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Photo-induced magneto-optical phenomena in magnetic semiconductors: Europium chalcogenides

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Europium chalcogenides EuX (X = O, S, Se, Te) are a compact group of magnetic semiconductors with unique electronic, magnetic, optical and magneto-optical properties. The physical properties of the europium chalcogenides EuX are determined by the electronic structure of the Eu^{2+} ions, which have strongly localized $4f^7$ electrons with a large spin S = 7/2. A photo-induced Faraday effect (FE) was studied in the chalcogenides EuTe and EuSe by the optical pump-probe technique using continuous lasers and a broadband light source. The photo-induced FE was investigated as a function of the intensity of light, magnetic field, and temperature. Figure 1 shows field dependences of the photo-induced FE in EuTe at various optical pumping intensities. It has been established that resonant excitation of the $4f^7 5d^0 \rightarrow 4f^6 5d^1$ optical electric-dipole transition in EuTe produces magnetic polarons with a quantum efficiency of about 10% and a magnetic moment exceeding 600 μB for EuTe and 6000 μB EuSe at low temperatures. A quantum mechanical model has been developed for calculating the photoinduced FE associated with the formation of giant magnetic polarons in EuTe. The developed theory describes well the experimentally observed dependencies. The optical pump-probe technique with a femtosecond time resolution was used to study ultrafast dynamics in EuTe near the absorption band gap. A magnetic-field-induced crossover from the inverse FE to the optical orientation was observed. In conclusion, a number of new photo-induced optical effects in magnetic semiconductors EuX were observed.

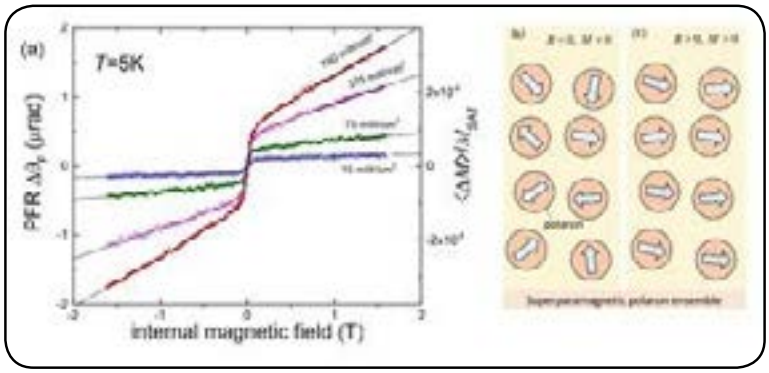

Figure 1: (a) Field dependences of the photo-induced FE in EuTe at various optical pumping intensities. (b) Photo-induced polarons form a paramagnetic ensemble: in the zero magnetic field each polaron has an arbitrary orientation, the average magnetic moment is zero. (c) Due to the large magnetic moment of the polaron a small magnetic field is needed to align all polarons at low temperature.

Recent Publications

1. Henriques A B, Naupa A R, Usachev P A, Pavlov V V, Rappl P H O and Abramof E (2017) Photoinduced giant magnetic polarons in EuTe. Physical Review B 95:045205.
2. Henriques A B, Gratens X, Usachev P A, Chitta V A and Springholz G (2018) Ultrafast light switching of ferromagnetism in EuSe. Physical Review Letters 120: 217203.
3. Henriques A B and Usachev P A (2017) Faraday rotation by the undisturbed bulk and by photoinduced giant polarons in EuTe. Physical Review B 96:195210.
4. Henriques A B, Galgano G D, Rappl P H O and Abramof E (2016) Light-induced polaron magnetization in EuTe at temperatures reaching 150 K. Physical Review B 93:201201(R).
5. Pavlov V V, Pisarev R V, Nefedov S G, Akimov I A, Yakovlev D R, Bayer M, Henriques A B, Rappl P H O and Abramof E (2018) Magnetic-field-induced crossover from the inverse Faraday effect to the optical orientation in EuTe. Journal of Applied Physics 123:193102.

Biography

Victor Pavlov has completed his PhD in the year 1993 and second PhD in the year 2007 at the Ioffe Institute, St Petersburg, Russia He is the laboratory head of optical phenomena in magnetic and semiconductor crystals He has published more than 80 papers on linear and nonlinear magneto-optical phenomena in bulk magnetically ordered materials and nanostructures.

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