X-ray Image Reconstruction using the Transport of Intensity Equation

Keith A Nugent

School of Physics, The University of Melbourne, Vic., 3010, AUSTRALIA

The transport of intensity equation (ToI) describes the flow of energy in a wavefield and applies quite generally to all forms of waves, including quantum mechanical waves such as neutrons, atoms, electrons, as well as light and x-rays. The only assumption in its derivation is that the flow of light is paraxial, meaning that the flow of light is predominantly along a given direction. This is almost always true for synchrotron-based imaging. The ToI can be used to create a phase image by measuring the intensity in the plane of interest and the rate at which the intensity is changing along the optical axis. It has been used to reconstruct phase images for all of the types of wave mentioned above.

For longer wavelength waves, such as visible light, a number of quantitative phase measurement tools are available. Interferometry is the most familiar of these and it requires waves with a high degree of spatial coherence. This level of coherence is harder to achieve with x-ray sources. Phase recovery using the ToI is very forgiving in terms of spatial coherence and can be used to obtain phase images even for almost completely incoherent light. Moreover, the method of image acquisition is inherently linear and so it has the unique property that image formation can be properly described using optical transfer functions even for partially coherent illumination.

In this talk I will review the ideas underlying imaging using the ToI, present experimental results and then discuss how the ideas may be extended to very high resolution coherent diffractive imaging.