Ten years of X-ray phase imaging development with grating analyzer
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In the 1990s, a variety of techniques for generating X-ray phase contrast were extensively studied to observe weakly absorbing objects [1]. In an early stage, X-ray phase-contrast images were recorded simply by X-ray films or X-ray image detectors. Even if X-ray phase contrast is successfully generated, however, not only absorption contrast but also other contrasts originating from the phase-contrast method used and imperfection of optical elements are normally contained. Therefore, the contrasts in resultant images were occasionally too complicated to understand the inner structure of samples. ‘X-ray phase imaging’ has been developed to solve this inconvenience; that is, X-ray phase imaging involves a phase retrieval technique that extracts images quantitatively corresponding to amplitude and phase of X-rays passing through a sample from digitally recorded phase-contrast images. All X-ray phase-contrast methods were combined with some phase retrieval technique in that decade. Thanks to the quantitative feature of X-ray phase imaging, the combination with X-ray computed tomography was realized (X-ray phase tomography) for three-dimensional high-sensitive image reconstruction.

The performance of X-ray phase imaging motivates us to realize its practical applications to medicine and industry. However, the technology only at synchrotron radiation facilities never meet these demands. While many types of X-ray phase imaging methods essentially require the use of synchrotron radiation because of its high brightness and high coherence, X-ray grating interferometry (XGI), such as X-ray Talbot or Talbot-Lau interferometry, which detects X-ray refraction and scattering by using a analyzer grating, brought a breakthrough towards practical applications in the 2000s [2, 3]. A XGI-based apparatus for diagnosing articular rheumatism by depicting cartilage has been successfully developed and used for patients at hospitals now for clinical study [4].

XGI has also brought great flexibility to synchrotron-based X-ray phase imaging. Since
it is compatible with a spherical wave, the combination with an X-ray imaging microscope is possible. This enables us to realize X-ray phase imaging/tomography with a mesoscopic spatial resolution [5,6]. Furthermore, since XGI is compatible with polychromatic X-rays, X-ray phase imaging with white synchrotron radiation is possible. This implies that high-speed phase imaging and four-dimensional phase tomography is attainable [7,8]. Recently I have established a team at SPring-8 to explore these technologies further under JST-ERATO Momose quantum-beam phase imaging project.

In the presentation, I will review the last decade of XGI development and discuss the future of this field.

References