

Implementation of free-space Fourier Ptychography with near maximum system numerical aperture: supplement

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1. Resolution quantification for simulated high-NA FPM and standard transmission microscope

We simulated Siemens star images from both high-NA FPM and standard transmission microscope. Parameters used in simulation were the same as experimental set-up, with objective lens NA of 0.95, maximum illumination of 0.95, objective lens magnification of 50x and camera pixel size of $6.5 \mu\text{m} \times 6.5 \mu\text{m}$.

We simulated high-NA FPM modality by first generating raw data from simulated coherent imaging and then performing reconstruction with the FPM rendering algorithm used in the experiments. For each oblique-illuminated raw data, the object field was directly Fourier transformed to get the Fourier spectrum and then applied to spatial-shifted coherent transfer function (CTF) with objective NA of 0.95. The shift vector was determined by the illumination angle. Then an inverse Fourier transform was performed to convert the Fourier spectrum back to the image field. The final image was generated by modulus squaring the image field and then sampling by the camera sensor array. The FPM rendering from simulated raw data is shown in Fig. S1(a1).

For standard transmission microscope, which is an incoherent imaging modality, the object field was modulus squared and Fourier transformed to generate the Fourier spectrum of the object intensity. Then the optical transfer function (OTF) with objective NA of 0.95 was applied to the object intensity Fourier spectrum. The final image was generated by inverse Fourier transforming the modulated frequency spectrum followed by sampling with the camera sensor array, which was showed in Fig. S1(b1).

We adopted Sparrow's criterion and full pitch resolution when claiming resolution for both systems. Under such criterion the resolution is defined as the minimum periodicity where every spoke of the Siemens target can be resolved. From simulation the simulated resolution of high-NA FPM and standard transmission microscope are separately 245 nm and 278 nm. Simulated Siemens star images from both systems and intensity plot along minimum circles are shown in Fig. S1(a2) and Fig. S1(b2).

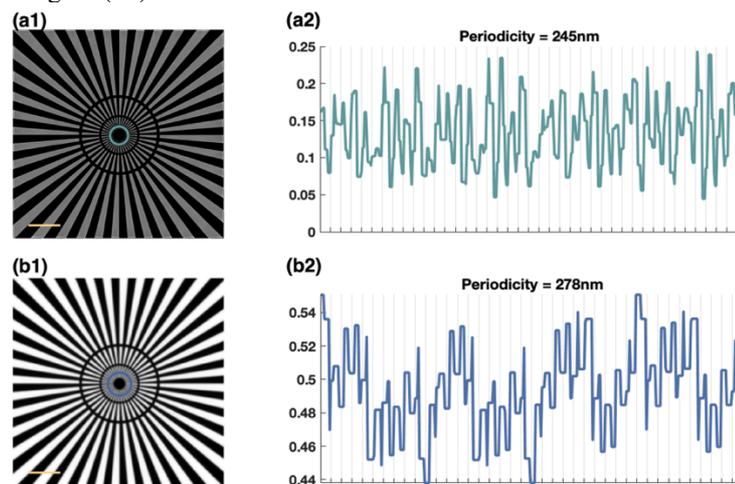


Fig. S1. Simulated Siemens star imaging and resolution quantification. (a) Siemens star imaged by simulated high-NA FPM (a1) and intensity plots along the minimum resolvable circle (a2). (b) Siemens star imaged by simulated standard transmission microscope (b1) and intensity plots along the minimum resolvable circle (b2). Scale bar: $5 \mu\text{m}$.

2. Imaging results of bone marrow smear sample

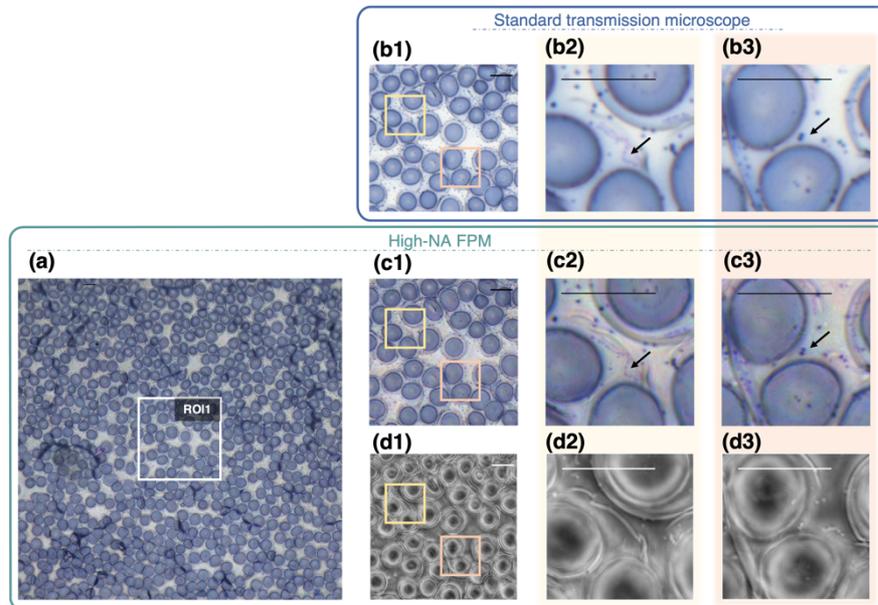


Fig. S2. Bone marrow sample imaging by high-NA FPM and standard transmission microscope. (a) Whole-frame color high-NA FPM bone marrow smear image. (b) Color image and enlarged details of the region of interest (ROI) 1 from standard transmission microscope. (c) Color image and enlarged details of the ROI 1 from high-NA FPM. (d) Phase image reconstructed from blue channel and enlarged details of ROI 1. Scale bar: 10 μm .

3. Resolution quantification for high-NA FPM and standard transmission microscope under defocus condition

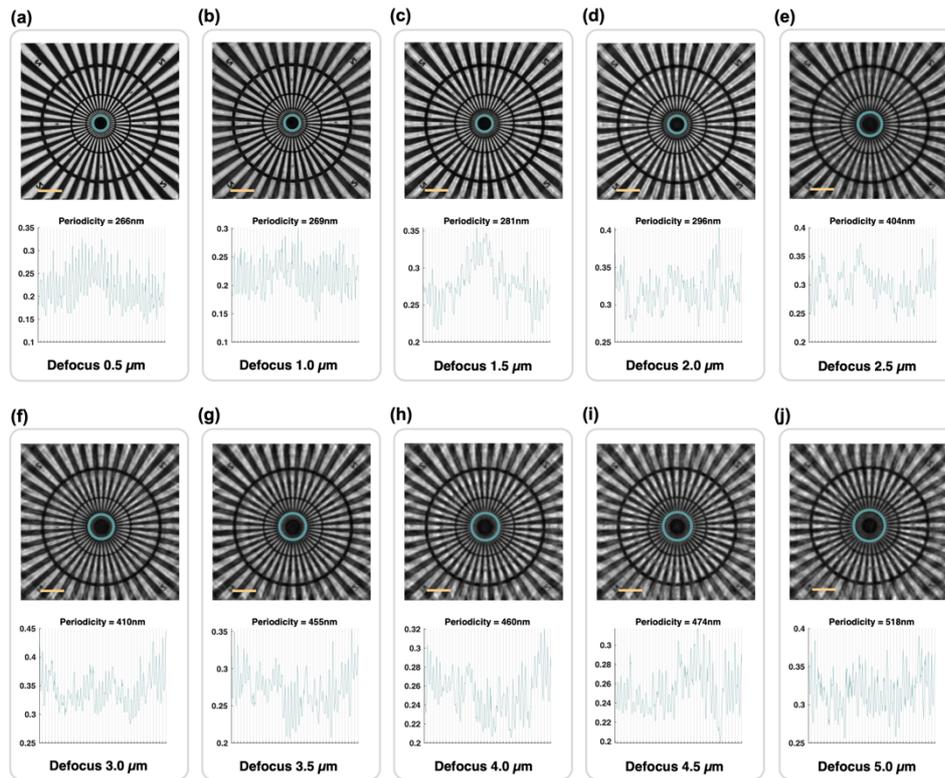


Fig. S3. Resolution quantification for high-NA FPM under defocus condition. Both high-NA FPM with digital refocusing images and intensity plots along the minimum resolvable circle are provided. Scale bar: $5 \mu\text{m}$.

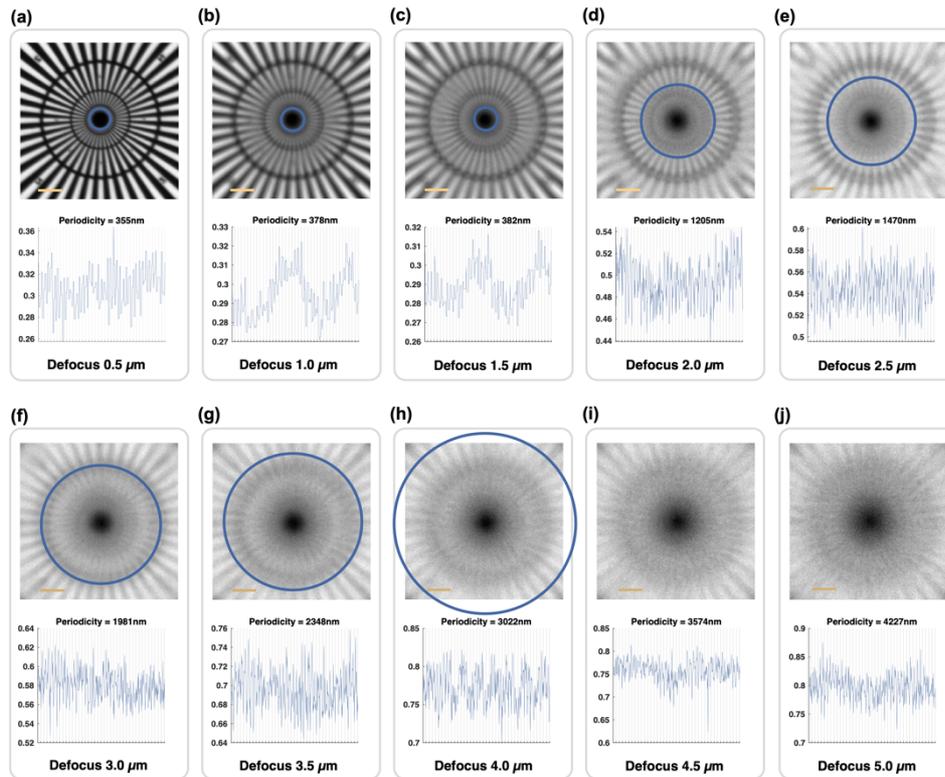


Fig. S4. Resolution quantification for standard transmission microscope under defocus condition. Both standard transmission microscope images and intensity plots the along minimum resolvable circle are provided. Minimum resolvable rings became so large that they fall out of demonstrated Siemens star images when defocused for 4.5 μm (i) and 5 μm (j). Scale bar: 5 μm .