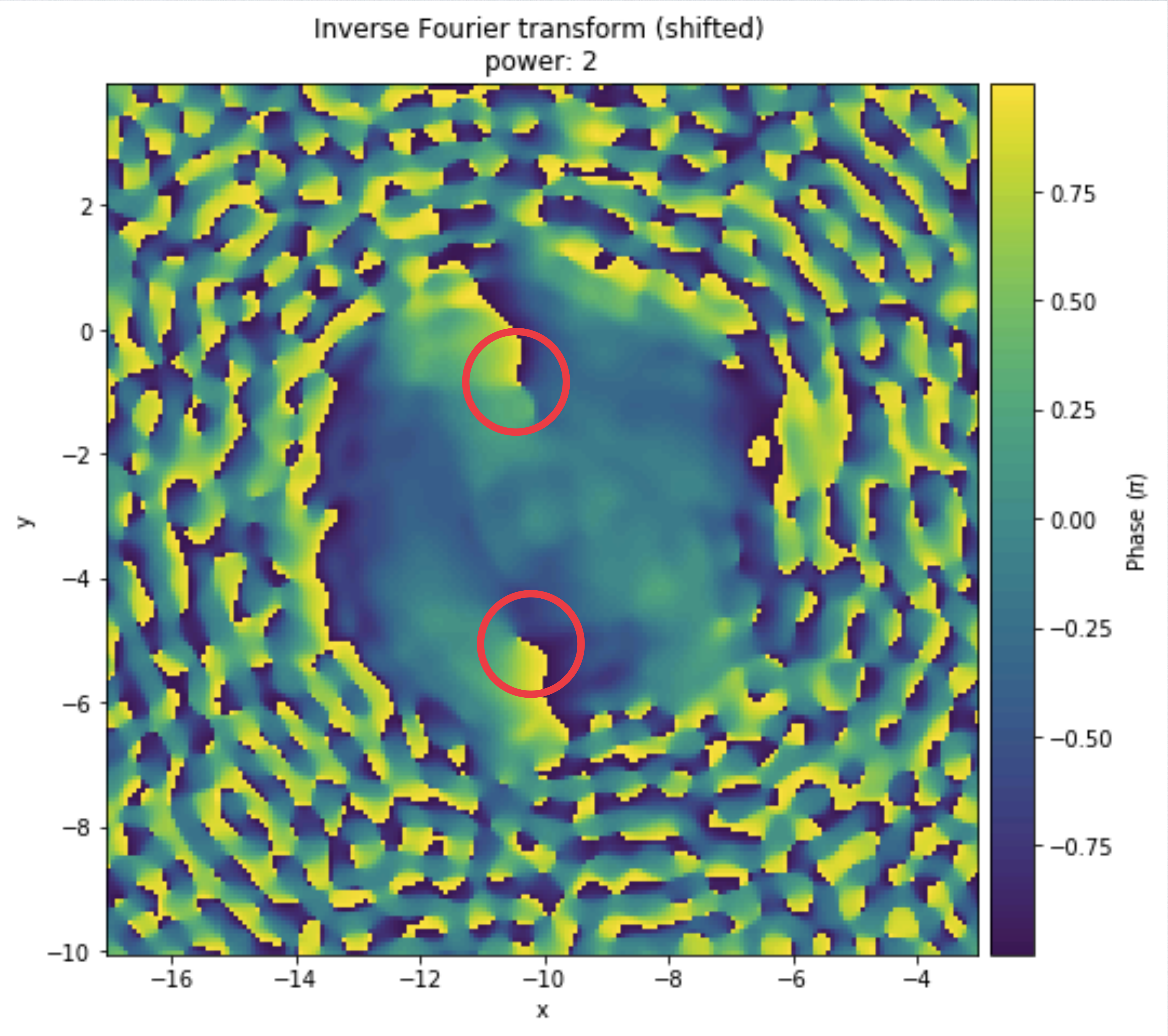
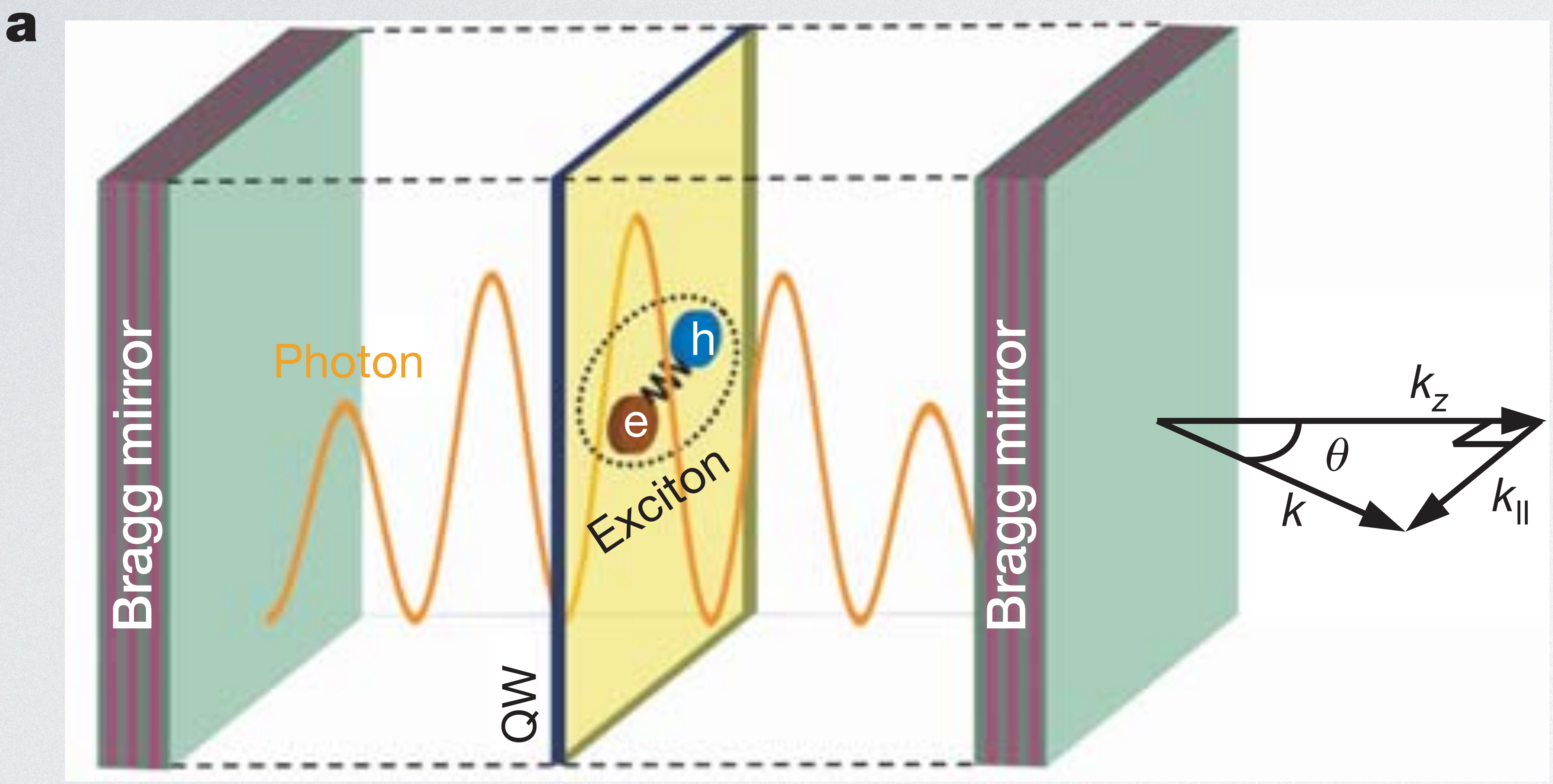
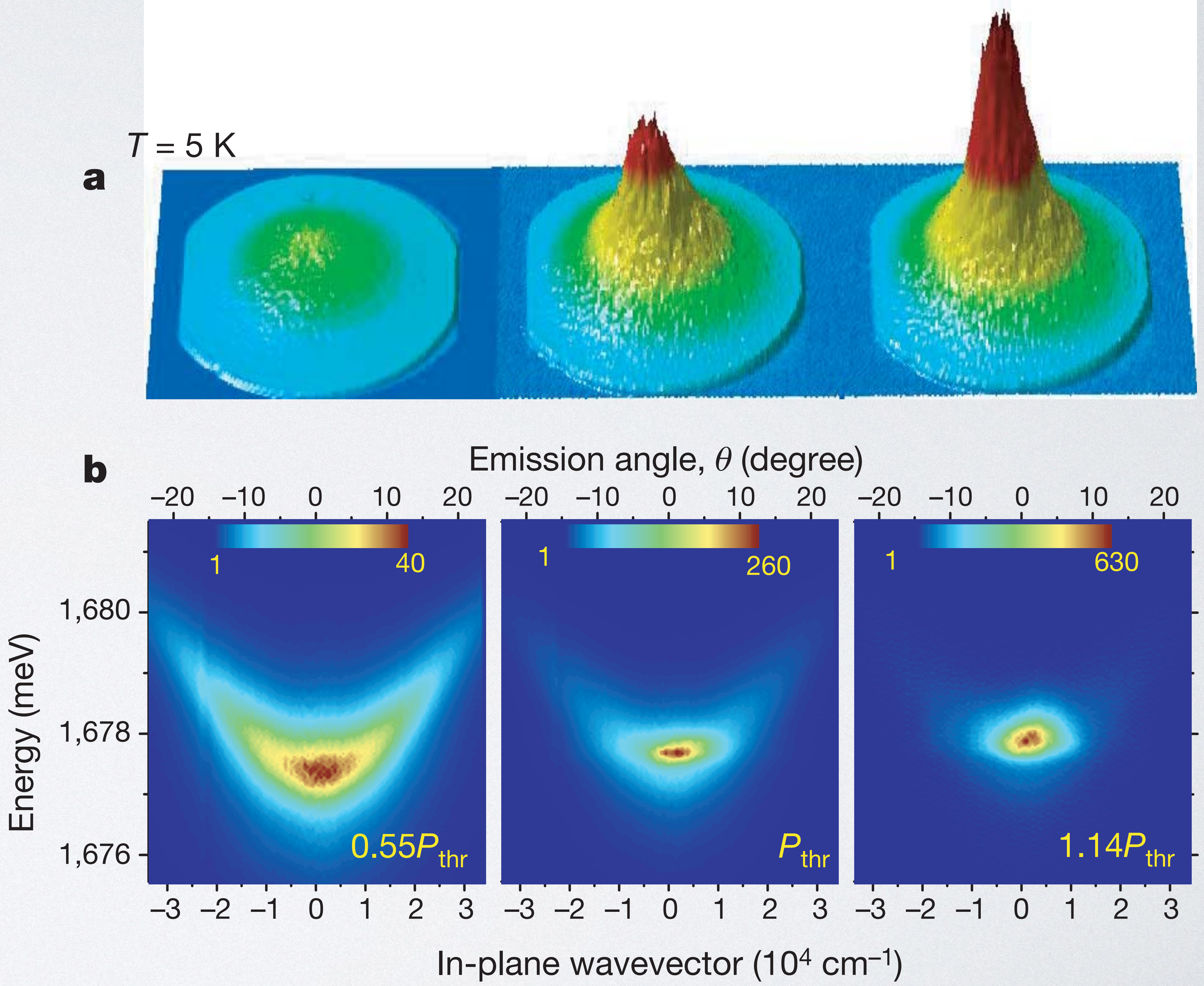
QUANTUM VORTEX PROJECT

FUW Hackathon 24.3.2018



POLARITON CONDENSATES



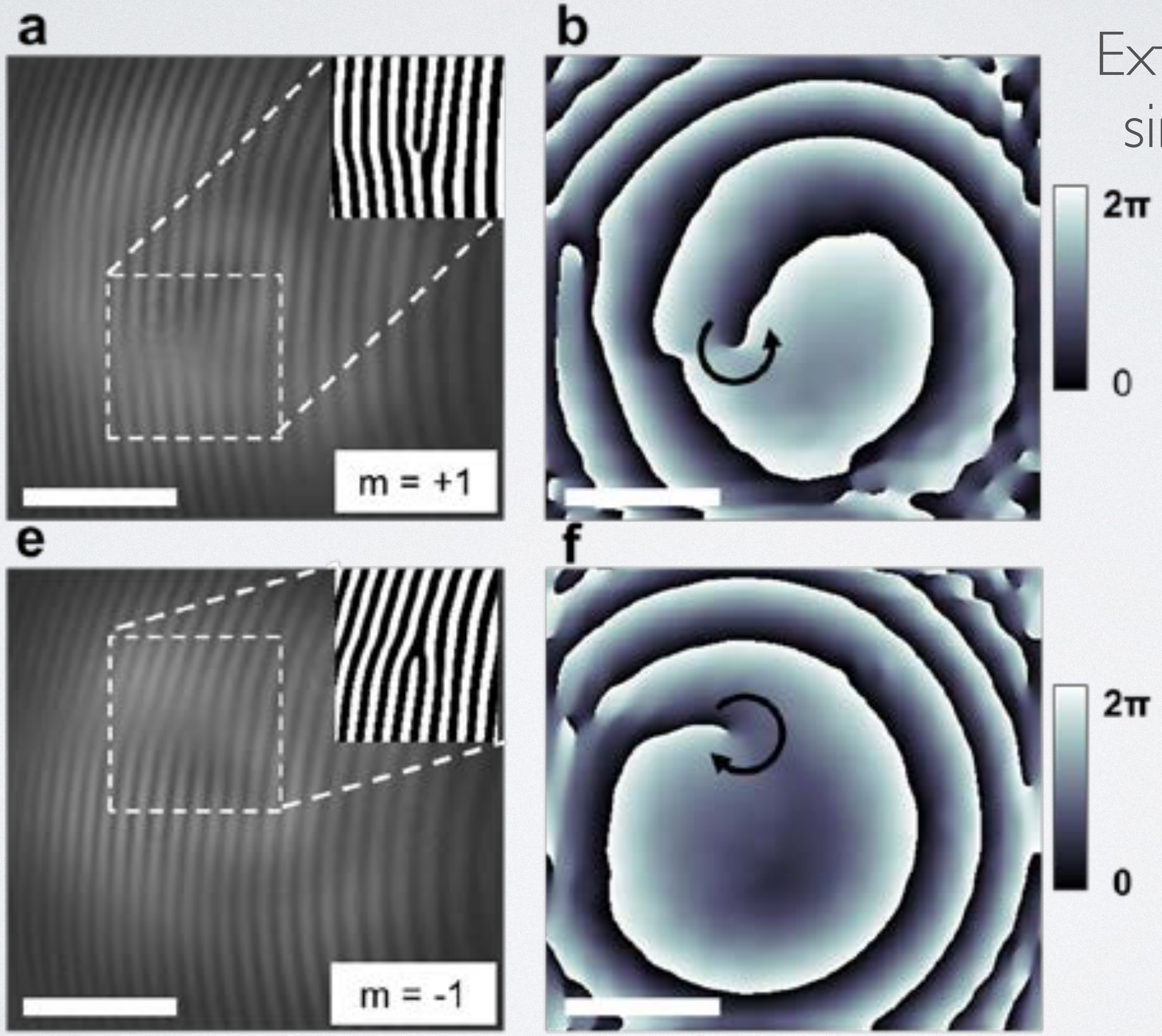


- Macroscopic ground state population
- Temporal and spatial coherence

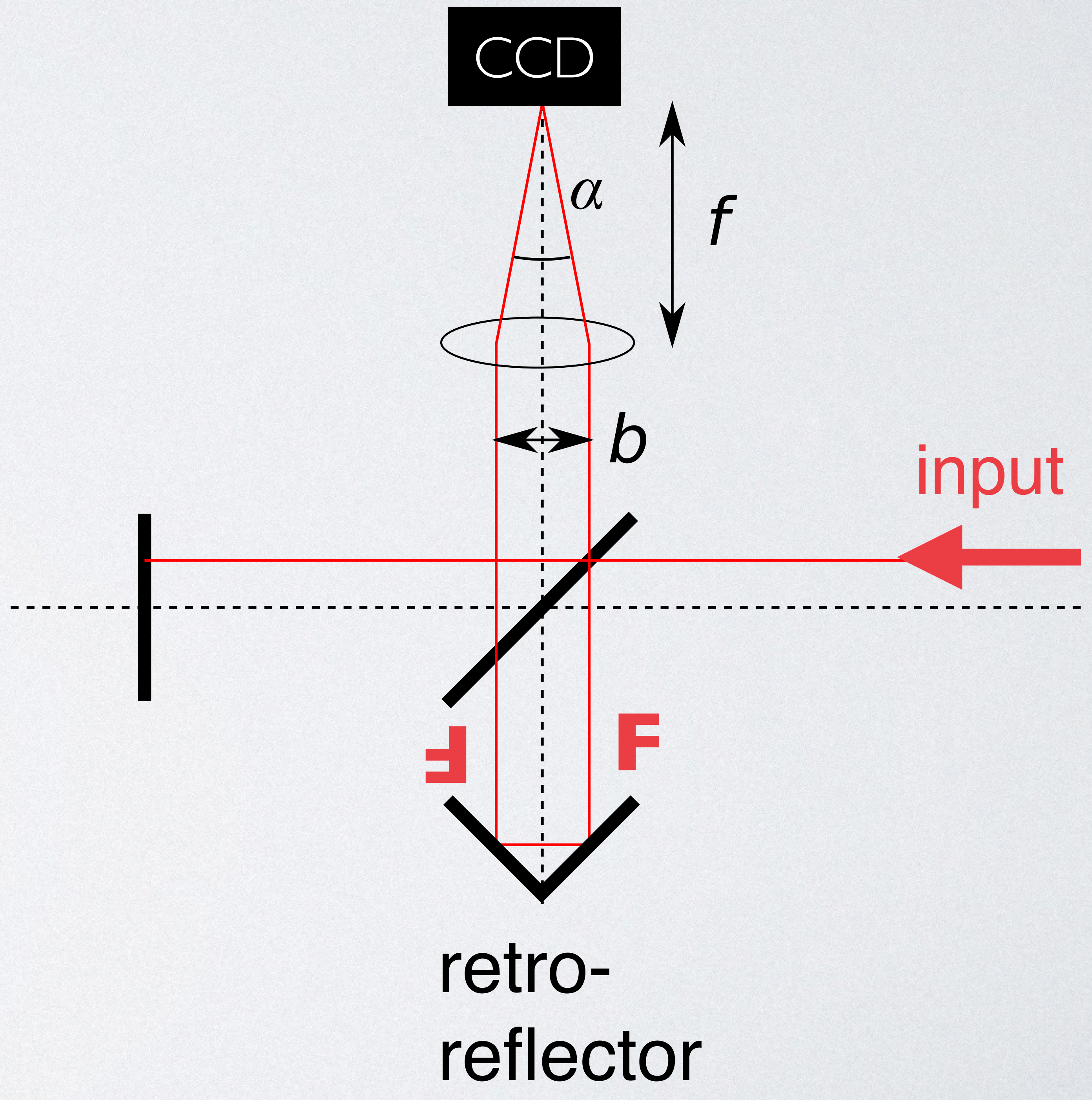
J. Kasprzak,et al., Nature 443, 409 (2006).

INTERFEROMETRIC MEASUREMENTS

Interferogram



Extracted phase with singularity (vortex)



B.Y. Oh et al., arXiv: 1708.07421 1 (2017).

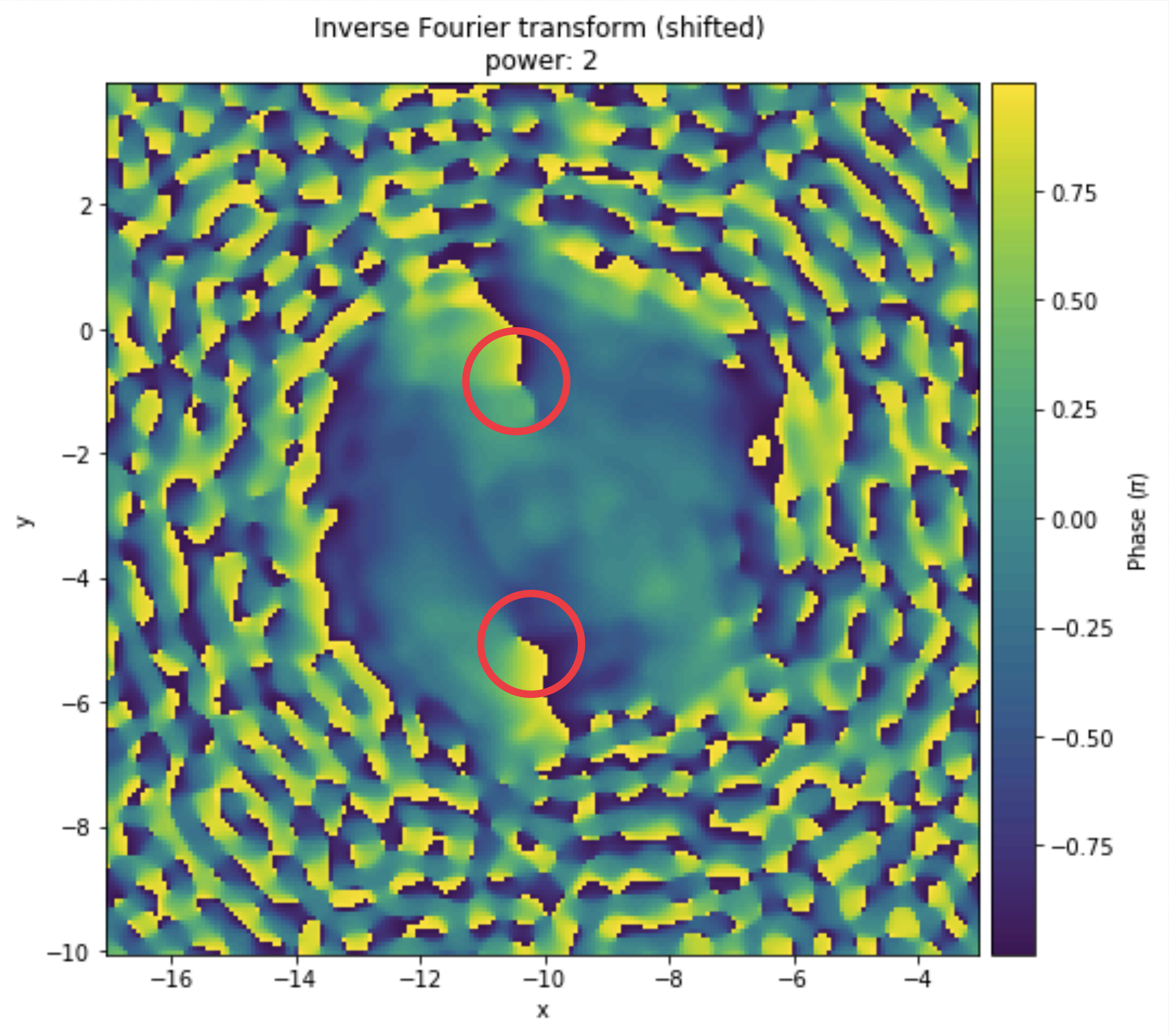
GOAL 1: VORTEX TRACKING

- Write a function to automatically find every vortex in a phase map.

- Note: If you've found a solution, try adding an offset to the phase, like this:
```
phase_off = (phase + offset) % 2 - 1
```

  If the position changes, your procedure does not work right…

- Bonus points: use the physical units instead of pixel numbers for the plots and vortex positions (in my own code, I use the plotting package "HoloViews" to deal with this)



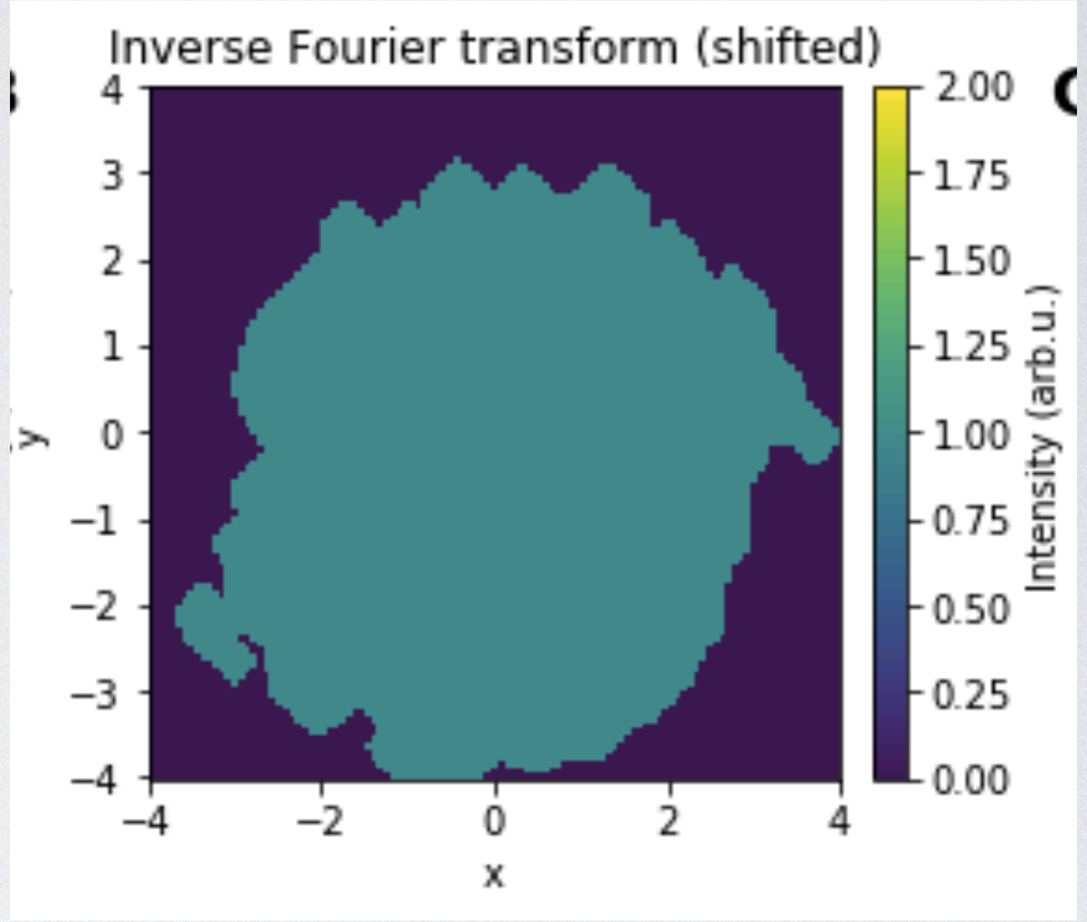
GOAL 1: HINTS

- Consider that there is always an arbitrary offset on the phase with this method. Also, the phase is continuous, i.e. 0 = 2pi etc.

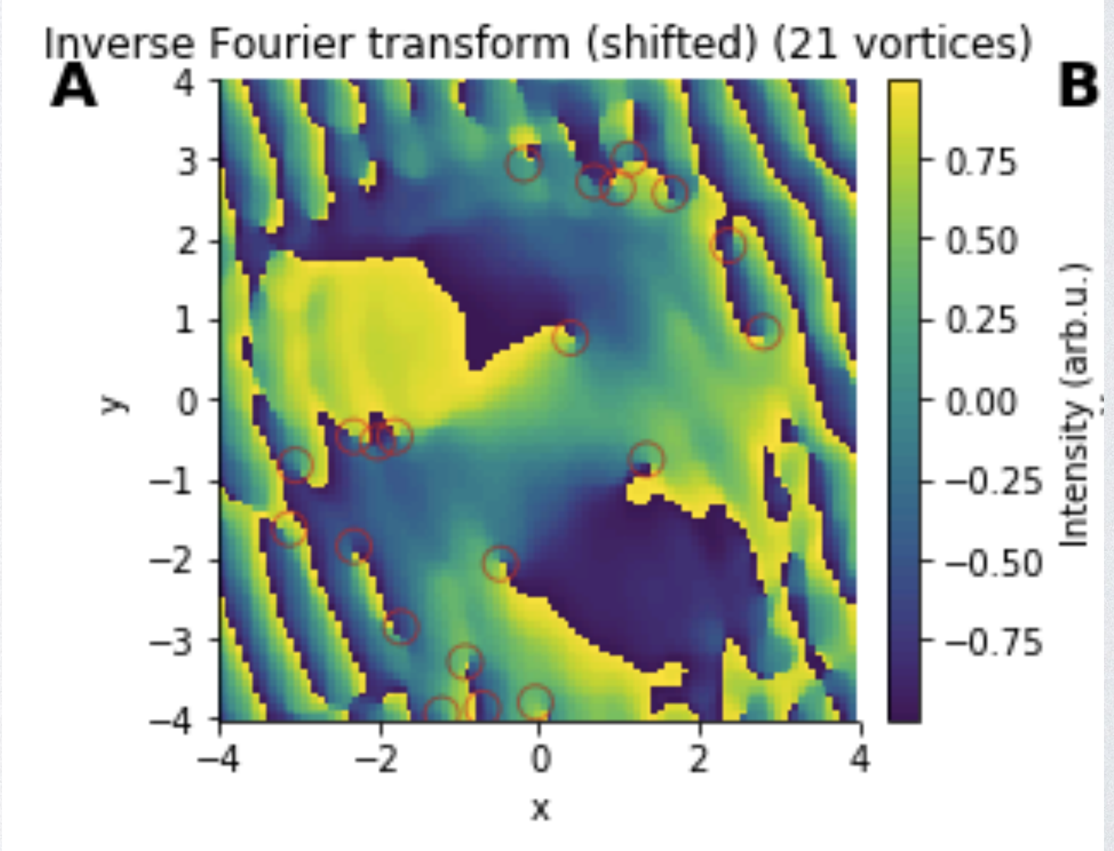
- Standard edge finding algorithms like kind of work, but not very well.

- There are specialized algorithms for this, see Murphy and Taylor in the "papers" folder.

- You should make a mask from the intensity map to get rid of the noise at the edges; there is already code for this.



mask

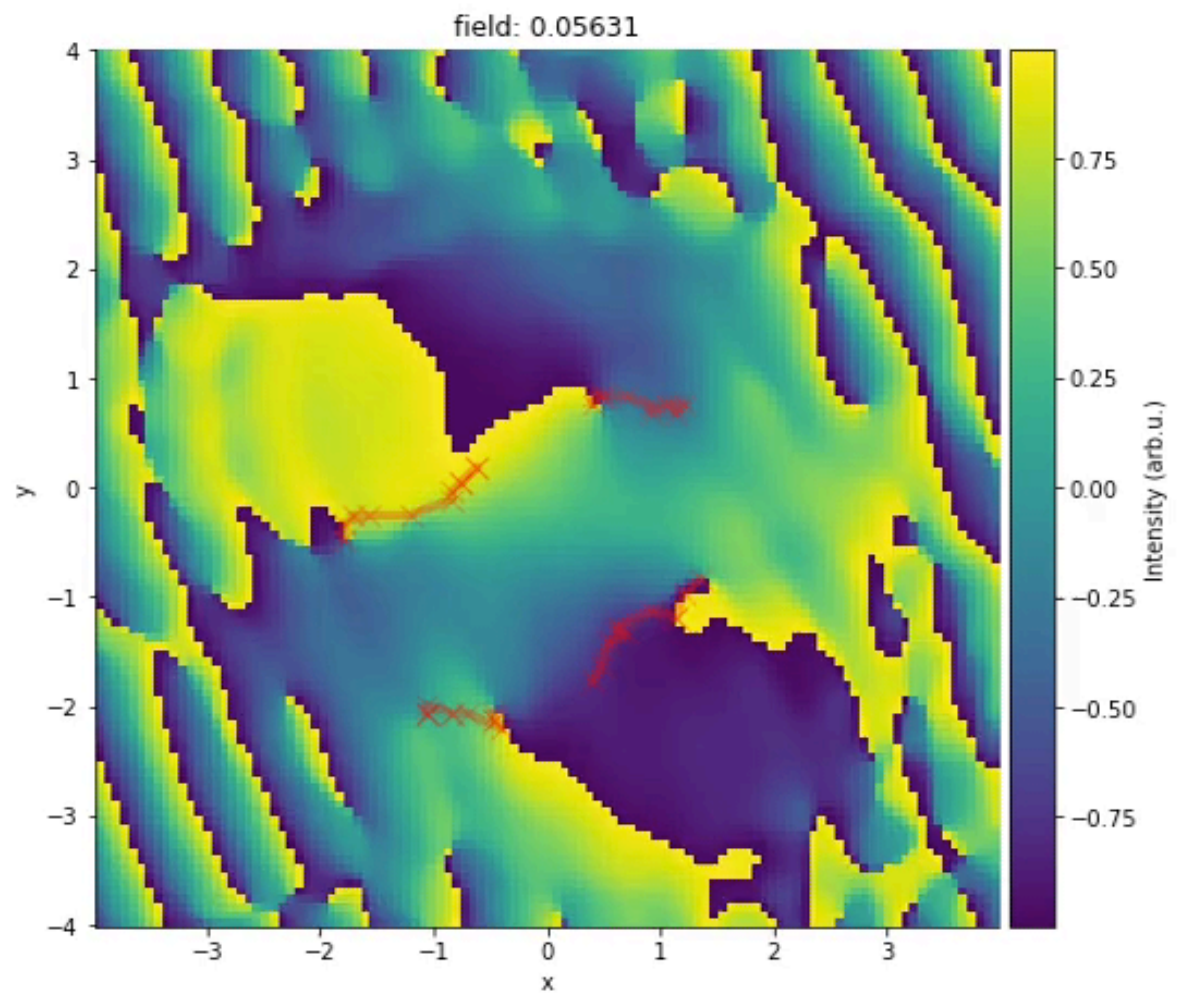


vortices

GOAL II: VORTEX TRACKING FOR A SEQUENCE

- Using the solution for goal 1, make a function to find the vortices in a sequences of images, without needing to adjust any parameters

- Find a nice way to plot the trajectory of every vortex, like in the video



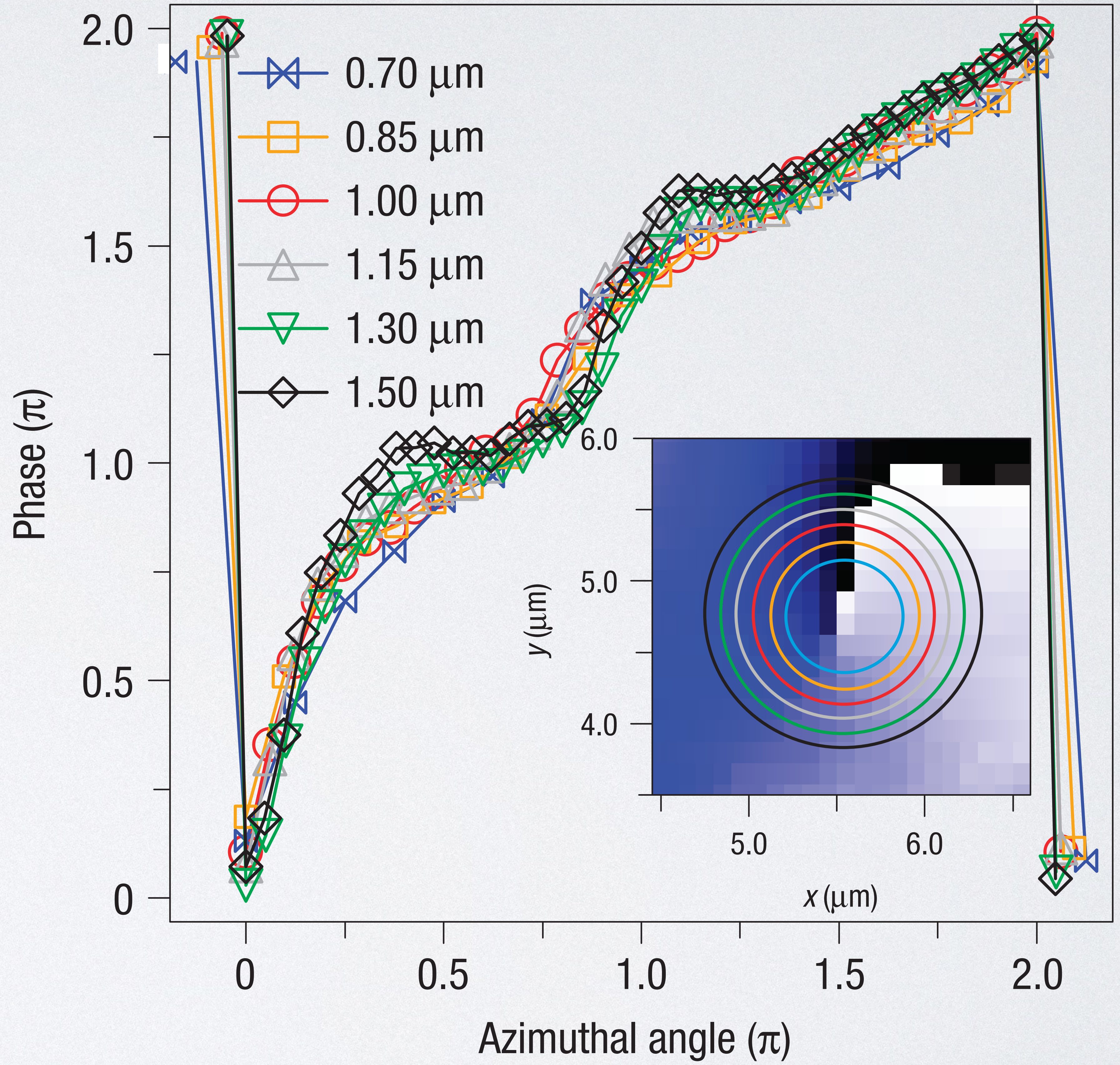
GOAL 2: HINTS

- Like in goal 1, you definitely need to mask the data before finding the vortices (again, there is code for this).
- When you have the vortices for each image, you need to see which positions correspond to the same vortex. There is some code already, but it could be improved.

GOAL 3: PHASE VS AZIMUTH

Write a function for a single frame:

- Go around the singularity in a circle of a given radius and plot the value of the phase
- Also make a plot of the circle, like on the right (actually, it would be better to indicate the individual pixels instead of drawing an ideal circle)
- Background: in some systems, the phase jump can be less than 2pi



K.G. Lagoudakis et al., Nat. Phys. 4, 706 (2008).

EXISTING CODE

- Look in the "code" folder…
- Recommended environment: Anaconda with Python 3 and Jupyter notebooks
- Holoviews plotting package with Matplotlib backend: install with

```
conda install holoviews
```

- There is a notebook with some demos, also check www.holoviews.org