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Title:Femtosecond all-optical modulation of collective spin in the (Ga,Mn)As ferromagnet
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Abstract:Using a many-body theory, we discuss some fundamental issues of femtomagnetism in magnetic electronic systems. We address the question of how spin may couple to transient optical coherence during time scales shorter than the photoexcitation duration and the characteristic times of interaction with the lattice. We also discuss the role of the competition between magnetic exchange and spin-orbit interactions in the nonthermal temporal evolution regime. Using density matrix equations of motion, we predict a femtosecond collective spin tilt leading to nonthermal magnetization modulation and all-optical ultrafast switching between different metastable magnetic states of (Ga,Mn)As ferromagnets. This spin dynamics is triggered by carrier coherences and by nonthermal populations photoexcited along the f111g equivalent directions of the Brillouin zone, which can be controlled by tuning the laser frequency/intensity and by using a small magnetic field. We present femtosecond magneto-optical spectroscopy experimental results that agree with our predictions. Our results indicate the possibility of reading the (Ga,Mn)As magnetic memory at THz speeds limited only by the pulse duration. © 2012 Optical Society of America.
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Main heading:Manganese
Controlled terms:Equations of motion - Ferromagnetic materials - Ferromagnetism - Gallium - Magnetic fields - Magnetic storage - Magnets - Matrix algebra - Photoexcitation
Uncontrolled terms:All-optical - Brillouin zones - Collective spin - Density matrix equations - Electronic systems - Femtoseconds - Ferromagnets - Laser frequency - Magnetic exchange - Magnetic memories - Magneto-optical spectroscopy - Many-body theory - Metastable magnetic state - Nonthermal - Pulse durations - Spin orbit interactions - Temporal evolution - Time-scales -

Ultrafast switching

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