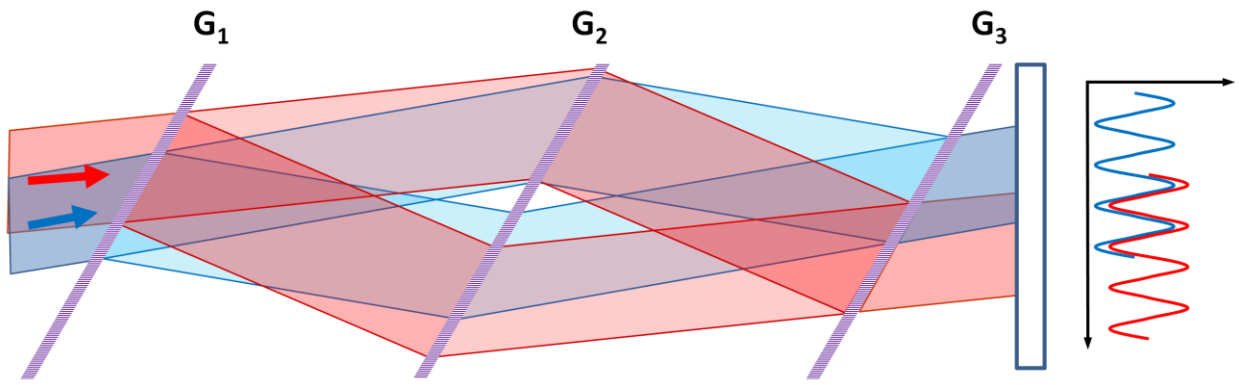
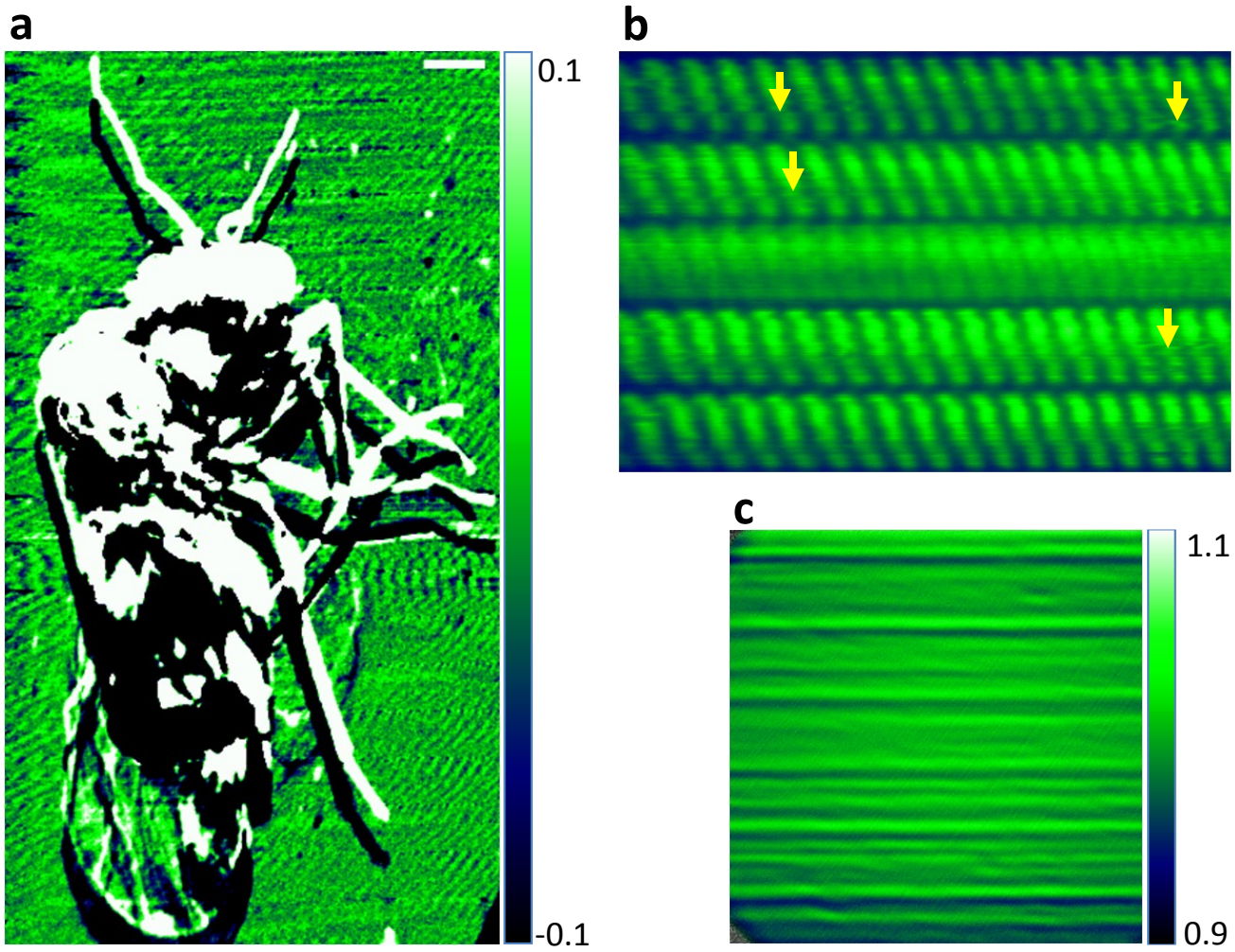
Supplementary Information

Supplementary Figure S1



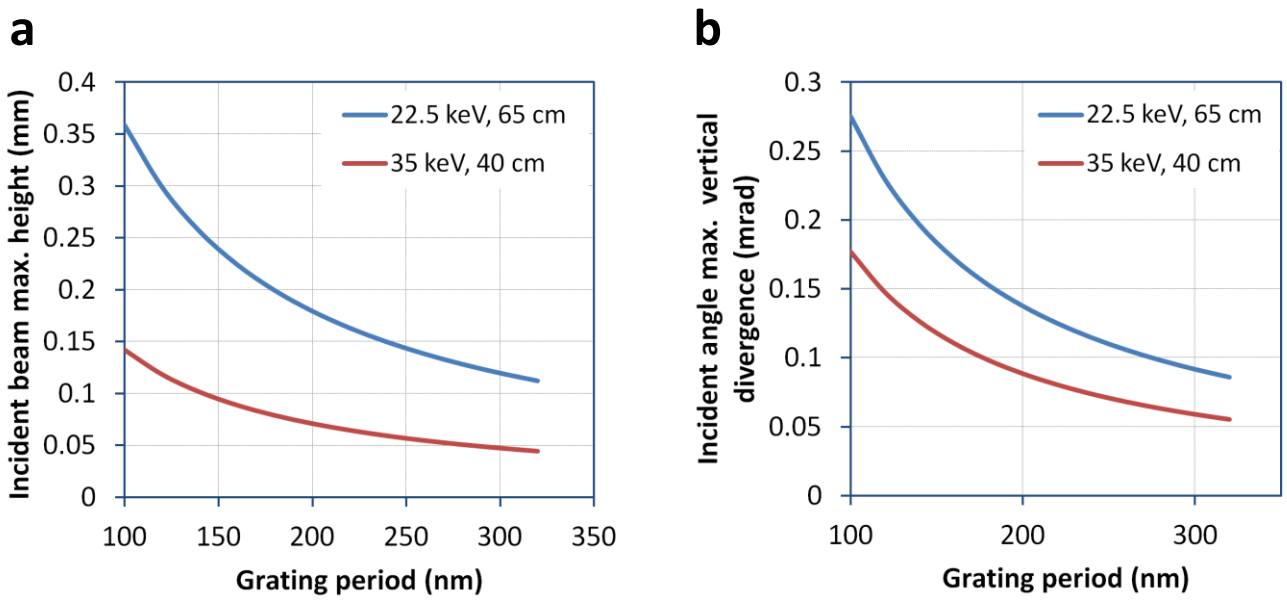
Supplementary Figure S1: Fringe patterns from different wavelengths and incident angles are phase-locked. Two incident beams of different wavelengths and directions are represented by red and blue bands. They each produce a pair of symmetric diffraction pathways that result in interference fringes on the image plane (the red and blue curves on the right). Due to the symmetry of the grating arrangement, these patterns are aligned in their peaks and troughs (phase-locked). Generally, with a polychromatic and divergent source, the fringes from all wavelengths and incident directions are aligned with each other and sum constructively.

Supplementary Figure S2



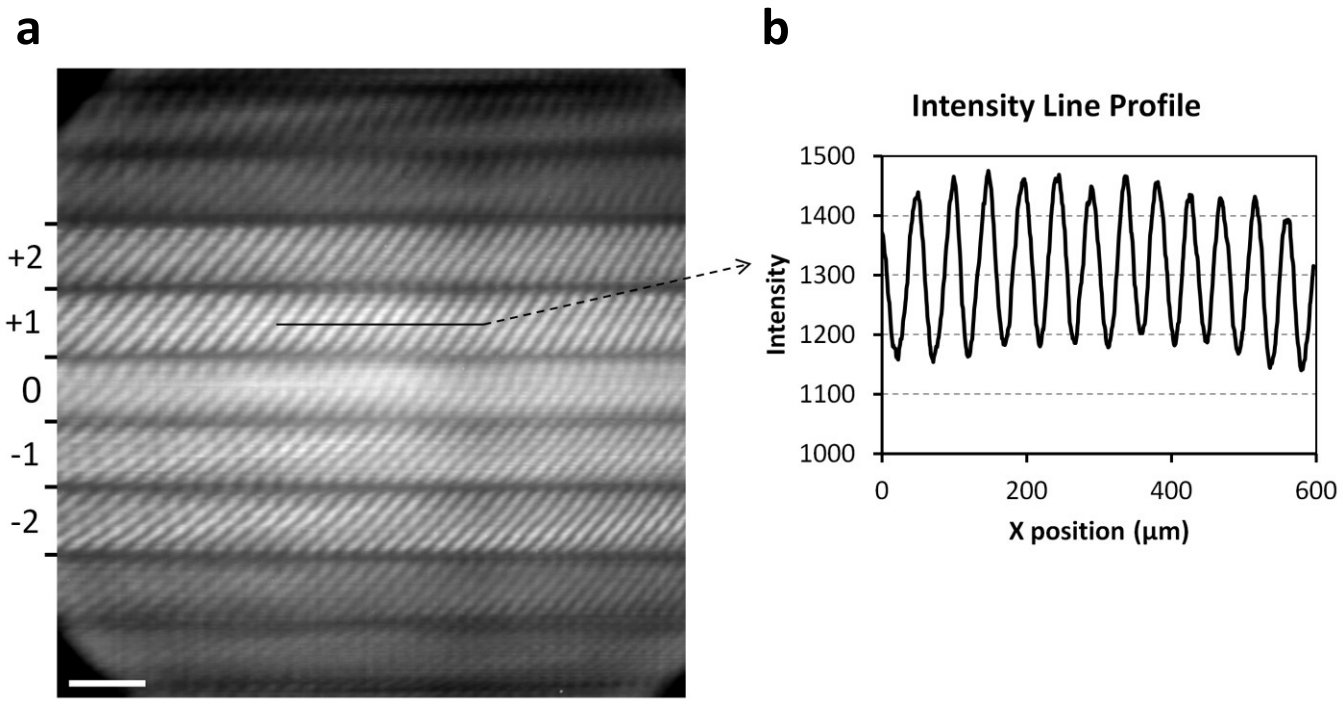
Supplementary Figure S2: Structured background phase noise and its sources. **a**. The unwrapped phase difference image of a fruit fly is shown in a color scale from -0.1 to 0.1 radians. The scale bar is 200 μm. The background noise displays regular patterns. The structured noise is likely coming from, **b**, imperfections in the gratings causing dislocations and defects in the interference fringe pattern (indicated by arrows), and, **c**, temporal fluctuations in the intensity pattern of the beamline during the phase stepping process, which can be seen in this ratio image between two consecutive shots of the beam, taken within 10 seconds.

Supplementary Figure S3



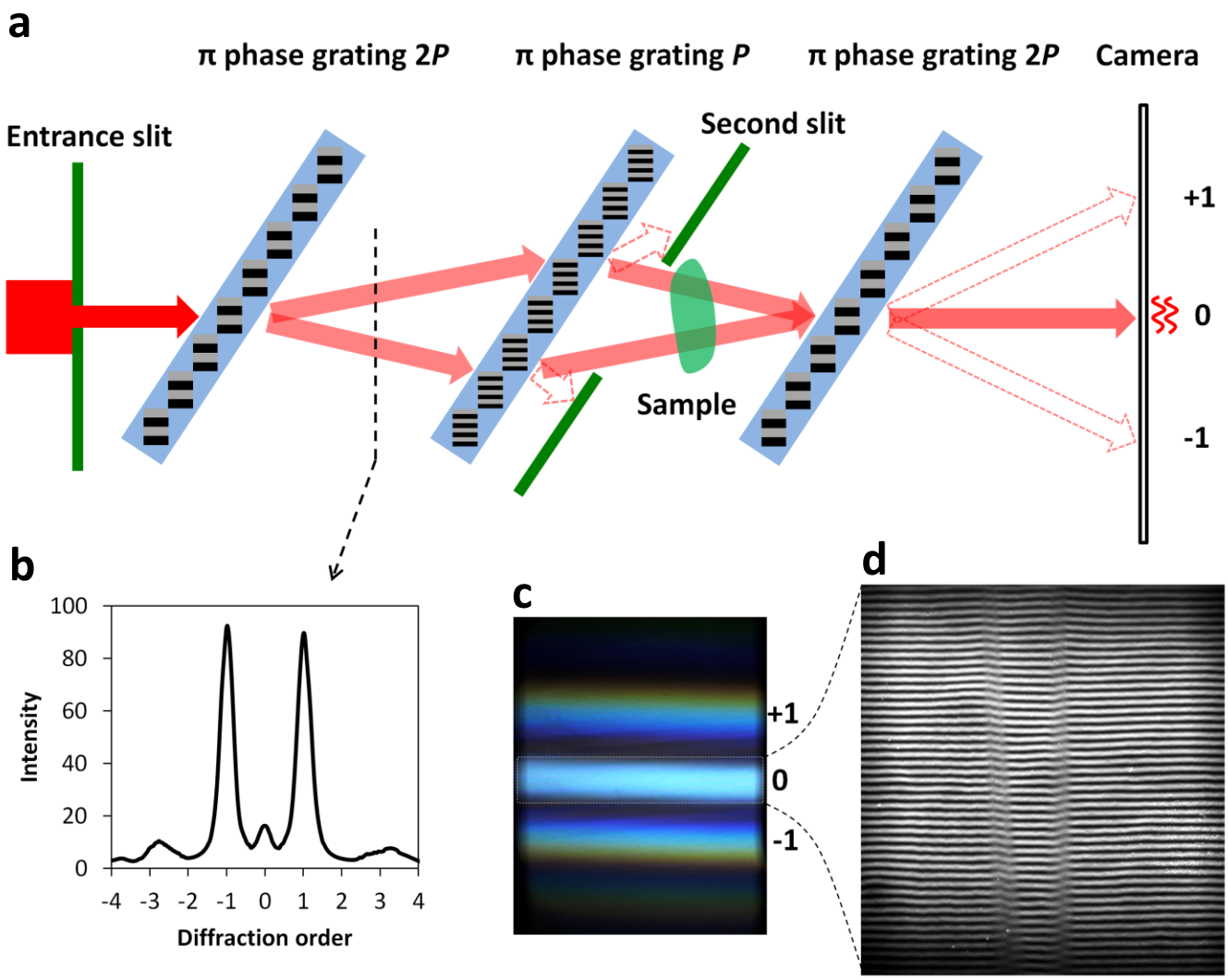
Supplementary Figure S3: Conditions on the vertical height and vertical angular divergence of the incident beam. Based on the requirement that the different diffraction pathways are separated on the image plane, the maximum height of the incident beam, **a**, and vertical angular divergence, **b**, are plotted as functions of the grating period for two system settings. The first is the setting of the current study (22.5 keV and 65 cm inter-grating distance), the second is a projected system of 35 keV photon energy and 40 cm inter-grating distance.

Supplementary Figure S4



Supplementary Figure S4: Intensity profile of the interference fringes in an image from the x-ray GBH interferometer. **a**, an image from the x-ray GBH interferometer of the P-P-P configuration contains distinct diffraction bands. The +/-2 and +/-1 bands include coherent diffraction pathways which produce interference fringes, as well as other incoherent diffraction paths which form a background intensity. The scale bar is 200 µm. **b**. The intensity profile across the +1 band displayed a fringe visibility of 12%. The fringe visibility is defined as $(I_{max}\text{-}I_{min})/(2I_{average})$.

Supplementary Figure S5



Supplementary Figure S5: The 2*P*-*P*-2*P* configuration of a visible-light GBH interferometer with π phase shift gratings achieves near ideal fringe visibility. **a**. The 2*P*-*P*-2*P* design of a GBH interferometer was tested in a visible light version using a white flashlight as the source. The pair of symmetric diffraction pathways are fully isolated from other light paths, forming the central 0th order band on the image plane. **b**. The measured grating diffraction profile under white light indicates that most of the energy is diffracted into the +1/-1 orders. **c**. The diffraction pathways fall on three bands on the image plane. **d**. The central band contains interference fringes of 78% visibility. A phase object caused a visible shift of the fringes in the central area.