**Linear and nonlinear magneto-photonics**

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**Examples of the homework tasks on different subjects**

***1. Basics of magnetism***

Derive an expression for the temperature dependence of the susceptibility of an antiferromagnet in a field applied perpendicular to the sublattices magnetizations (using the concept of the molecular (Weiss) fields).

***2. Linear magneto-photonics***

Consider the light propagating though the transparent ferromagnet perpendicularly to the magnetization direction:

z

**M**

x

y

**E0**

θ

Write down the dielectric tensor describing the optical properties of the ferromagnet (neglect the crystallographic birefringence).

Derive the Eigen-polarization states for the light in this material.

Obtain the expression describing the polarization of light after passing through the sample, if the initial polarization of light was given by the Jones vector E0[cos(θ); sin(θ)]. Sample thickness is *d*. Consider two cases: fully transparent medium and the medium with absorption.

***3. Nonlinear magneto-photonics***

Thin YIG film is grown epitaxially on the GGG substrate with orientation (111). Such a film is described by the point group 3*m* (*z*||[111]). External magnetic field is applied along the *z*-axis. Consider the light propagating along the *z*-axis.

Using the Birss tables [*R. R. Birss, Rep. Prog. Phys.* ***26****, 307 (1963)]*, find the nonlinear susceptibility tensor component describing SHG of electric-dipole crystallographic and magnetic origins.

Consider that the incident light is polarized along the *y-*axis. Derive and plot the intensity of the SHG light polarized along the *y*-axis as a function of the azimutal angle of the sample. Consider two cases: fully transparent medium and the medium with the absorption.

***4. Ultrafast opto-magnetism***

z

Excitation of the magnetization precession (coherent magnons with **k**=0) can be realized via impulsive stimulated Raman scattering process (ISRS). In *[Gridnev, Phys. Rev. B.* ***84****, 3465 (2004)]* the phenomenological theory of the ISRS process is presented.

Consider the case of simple single-sublattice ferromagnet (crystallographic point group ):

z

**M**

x

pump

y

Derive the modulation of the dielectric permittivity components *εxy* due to the coherent magnons excited (i) by circularly-polarized pump pulses and (ii) by linearly-polarized pump pulses (azimuthal angle of polarization is 45o with respect to the *x*-axis).

What is the initial phase of the magnetization precession in these two cases?

Compare the result to the analysis performed using the effective laser-induced field approach (see Lecture #9 “Opto-magnetic phenomena”).