnetic field curves? What information do they supply?
- 4.8. What information can be obtained from electronic Raman scattering in DMS?
- 4.9. What can we learn on ion-ion coupling from neutron scattering and how?
- 4.10. How does spin freezing temperature in DMS depend on magnetic ion concentration? What can be obtained from this dependence?

#### 5. Influence of magnetic ions on charge carriers (II)

- 5.1. What new possibilities offer DMS in quantum structures?
- 5.2. Why it was difficult to determine the band offsets for CdTe/CdMnTe system?
- 5.3. What is spin tracing?
- 5.4. What is the utility of DMS in studies of charged excitons?
- 5.5. Why is it interesting to use DMS in studies of in-plane anisotropy of confined excitons?
- 5.6. When is the mean field approximation insufficient to describe properties of DMS?
- 5.7. How do magnetic fluctuations influence the properties of DMS?
- 5.8. What new effect has been predicted for DMS, apart from those related to magnetic interactions?

Part 3

6. **Influence of charge carriers on magnetic ions**

- 6.1. What experimental method was used for first direct observation of Bound Magnetic Polaron?
- 6.2. What was the novelty of Dietl-Spalek model of BMP?
- 6.3. What is the meaning of : „fluctuation regime” and „true polaron” regime for BMP in 3D material?
- 6.4. How are the CdMnTe quantum wells doped to obtain ferromagnetism?
- 6.5. What are typical ferromagnetic temperatures for II-VI compounds?

7. **III-V semimagnetic semiconductors**

- 7.1. What methods should be used to grow III-V compounds with Mn concentration up to 10%?
- 7.2. What is the main factor limiting the ferromagnetic transition temperature?
- 7.3. Is it possible to determine the s,p-d exchange integrals for GaMnAs from excitonic splittings?

8. **Semimagnetic quantum dots**

- 8.1. What is the difference between QD's containing many and single magnetic ion?
- 8.2. Why the studies of the systems other than Mn in CdTe and in InAs QD were postponed until 2014?
- 8.3. What are the methods of spin orientation of the single magnetic ion in single quantum dot?

9. **DMS in microcavities**

- 9.1. What will be the advantage of placing single Mn ion in single QD in microcavity?
- 9.2. How the DMS could be used for polariton condensate?