

Phase Recovery Fourier Ptychographic Microscopy

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Why a Phone as the Light Source

- Standard FPM uses a programmable LED array, dozens to hundreds of individually addressable elements, as the angular-diversity source. That hardware is expensive and hard to access outside a specialized optics lab.
- I replaced the LED array with an ordinary smartphone screen: sweeping a bright point across the display provides the same angularly diverse illumination at near-zero hardware cost.
- Each screen position acts as a “virtual LED.” I built the acquisition sequencing and the full EPRY-based reconstruction pipeline around this substitution.
- This allows for usage outside of the lab and excluding complex and expensive cameras and LEDs

Planned Experimental Setup (Planned)

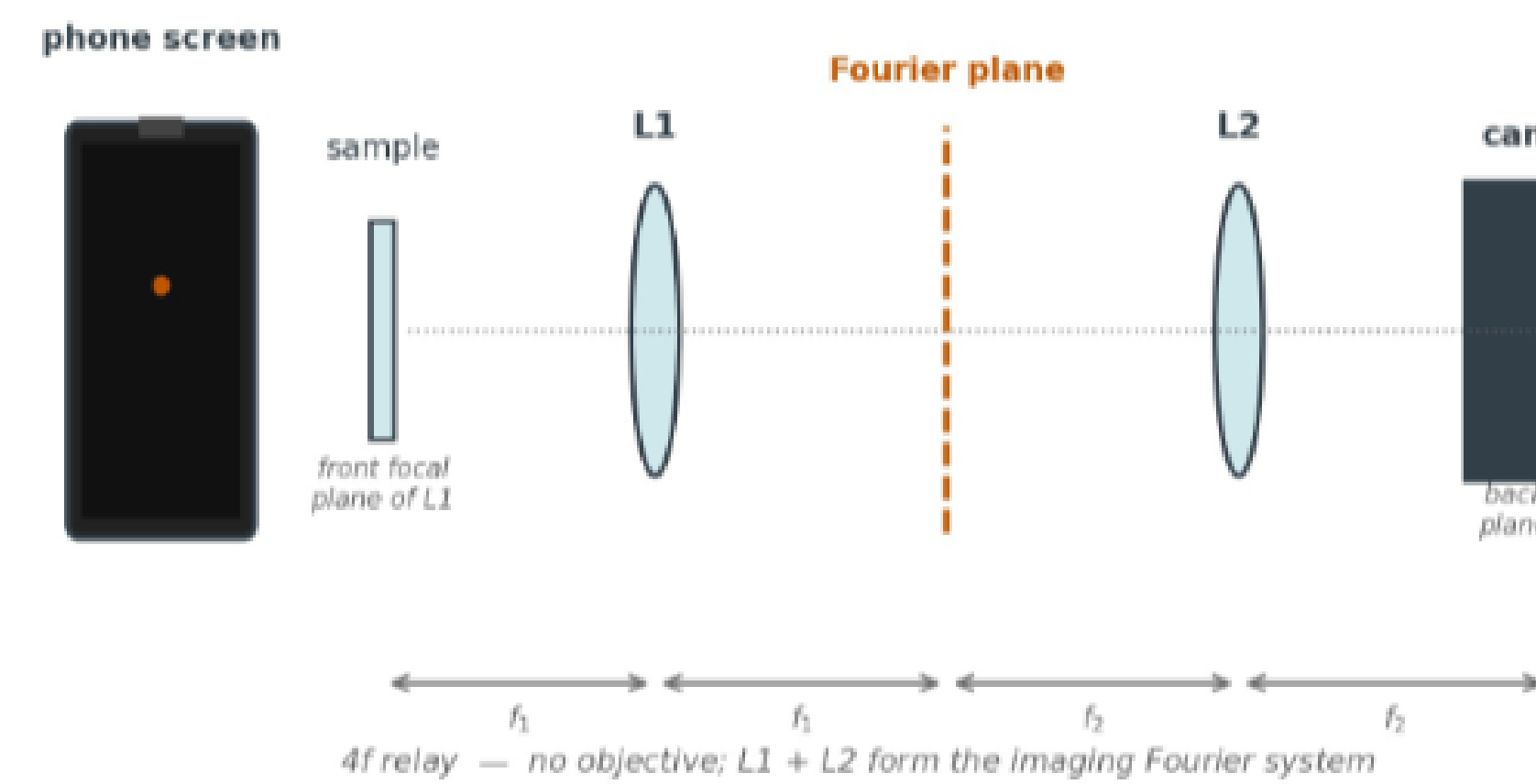


Figure 1. Phone-illuminated FPM acquisition. The phone screen replaces the LED array; standoff distance and screen pitch set the achievable illumination NA.

- 4f relay with two 50 mm lenses (1× magnification) and an iris at the shared Fourier plane; no objective.
- Phone sits behind the sample and displays a moving bright point, stepping through a grid of $N = 200$ positions, each giving a different illumination angle.
- A [laptop/script] drives the phone and triggers the camera, so each frame maps to one known illumination angle.
- Used a single color channel (blue) from the phone for a well-defined illumination wavelength.
- Fixed the phone-to-sample distance z with a sample stage to set the illumination NA.
- Calibrated each screen position's illumination angle against a known target before acquisition.

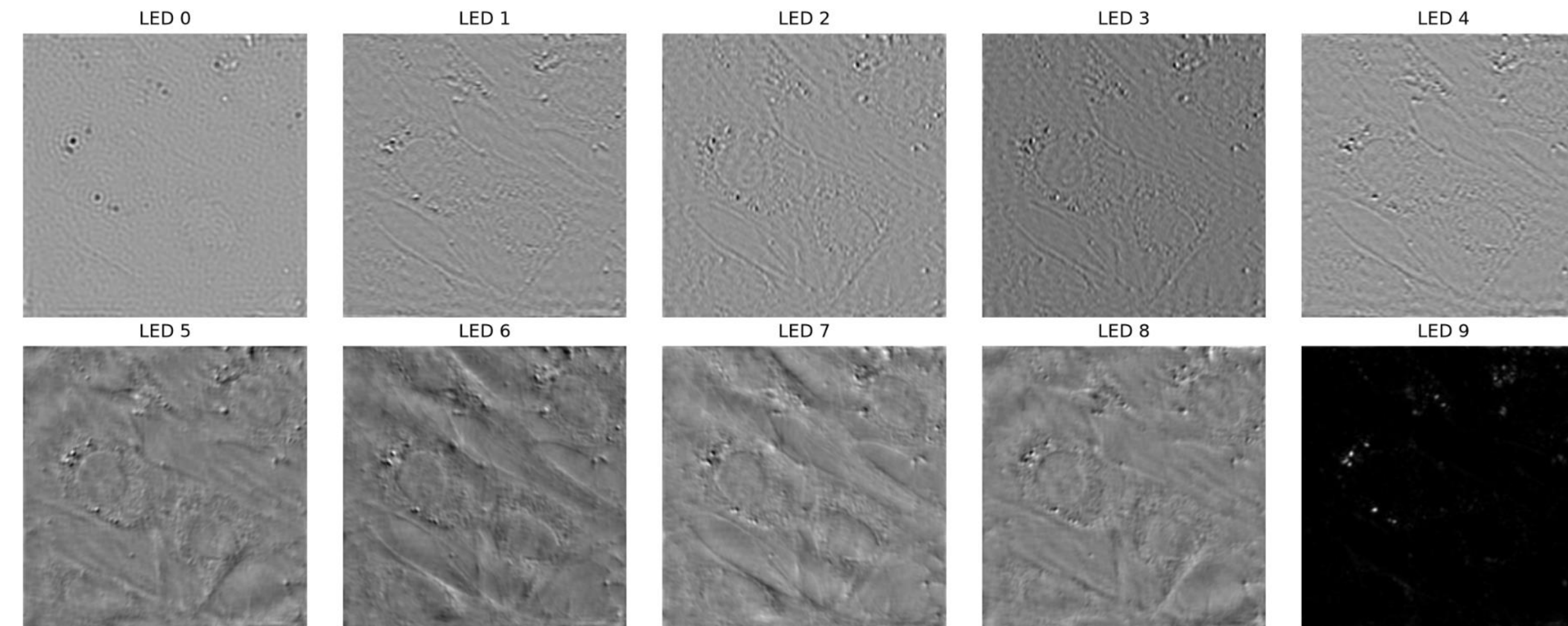
References

- [1] G. Zheng, R. Horstmeyer, C. Yang. Wide-field, high-resolution Fourier ptychographic microscopy. Nat. Photonics 7, 739–745 (2013).
- [2] X. Ou, G. Zheng, C. Yang. Embedded pupil function recovery for Fourier ptychographic microscopy. Opt. Express 22, 4960–4972 (2014).
- [3] L. Tian, X. Li, K. Ramchandran, L. Waller. Multiplexed coded illumination for Fourier ptychography. Biomed. Opt. Express 5, 2376–2389 (2014).

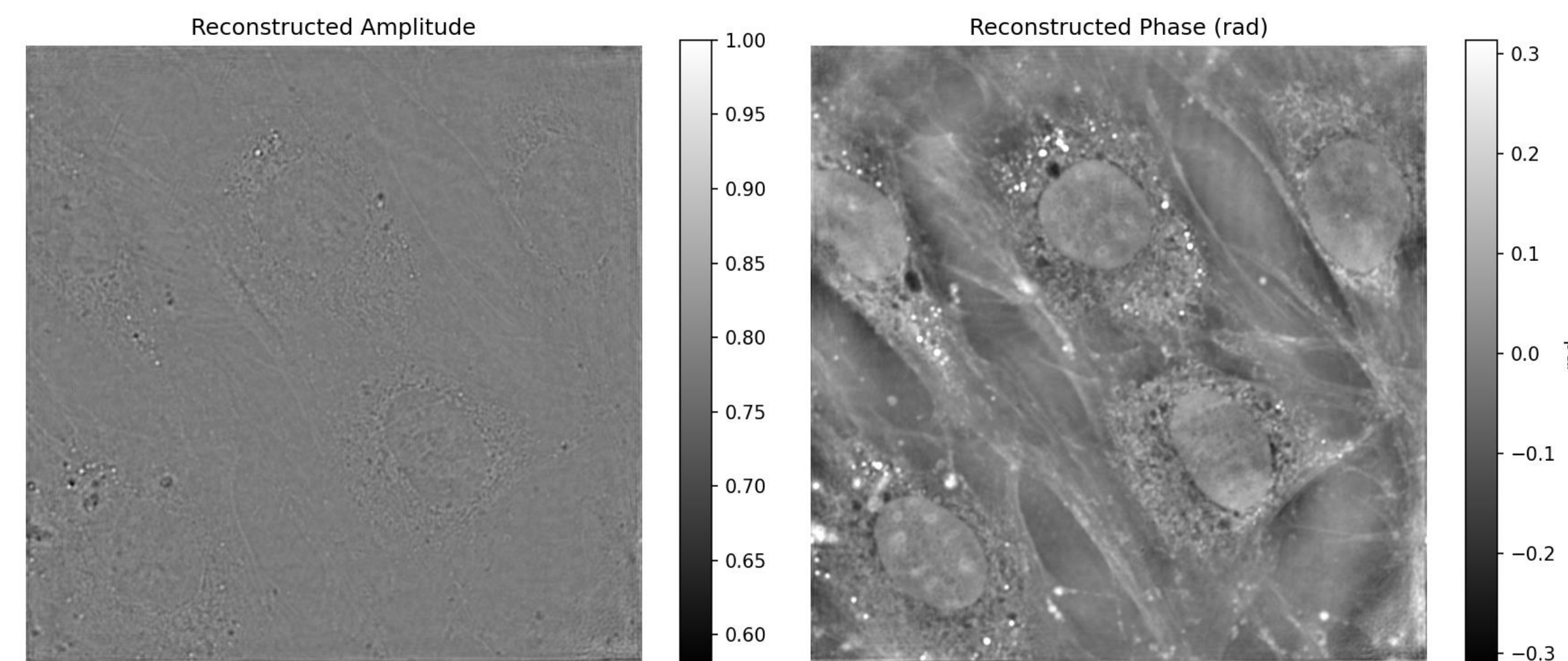
Reconstruction Pipeline

- Sequentially display a bright point at each of N calibrated screen positions, capturing one low-resolution intensity frame per position.
- Take the FFT of each capture and place it in the correct location in the full Fourier spectrum, based on the illumination angle for that position.
- Crop the matching patch from the current image estimate, replace its magnitude with the measured magnitude (keeping the estimate's phase), then transform back and update that region of the estimate.
- Repeat across all N images, iterating until the estimate stops changing significantly, then assemble the final high-resolution amplitude and phase reconstruction.

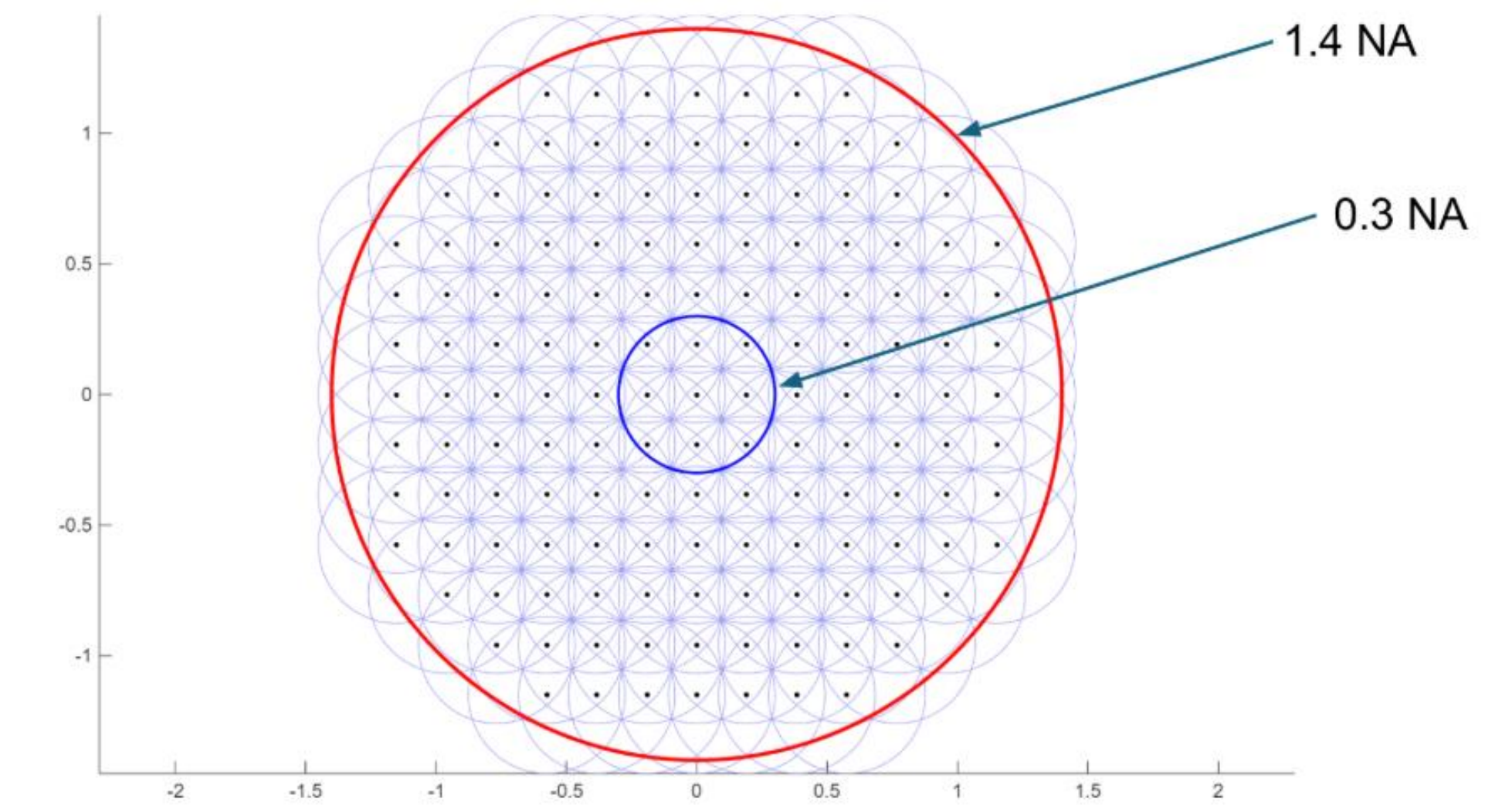
Raw Captures



Reconstruction

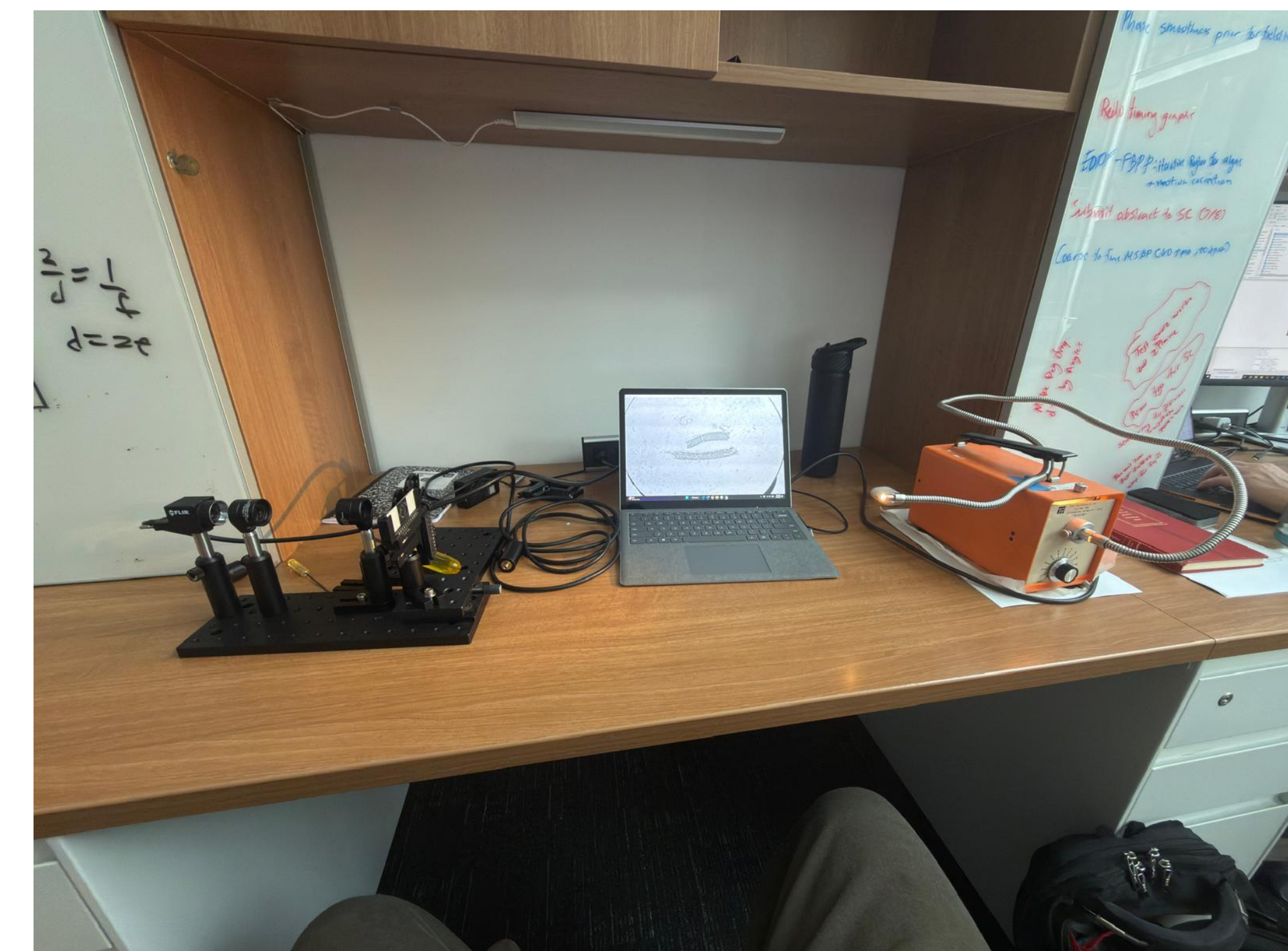


Fourier Synthesis



What I Observed

- Phone-screen brightness is lower than a dedicated LED, so I [increased exposure / used a bright-spot pattern] to keep SNR usable.
- Screen pixel pitch and standoff distance jointly cap the achievable illumination NA, I mapped this for my setup.
- Position-to-angle calibration is critical: small errors visibly blur the EPRY-recovered pupil.



Conclusions

- A smartphone screen is a fully functional, near-zero-cost, programmable angular-diversity source for FPM, it reproduces standard LED-array acquisition geometry.
- This substitution meaningfully lowers the hardware barrier to quantitative phase imaging.