MAGNETOREFRACTIVE EFFECT AND CUBIC NONLINEAR MAGNETOOPTICS IN MAGNETIC GRANULAR ALLOYS

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Granular metal-insulator alloys, consisting of nano-scale magnetic particles in an insulating matrix are of unique consideration for the technological application and fundamental physics. They display a wide variety of unusual both linear and nonlinear electric-transport, optical and magnetooptical properties, especially for compositions close to the percolation threshold.

In the discussion, we will review recent experimental and theoretical results on new magnetooptical phenomena in magnetic granular metal-insulator alloys with tunnel-type magnetoresistance, focusing on magnetorefractive effect and cubic nonlinear magnetooptics.

Recently, the strong magnetorefractive effect in the infrared region of spectrum has been found in some granular metal-insulator alloys Co-Al-O, Fe-SiO_n, CoFeZr –SiO_n CoFe-MgF. The change of reflectivity in applied magnetic field is more than 1%, that is two orders of magnitude larger than that for conventional magnetooptical effects.

At finite frequencies, the nonlinear dependence of electrical displacement $\boldsymbol{D}$ on electric field $\boldsymbol{E}$ is the basis of nonlinear optics and magnetooptics. Nonlinear magnetooptical phenomena can be observed at the frequency of incident light and in the case of high harmonic generation. Magneto-induced second harmonic generation and nonlinear magnetooptical Kerr effect are the well-known examples of the second type nonlinear magnetooptics. We predict nonilinear magnetooptics at the frequency of incident light due to weakly nonlinear relation between electric displacement $\boldsymbol{D}$ and electric field $\boldsymbol{E}$ for both constituent materials of the form $\boldsymbol{D}_i = \varepsilon_i^{(0)}\mathbf{E}_i + \chi_i^{(3)}|\boldsymbol{E}_i|^2\boldsymbol{E}_i$. We suppose that linear $\varepsilon_i^{(0)}$ and cubic nonlinear $\chi_i^{(3)}$ dielectric functions have diagonal and linear with magnetization non-diagonal components. For such a metal-insulator composite magnetooptical effects depend on a light intensity and the effective cubic dielectric function $\chi_{eff}^{(3)}$ can be significantly greater (up to 10^3 times) than that for constituent materials. The giant cubic magnetooptical nonlinearity is predicted for composites with metallic volume fraction close to the percolation threshold and at a resonance of optical conductivity.