Atomic Diffusion studied by Coherent X-ray Scattering

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Diffusion in condensed matter is fundamental to aspects as diverse as phase transitions, corrosion, high-temperature materials stability, or ionic conduction. On the macroscopic scale, the temporal evolution of diffusion gradients is fully captured by the partial differential diffusion equation, and the experimentally accessible handle is how the diffusion constant depends on, e.g., composition and temperature. However, an understanding of the processes at work can only be achieved in terms of an atomic-scale picture, and corresponding direct experimental evidence is thus clearly desirable. Specifically, this pertains to the discrete jump vectors and frequencies of the atoms on their random walk as well as possible correlations between subsequent jumps.

In this talk I will introduce atomic-scale X-ray photon correlation spectroscopy, a synchrotron-based experimental method that allows us to follow the atoms during their movement in real time in a statistical sense, with a sensitivity to jump rates on timescales of seconds to hours [1]. I will review the theoretical concepts and discuss the relations to alternative atomically-resolved methods. Further, I will give an overview on our results in crystalline and amorphous matter, comprising metals, semiconductors and insulators. Apart from jump vectors and frequencies as well as short-range order effects in equilibrium diffusion, I will present also our interpretation of the recent findings of beam-induced dynamics, where in specific systems the absorption of hard X-ray photons leads to athermal atomic motion.

References

[1] M. Leitner, B. Sepiol, L.-M. Stadler, B. Pfau, and G. Vogl: *Atomic diffusion studied with coherent X-rays*. Nature Materials **8**, 717-720 (2009).