HOLOGRAPHIC FINE STRUCTURE IN NUCLEAR RESONANT ABSORPTION

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The majority of x-ray, electron and neutron scattering techniques are based on measuring the scattered wave intensity in the far field. Probing the scattered wave field inside the sample, which can be effected by monitoring the absorption of particular atoms or nuclei of the sample, makes it possible to use Gabor's holographic formalism [1] to analyze the scattering pattern and to overcome the crystallographic phase problem. The interference between the external radiation reaching the absorbing atoms either directly (the holographic reference wave) or after scattering on nearby atoms (the object waves) results in angular fine structure of absorption, which can be directly back-transformed [2] to yield a three-dimensional image of local structure around absorbing atoms. By selection of the characteristic radiation emitted from atomic detectors, chemical resolution can be achieved. However, holographic methods using x-rays and neutrons were unable to distinguish between atoms of the same kind, which occupy non-equivalent crystallographic sites. This ability is provided by γ-ray holography [3] utilizing coherent effects in the Mössbauer nuclear absorption, as it gives spectroscopic information. With hyperfine interactions, nuclear detectors can probe internal electromagnetic fields inside the sample and thus provide local spectroscopic information, which can be used to distinguish between crystallographic sites having different chemical environments and magnetic properties.

In this talk we describe the principles of γ-ray holography and we discuss recent results [4] of site-selective imaging of Fe_3O_4 local structure using complex γ-ray holograms [5]. This work was supported by Volkswagen Foundation, Federal Republic of Germany.

[1] G. Faigel and M. Tegze, Rep. Prog. Phys. **62** (1999) 355.
[2] J. J. Barton, Phys. Rev. Lett. **61** (1988) 1356.
[3] P. Korecki, J. Korecki, and T. Slezak, Phys. Rev. Lett. **79** (1997) 3518.
[4] P. Korecki, M. Szymonski, J. Korecki, and T. Slezak, Phys. Rev. Lett. **92** (2004) 205501.
[5] P. Korecki, G. Materlik, and J. Korecki, Phys. Rev. Lett. **86** (2001) 1534.