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Birefringent Spin-Laser as a System of Coupled Harmonic Oscillators

Adding spin-polarized carriers to semiconductor lasers strongly changes their properties and, through the transfer of angular momentum, leads to the emission of the circularly polarized light. In such spin-lasers the polarization of the emitted light can be modulated an order of magnitude faster than its intensity in the best conventional lasers[1]. This ultrafast operation in spin-lasers relies on the large linear birefringence, usually viewed as detrimental in spin and conventional lasers, which couples the two linearly polarized emission modes. We show that the dynamical properties of birefringent spin-lasers under intensity and polarization modulation are accurately described as coupled harmonic oscillators[2]. Our model agrees with the intensity-equation description[3] which, unlike the common complex field components describing the role of birefringence in laser dynamics, uses simpler real quantities and allows analytical solutions. We further predict unexplored operation regimes and elucidate the difference between the weak and strong coupling in spin-lasers[2] and how they can build on the recent breakthroughs in spin-light emitting diodes[4].

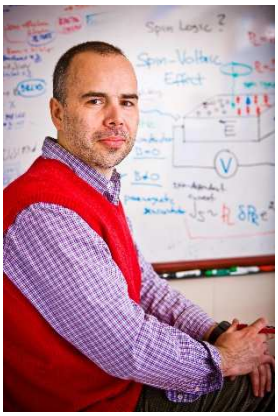
References:

1. M. Lindemann, G. Xu, T. Pusch, R. Michalzik, M. R. Hofmann, I. Žutić, *Nature* **568**, 212 (2019).

2. V. Labinac, J. D. Cao, G. Xu, I. Žutić, *Phys. Rev. B,* under review.

3. G. Xu, J. D. Cao, V. Labinac, I. Žutić, *Phys. Rev. B* **103**, 045306 (2021).

4. P. A. Dainone,…, I. Žutić, Y. Lu, *Nature* **627**, 783 (2024), highlighted in news & views S. Hiura, *Nature* **627**,737 (2024).



Igor Žutić is a Professor of Physics at the University at Buffalo, the State University of New York. He received PhD in theoretical physics at the University of Minnesota in 1998. His work spans topics from spin transport, superconductors, and Majorana fermions, to magnetic semiconductors, proximity effects, and two-dimensional materials. His predictions for spin devices not limited to magnetoresistance, such as spin-photodiodes, transistors, and lasers, have been experimentally realized. Igor Žutić is a fellow of the American Physical Society, a recipient of 2006 National Science Foundation CAREER Award, and 2019 State University of New York Chancellor's Award for Excellence

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