Summer School 2007
Magnetic Heterostructures and Nanomagnetism
Haus Villigst, Schwerte, Germany, 8 - 13 July 2007
Questions to the presented lectures (in alphabetic order)

Bacher:

Q1: What is the reason for the failure of spin injection from metal ferromagnets into semiconductors accross an Ohmic contact?

Q2: Why is it possible to use the two channel model (spin-up and spin-down channel) for describing spin transport in heterostructures?

Q3: Is there a material which can act as a 100 % spin source?

Q4: Are there alternative (except electrical spin injection) approaches for localling defining spin states in semiconductors?

Bürgler:

Q5: How are current-induced magnetization switching and current-driven magnetic excitations (usually) detected?

Q6: Why is it required that the pillar diameter is of the order of 100 nm?

Q7: What are the experimental conditions for current-induced switching and current-driven excitations?

Dahlberg:

Q8: Take a small particle of magnetic material with some anisotropy energy. How does the coercivity change with size (diameter)?

Q9: What are the four energies relevant for magnetic materials?

Q10: How can one make sure the field produced by an MFM tip is not altering the physics they wish to study?

Eimüller:

Q11: Compare X-ray absorption spectroscopy (XAS) in transmission and total electron yield (TEY). What happens if you increase the thickness of the sample?

Q12: Zone plates

Show that the focal length of a zone plate depends linearly on the energy of the radiation.

(Derive the equation for the focal length of a zone plate from geometrical optics)

How is this property be used in a transmission x-ray microscope?

Q13: X-ray contrast mechanisms

Describe and compare three contrast mechanisms that can be used in X-PEEM and MTXM. Which information can be obtained? How can the different contrast mechanisms be separated from each other?

Felser:

Q14: Please explain the Slater Pauling rule in the general context of ferromagnetic alloys and of Heusler compounds, what is the difference?

Q15: Why does a chemist directly know that GdNiSb is a semiconductor with a low magnetic ordering temperature?

Q16: Why is Mn_3Ga a good material for a spin switch-device?

Q17: Do you know the meaning of SPINHAXPES, please explain this method?

Kleemann:

Q18-20: See attachment

König:

Q21: What defines the energy scale for the charging energy associated with adding a charge in an island?

Q22: What is the spin – valve effect?

Q23: What is the dominant transport mechanism through a quantum dot in the Coulomb-blockade regine, where sequential tunnelling is suppressed?

Q24: How does a (perpendicular) magnetic field affect transport through a quantum-dot spin valve?

Korenivski:

Q25. What transport regime through a point contact allows measuring the details of the electron phonon interaction in the contact core and why?

Q26. What information about the point contact core does the phonon spectrum provide in the case of a homo- and a hetero-contact?

Q27. What is the mechanism of the single-interface spin-torque effect? Why such spin torques and the spin-waves they cause are seen in the conductance spectra.

Oppeneer:

Q28: What methods can be used to image domains in an antiferromagnet? Consider and describe the method(s) that can be used for antiferromagnetic surfaces and for a bulk antiferromagnet.

Q29: Suppose you want to measure the decay of a certain spin state (up or down) into a semiconductor after injection. The semiconductor is a thin film sample of a few hundred micrometers. How would you do the measurement?

Q30: Suppose you are a theoretician and a colleague comes to you and asks if you could compute the spin Hall conductance in a ferromagnet. What could be a sensible definition for this quantity, in terms of spin parts of the anomalous Hall conduction? Give a proposal of how you would do a calculation.

Shinjo:

Q31: What are the main features of CPP-GMR in comparison with CIP-GMR?

Q32: What is a magnetic vortex and how can the behavior of a vortex core be measured?

Q33: Recent progress in the enhancement of MR ratio is remarkable: from a few % in AMR to 1000 % in TMR. For 1000% MR, new technical applications are expected. Propose some new device or new way of application for 1000% MR.

Magneto-optics

Problems

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Problem 1:

How can you measure the polar Kerr rotation and ellipticity with lock-in technique at the fundamental and second harmonic frequencies, respectively, of a photoelastic modulator?

- **To read:**
- Kerr rotation and ellipticity: lecture Kleemann, page 8 – 10, 13 – 14
- Photoelastic modulator

  S.N. Jasperson, S.E. Schnatterly, Rev. Sci. Inst. **40** (1969) 761
- Matrix calculus

R.C. Jones, J. Opt. Soc. Am. **31** (1941) 488

J. Badoz et al., J. Optics **8** (1977) 373

Problem 2:

a) Show that the electromagnetic eigenmodes of a transversally magnetized transparent cubic crystal with respect to the direction of the light propagation are described by

$$\vec{E}_1 = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} E_o \exp i(\omega t - ky)$$ and $$\vec{E}_2 = \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix} E_o \exp i(\omega t - ky)$$

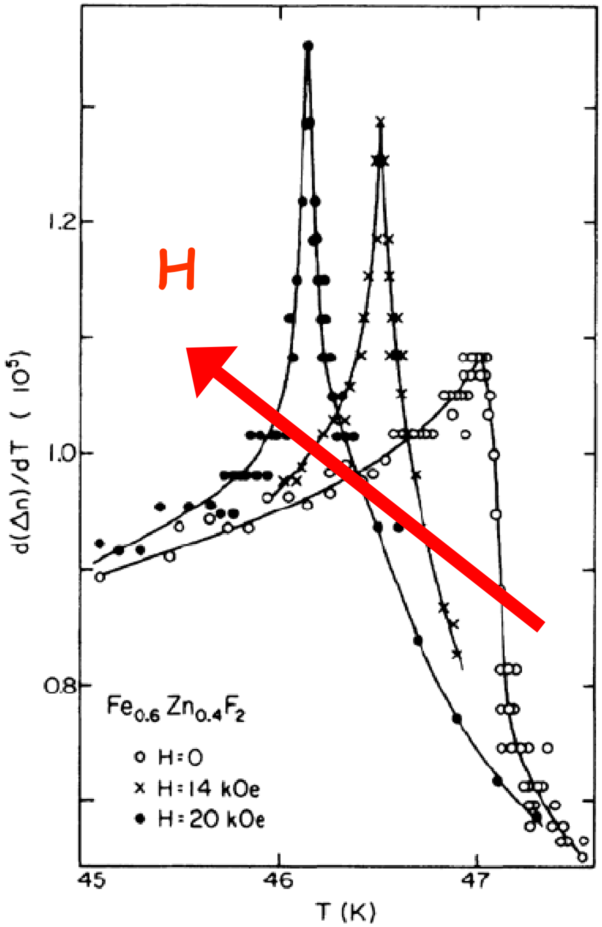
b) Calculate the induced linear magnetic birefringence and its dependence on the magnetic field and the magnetization, respectively.

c) Explain how to measure the linear magnetic birefringence with lock-in technique at the fundamental frequency of a photoelastic modulator?

Problem 3:

The spontaneous magnetic linear birefringence, Δn_m, of transparent crystals is often found to be proportional to the magnetic internal energy U_m (see figure). This allows to determine the magnetic specific heat $c_m \propto dU_m/dT$ by a comparatively simple optical method (cf. problem 2)

Give reasons for this surprising proportionality within a compressible Heisenberg model.



D.P. Belanger *et al.*
Phys. Rev. B **28** (1983) 2522

Literature:

J. Ferré, G. A. Gehring, Rep. Prog. Phys. **47** (1984) 513