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Hard X-ray Omnidirectional Differential Phase and Dark-Field Imaging

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Ever since the discovery of X-rays, tremendous efforts have been made to develop new imaging techniques for unlocking the hidden secrets of our world and enriching our understanding of it. X-ray differential phase contrast imaging, which measures the gradient of a sample's phase shift, can reveal more detail in a weakly absorbing sample than conventional absorption contrast. However, normally only the gradient's component in two mutually orthogonal directions is measurable. We demonstrate an approach to generate a new type of X-ray imaging mode, which called omnidirectional X-ray differential phase imaging.1 The proposed method enables us to detect the subtle phase changes in all directions of the imaging plane, which complements conventional X-ray imaging methods with information that they cannot provide. Importantly, the omni-directional dark-field images can also be simultaneously retrieved for studying a wide range of complicated samples, particularly strongly ordered systems. The extract information will not only provide insights into the micro-architecture of materials, but also enrich our understanding the macroscopic behaviour. The presented technique could potentially open up numerous practical imaging applications in both biomedical research and materials science.

FIG. 1. (a) and (b) The retrieved average D_0 and amplitude D_1 of dark-field signal of a woodlouse sample. The gray color indicates that the normalized D_0 and D_1 changes from 0 (dark) to 1 (bright). (c) The constructed omni-directional dark-field, as rendered in an HSV color scheme. (d) and (e) The main orientation □_A [0, 2□] and normalized amplitude A_1 [0, 1] of differential phase. (f) The constructed omni-directional differential phase, as rendered in an HSV color scheme. (g) and (h), The calculated horizontal and vertical differential phase from A_1 and □_A. The gradient varies from -3□rad to 3□rad (bright). (i) The reconstructed phase from (g) and (h), in which the phase ranges from -60 (dark) to 60rad(bright). The scale bar is 0.5mm.

Reference
1. H. Wang and K. Sawhney, Proc. Natl. Acad. Sci. U.S.A. 118, 2022319118 (2021).

I plan to submit also conference proceedings

Yes

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