Universität Bern
Institut für Angewandte Physik
Sidlerstrasse 5
3012 Bern
Schweiz

Telefon: +41 (0)31 631 89 11
Telefax: +41 (0)31 631 37 65
E-Mail: IAPemail@iap.unibe.ch
WWW: http://www.iap.unibe.ch/

UNIVERSITÄT BERN

Seminar über Ultrafast Science and Technology

Referent: Dr. Paul Beaud, FEMTO Group, Paul Scherrer Institut, Villigen

Titel: Ultrafast structural dynamics in solid matter studied by x-ray diffraction

In many modern materials the correlation among outer shell electrons leads to interesting properties such as superconductivity, colossal magnetoresistance and multiferroicity. Often the interactions of the long range order of the electronic degrees of freedom such as charge, orbital and magnetic order couples to the underlying lattice. The study of these different types of orders using x-ray diffraction has become an essential tool for the characterization of strongly correlated electron systems. Recent developments in ultrashort x-ray sources offer new possiblities to extend diffraction techniques into the time domain to study the coupling between the lattice and different electronic subsystems as they develop in time. Using our low flux femtosecond hard x-ray source at the Swiss Light Source [1] we had the opportunity to make significant scientific and technical contributions in developing femtosecond x-ray diffraction to study laser induced structural dynamics in solid matter. Nevertheless the future in this area of research lies in free electron laser facilities that provide much higher x-ray flux and significantly better time resolution [2]. In my talk I will start with an overview over hard x-ray diffraction techniques mainly addressing the issues that arise when adding an intense laser pump to the experimental configuration.
In the second part I will focus in more detail on one of our ongoing research topics. Perovskite-type manganites are prototypical examples of strongly correlated electron systems which exhibit properties such as colossal magnetoresistance and insulator-to-metal transitions that are intrinsically related to symmetry changes of the atomic lattice and to intriguing ordering patterns of the spins, orbitals and charges [3]. Here the application of an intense optical pulse melts the electronic order and induces an ultrafast insulator-metal transition [4]. Initial diffraction experiments performed at the SLS slicing source demonstrated a concomitant change of structural symmetry occurring on a sub-picosecond time scale [5-7]. In a recent experiments at the LCLS free electron laser we were not only able to study in more detail the lattice dynamics, but also the changes in long-range order of the electronic subsystems by tuning the x-ray energy ‘to’ and ‘off’ an atomic resonance [8]. Despite the complex nature of this phase transition that involves symmetry changes of valence charge, orbital order and atomic structure, a fairly simple description relying on a single time-dependent order parameter is sufficient to capture the most essential aspects of the change in symmetry in the time domain.
[1] P. Beaud, S. L. Johnson, A. Streun, R. Abela et al., Phys. Rev. Lett. 99, 174801 (2007). [2] P. Emma, R. Akre, J. Arthur, R. Bionta, C. Bostedt, J. Bozek et al., Nature Phot. 4, 641 (2010). [3] Y. Tokura and N. Nagaosa, Science 288, 462–468 (2000). [4] D. Polli, M. Rini, S. Wall, R. W. Schoenlein, et al., Nature Mater. 6, 643 (2007). [5] P. Beaud, S. L. Johnson, E. Vorobeva, U. Staub et al, Phys. Rev. Lett. 103, 155702 (2009). [6] A. Caviezel, S. O. Mariager, S. L. Johnson, E. Möhr-Vorobeva et al., Phys. Rev. B 86, 174105 (2012) [7] A. Caviezel, U. Staub, S. L. Johnson, S. O. Mariager et al., Phys. Rev. B 87, 205104 (2013). [8] P. Beaud, A. Caviezel, S. O. Mariager, L. Rettig, G. Ingold et al., Nature Mater. 13, 923 (2014).

Zeit: Donnerstag, 18.12.2014, 11:15 Uhr

Ort: **Hörsaal B116**, Gebäude exakte Wissenschaften, Sidlerstrasse 5, Bern, Schweiz