Comment on "Two-Dimensional Optical Control of Electron Spin Orientation by Linearly Polarized Light in InGaAs"

Schmalbuch *et al.* [1] report an efficient generation of spin polarized electrons in the conduction band in *n*-doped bulk $In_xGa_{1-x}As$ by the optical absorption of linearly polarized light. Such a generation is astonishing for the described symmetry of the experiment and is in strong contrast to the well known optical selection rules, which have been confirmed by many experiments during the last 50 years.

In the following we prove by simple symmetry arguments that the interpretation of the reported efficient generation of polar spins as two-dimensional optical control of the electron spin orientation is questionable.

Schmalbuch *et al.* measure in Fig. 3(d) of Ref. [1] a nonzero polar spin polarization with a negligible magnetic field dependence. The measurement is carried out at an angle of the polarization of the pump pulse where the polar spin orientation has a maximum. This measurement strongly suggests that the effect is present even at a zero magnetic field; i.e., the magnetic field does not define a characteristic direction. Second, the interpretation of the presented experiment is based on the fact that the detection of the polar electron spin orientation does not depend on the direction of the light polarization of the probe pulse; i.e., the light polarization of the probe pulse does not define a characteristic direction [2]. Third, Fig. 4(a) of Ref. [1] shows that the effect does not depend on the orientation of the crystal orientation; i.e., the sample axes do not define a characteristic direction. Fourth, the same figure shows that the polar spin orientation depends very strongly on the direction of the linear polarization of the pump pulse. However, if neither the magnetic field, nor the polarization of the probe pulse, nor the strain-free mounted sample defines a characteristic direction, a dependence of the polar spin orientation on the direction of the light polarization of the pump pulse is fundamentally impossible for symmetry reasons [3].

Imperfect linear polarization can be very easily inadvertently introduced into such a time-resolved Faraday rotation setup by, e.g., nonperfect $\lambda/2$ retarders for the rotation of the linear polarization, the dielectric or protective coatings of mirrors, noncentric lenses, strained windows of the cryostat, tilted surfaces, and a not perfect strain-free mounting or growth-related strain of the sample [4,5]. Here, especially great care has to be taken for extremely small polarization effects as in the case of the continuous phase shift in Fig. 2(c) of Ref. [1] and its interpretation as the selective excitation of spins in the transverse direction.

As an unquestionable example of an experimental artifact at a rather low polarization, we want to point out Fig. 2(a) of Ref. [1]. The experimentally observed time resolved Faraday rotation shows distinct oscillations for an excitation with $\varphi = 0°$ and nearly no oscillations at $\varphi = 180°$. However, $\varphi = 0°$ and $\varphi = 180°$ represent a mathematically identical linear polarization; i.e., this discrepancy can only originate from effects disturbing the measurements from outside the sample.

In summary, the experimental data in Ref. [1] are unequivocally impaired by extrinsic effects and the original conclusion of two-dimensional optical control of the electron spin orientation by linear polarized light has to be taken with care.

Michael Oestreich* and Jens Hübner
Institut für Festkörperphysik
Leibniz Universität Hannover
Appelstraße 2, D-30167 Hannover, Germany

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*oest@nano.uni-hannover.de

[1] K. Schmalbuch, S. Göbbels, Ph. Schäfers, Ch. Rodenbücher, P. Schlammes, Th. Schäpers, M. Lepsa, G. Güntherodt, and B. Beschoten, Phys. Rev. Lett. **105**, 246603 (2010).
[2] For overlapping laser pulses or time delays between the pump and probe pulse, which are 3 orders of magnitude shorter than in Ref. [1], coherent effects as in four wave mixing can play a role. However, such effects can be excluded here.
[3] The symmetry in the direction of light propagation, which is identical to the direction of crystal growth, is nonrelevant for our line of argument; i.e., electric fields by surface charges, a gradient of the (excited) carrier density, etc., are irrelevant.
[4] Strain in the sample would result in the necessary reduction of the symmetry but also introduces birefringence and thereby affects the polarization of the light.
[5] Schmalbuch points out in a previous publication that the observed effect depends on the strain of the sample; see K. Schmalbuch, Ph.D. thesis, RWTH Aachen, 2010, ISBN 978-3-86853-362-0, Verlag Dr. Hut, http://www.dr.hut-verlag.de/978-3-86853-362-0.html. Therefore, the observed zero crossings in Figs. 3(c) and 4 might result from, among other things, strain-induced birefringence.