Master 2 Thesis proposal

Academic year 2023-24

Ultrafast magnetization dynamics driven by THz pulses

Institution : Institut de Physique de Rennes, University of Rennes/CNRS

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Keywords: *Magnetization dynamics, Ultrafast optics, Light matter interaction, Femtosecond spectroscopy, Terahertz, Perovskites materials, Anti-ferromagnetism, Phase transitions*

Description:

This master thesis targets to study rare-earth iron based oxide materials (orthoferrites) for future information technologies in the THz domain. Manipulating THz waves requires the availability of active optical elements such as electro-optical modulators or insulators and the underlying physics is based in particular on spin or magnetization dynamics of the material. A building block will be the development of a material class capable to show active optical responses in the THz and sub-THz frequency range. It has been shown by optical pump-probe studies that antiferromagnetic iron-based perovskite systems possess magnetization dynamics in the THz frequency domain.

The challenge is the control of a phase transition allowing to manipulate either the magnetization dynamics or the terahertz absorption of the material. Throughout this master thesis one selected orthoferrite material exhibiting several intrinsic magnetic phase transitions will be studied. The first step will be the study of the magnetization dynamics through time resolved magneto-optical spectroscopy for different magnetization configurations below and above an internal spin-reorientation transition. The second step will be to induce with phase transition dynamically through an optical near-infrared or a terahertz pump pulse.

Expected skills and competences:

The candidate should have basic knowledge of the physical properties of solids concerning magnetism and optics. Basic skills in experimental physics are very welcome. In addition, skills in programming are very welcome as the setup is currently implemented with Python. The candidate is expected to have good communication and analytical skills. The candidate will be working on a time resolved magneto-optical pump probe setup which will be equipped with a large spectrum Terahertz pulse generator. She/he will be trained in the use of very intense and ultrafast lasers as well as time-resolved spectroscopy.

The Material and Light team is currently a main actor of the international French-Japanese laboratory IRL Dynacom (Tokyo University/CNRS/Rennes University: http://irl-dynacom.chem.s.u-tokyo.ac.jp) and has a worldwide recognition in the field of ultrafast science. The working environment is multicultural and international. English is the working language.

References

(1)“Optical properties of solids”, Mark Fox, Oxford Series;
(2)“Magnetism in Condensed Matter”, Stephen J. Blundell, Oxford Series;
(3)“Resonant and non-resonant control over matter and light by intense terahertz transients”, T. Kampfrath, K. Tanaka and K. Nelson , Nature Photonics (2013);
(4) “Ultrafast non-thermal control of magnetization by instantaneous photomagnetic pulses”, A. V. Kimel, A. Kirilyuk, P. A. Usachev, R. V. Pisarev, A. M. Balbashov and Th. Rasing, Nature (2005)

The Team: the candidate will work inside the “Materials & Light Group” which is a research group based at the Institute of Physics of the University of Rennes including CNRS researchers. Our researches focus on ultrafast out-of-equilibrium phenomena in materials and molecules using optical and X-ray techniques with femtosecond to picosecond time resolution. The team is now part of a newly establish International Research Laboratory (IRL) involving French and Japanese Universities (University Tokyo, Tokyo Institute of Technology, Tohoku University). More information can be found on the website:
https://ipr.univ-rennes.fr/departement-materiaux-et-lumiere

Duration: *from* 01/02 /2024 *to* 31 /07 /2024
Gratification/salary: 570 (€/month)
PhD opportunity: Yes, funding for one PhD project is 100% secured

Interested candidate should contact :

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