

**Coded aperture and Optical Heterodyning :
A mask-based approach for Digital Refocusing and Light
Field Acquisition by Conventional Cameras**

Heterodyne Light Field Camera

Consider a 2D camera that can capture 4D light fields ..

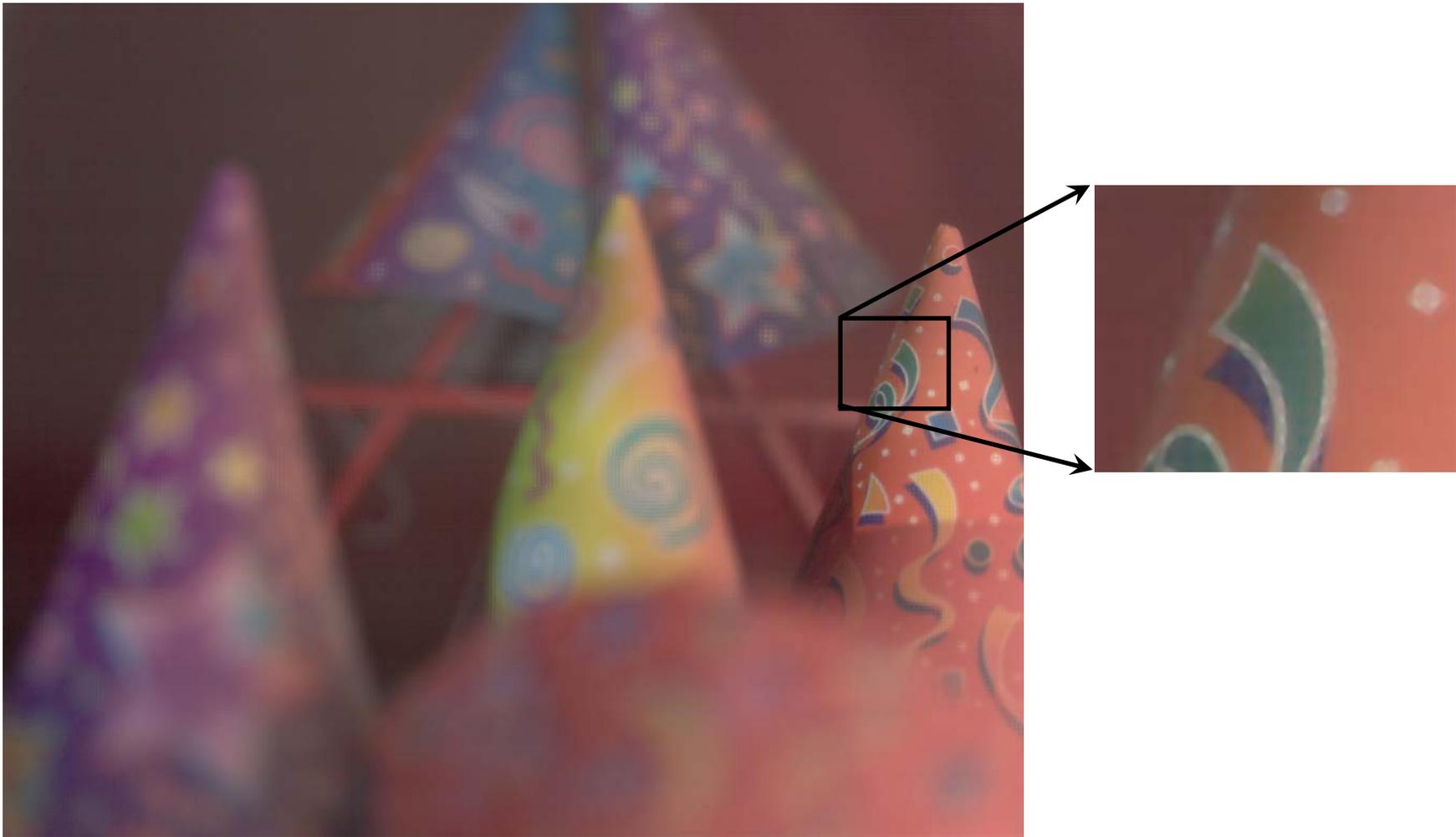


2D Sensor image



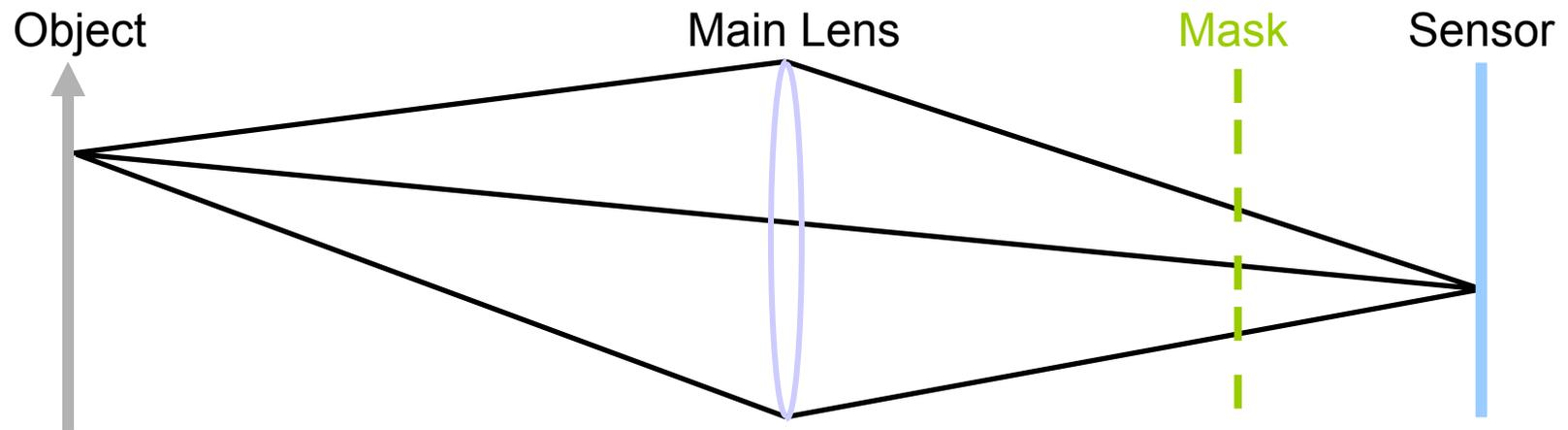
Video showing refocusing
from 4D light field

.. as well as high resolution image of focused parts of scene ..



High resolution image of in focus parts of the scene

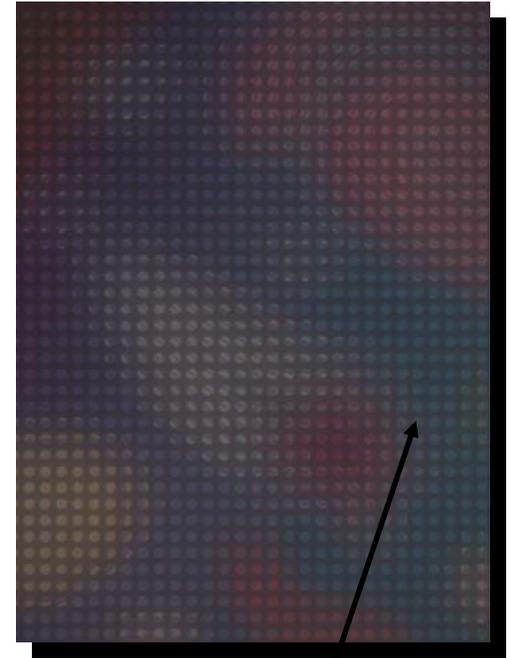
.. using only a mask placed inside the camera and
no additional optics



Results



2D Sensor image



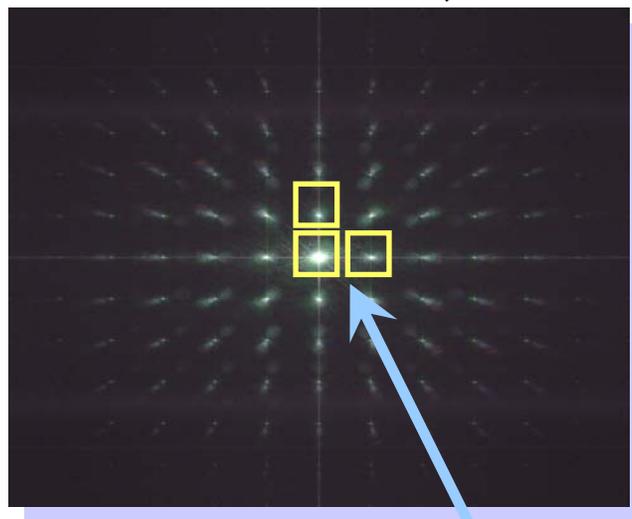
Zoom in showing
the effect of mask

Computing 4D Light Field

2D Sensor image, 1629*2052



2D Fourier Transform, 1629*2052

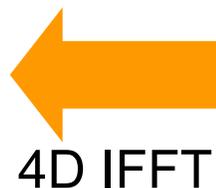


9*9=81 such tiles



Reshape 2D tiles into 4D planes

181*228*9*9

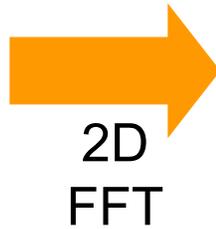


4D Light Field

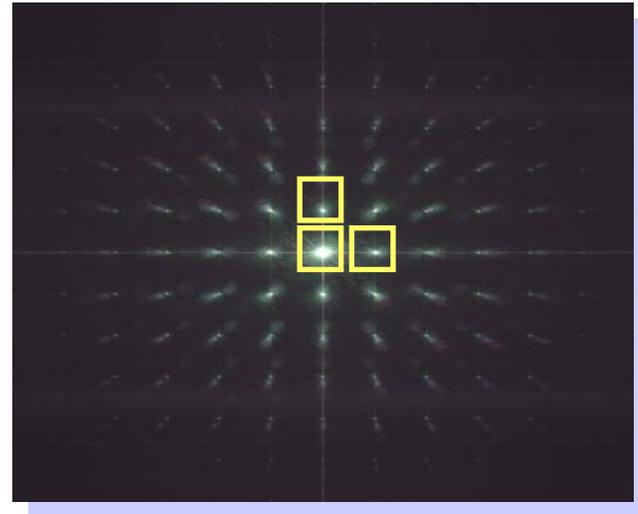
181*228*9*9

Refocusing: Take slices of 4D Fourier transform

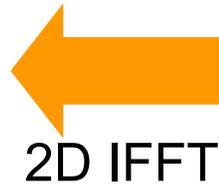
2D Sensor image, 1629*2052



2D Fourier Transform



Reshape 2D tiles into
4D planes
181*228*9*9

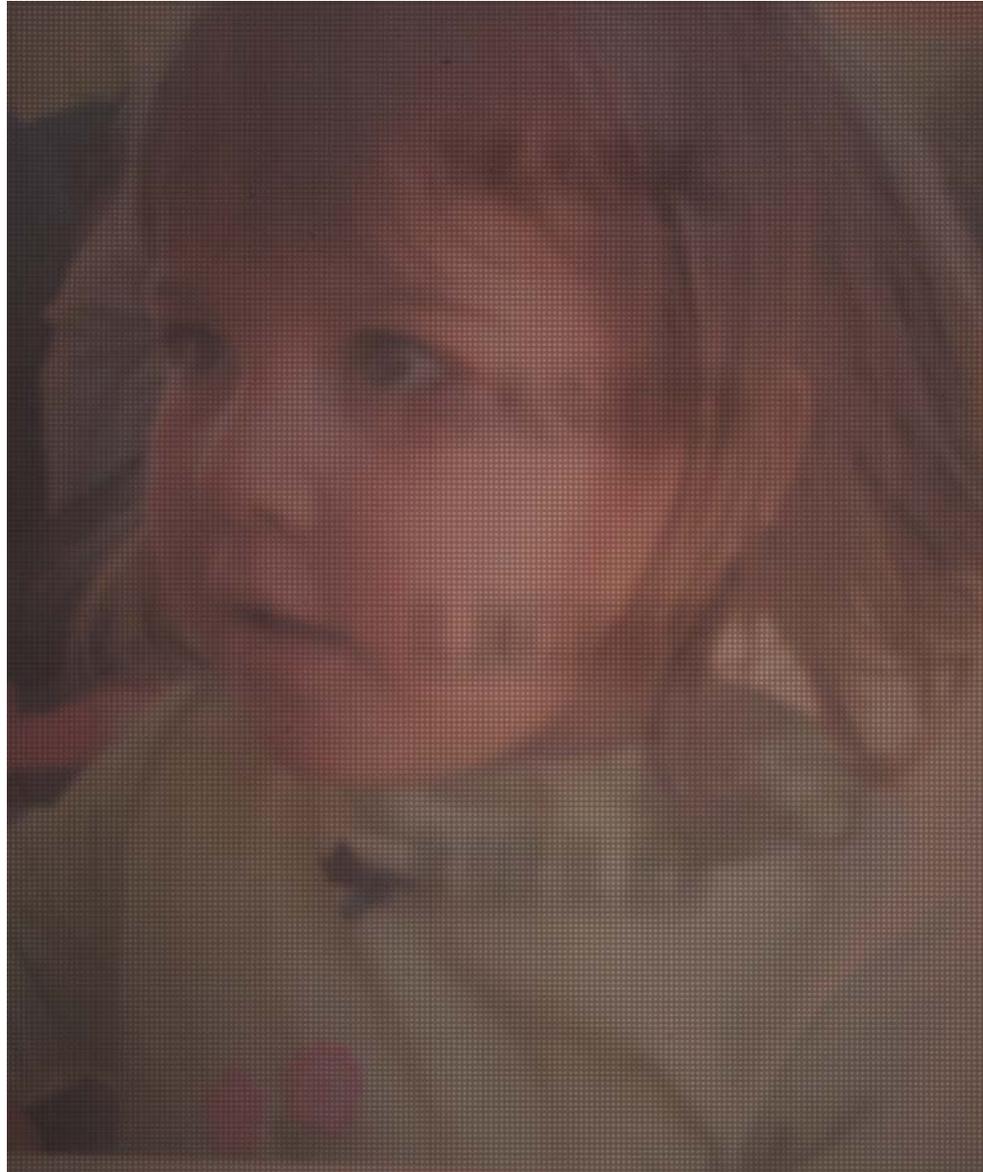


181*228
refocused image

Demonstrating parallax between two
of the views



Refocusing of transparent layers



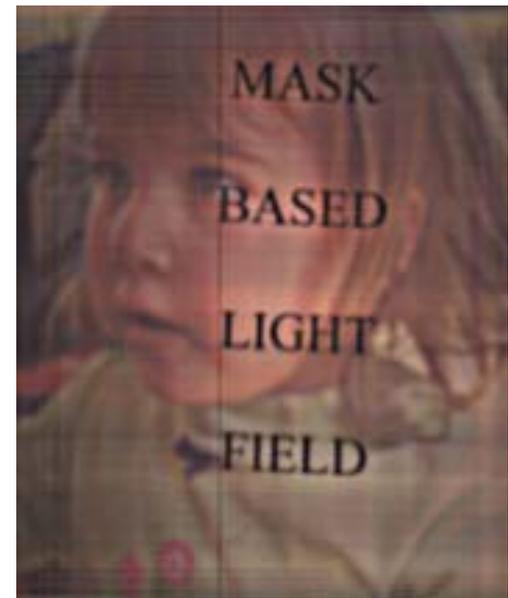
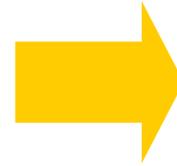
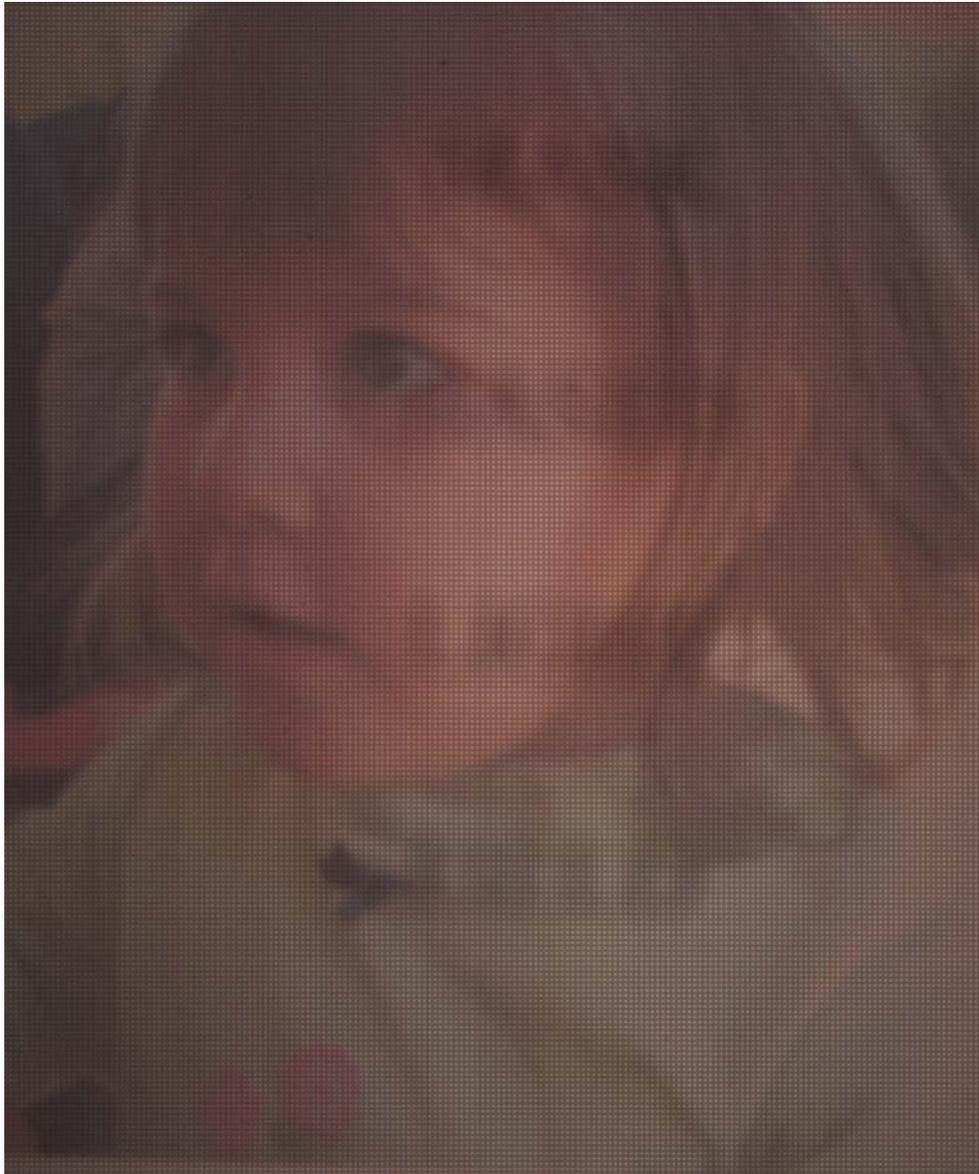
2D sensor image. The scene consist of a transparent glass sheet in front with text written on it.

Refocusing of transparent layers



High resolution image of the focused parts of the scene

Refocusing of transparent layers

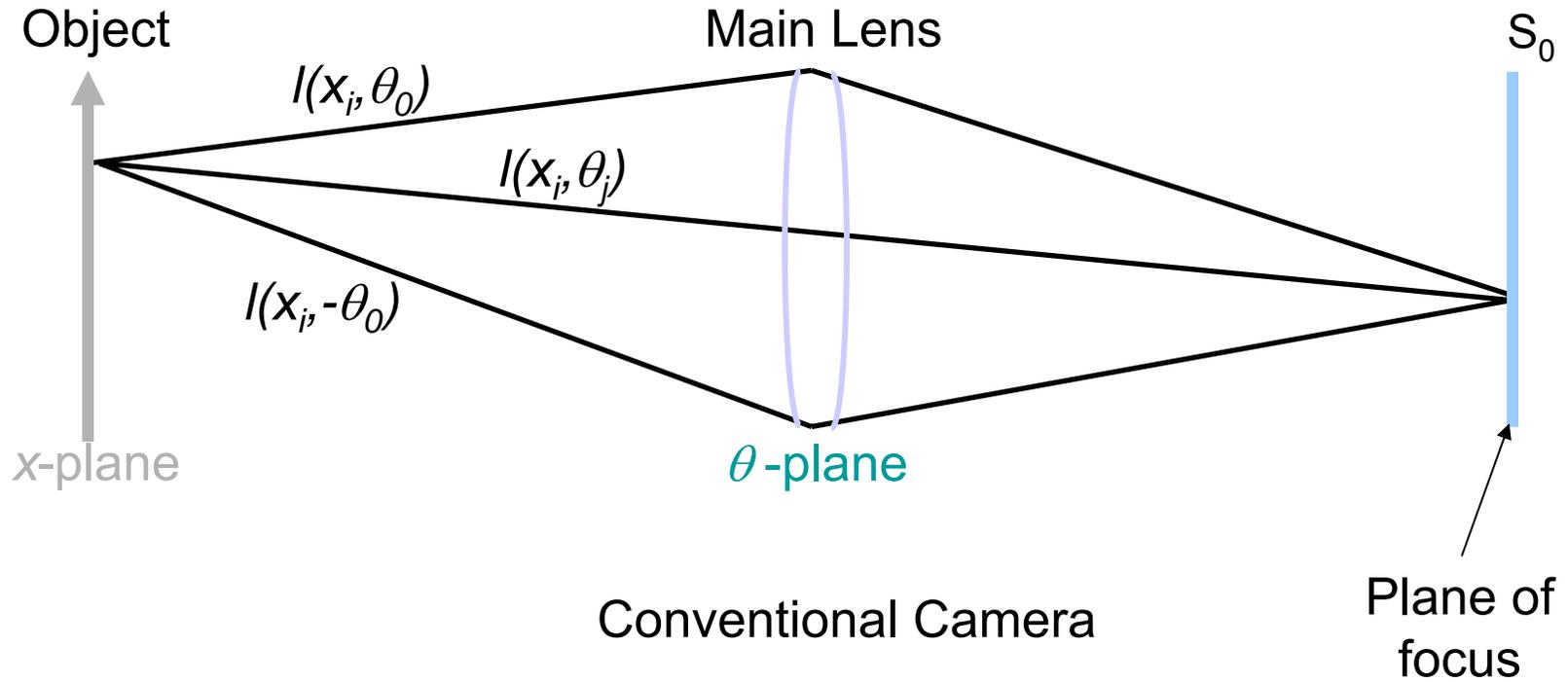


Low resolution refocused
image on the glass sheet
in front

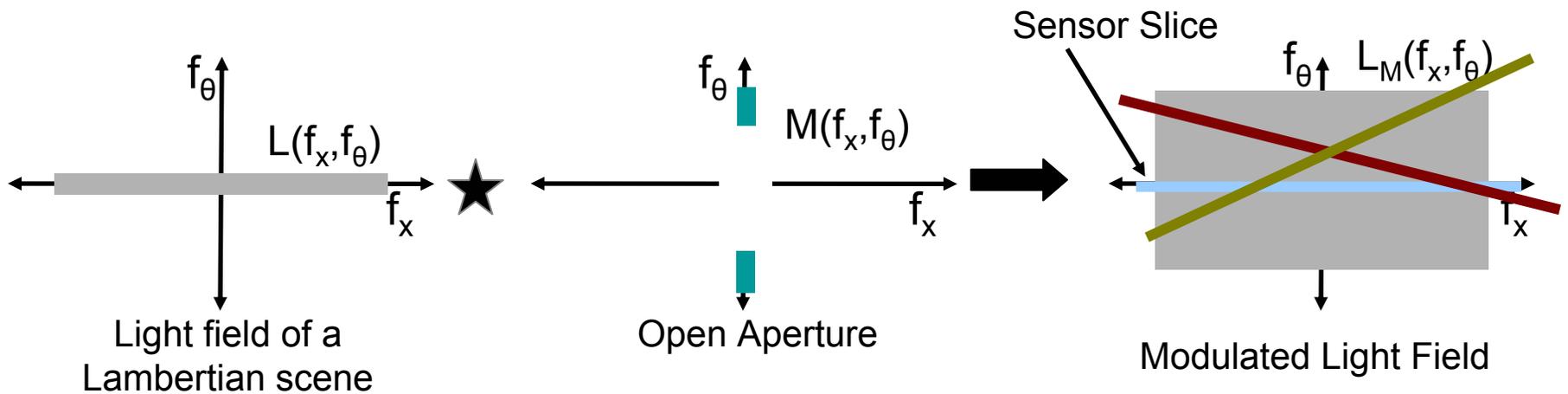
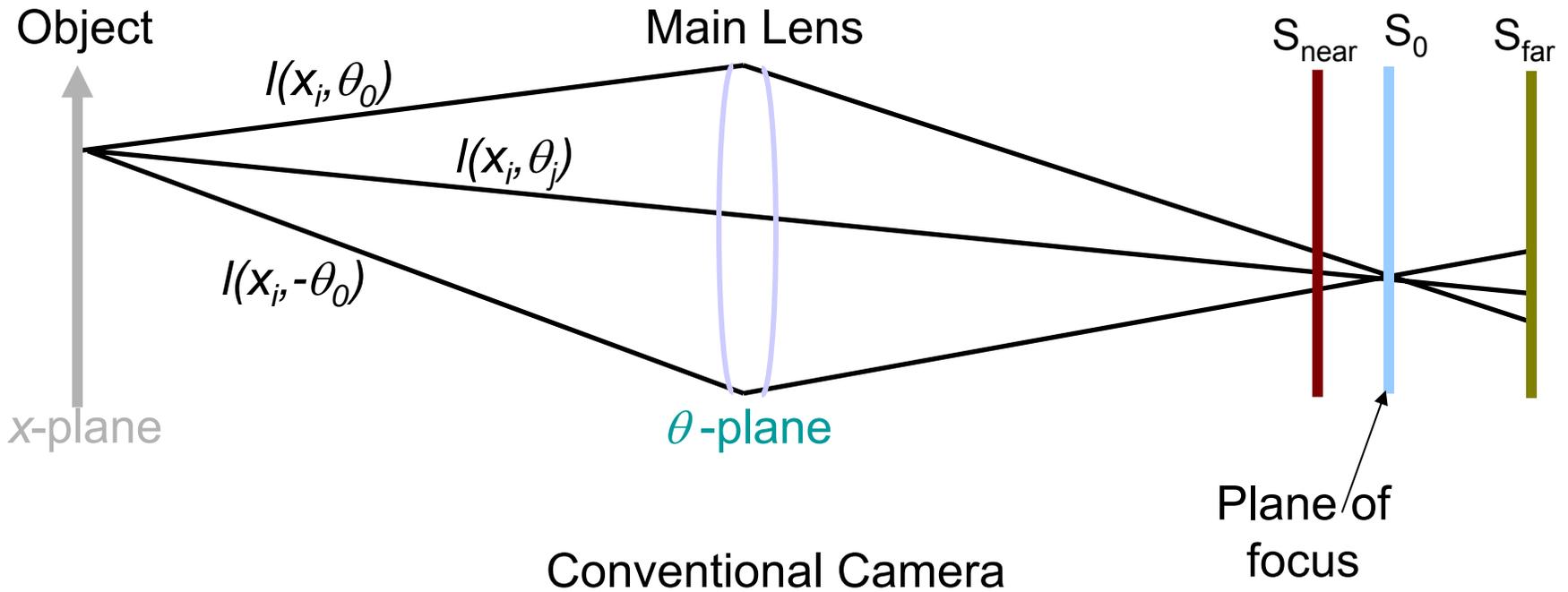
Encoded Blur Camera for Extended Depth of Field

(for Layered Lambertian Scenes)

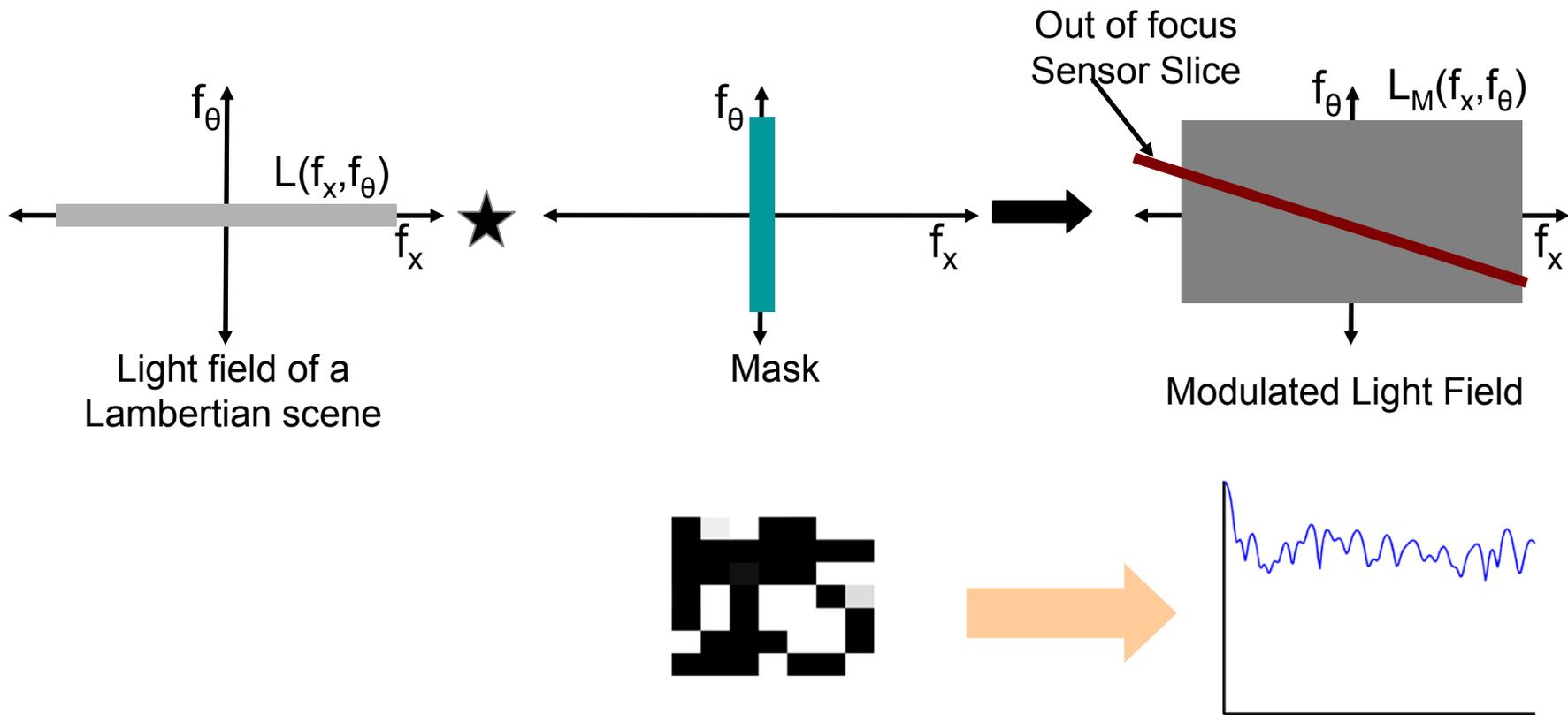
We analyze out of focus deblurring in 4D Fourier space



In Fourier domain, the image is a slice of light field



By putting a mask at the aperture, the aperture modulation function is *replaced* by the mask modulation function



High Frequencies are preserved if broadband mask is used

Digital Refocusing



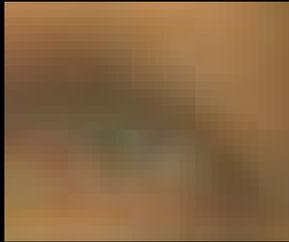
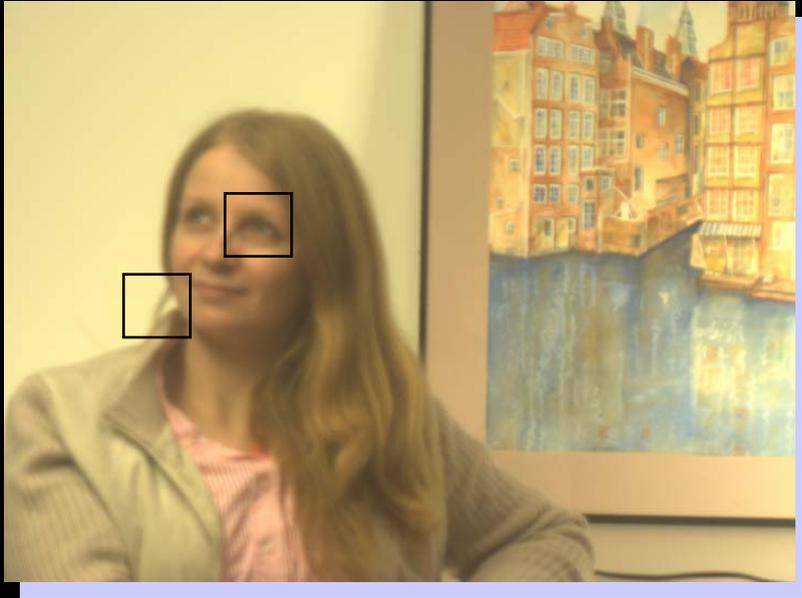
Captured Blurred Image

Digital Refocusing



Refocused Image on Person

Digital Refocusing



Digital Refocusing



Captured Blurred Image

Digital Refocusing

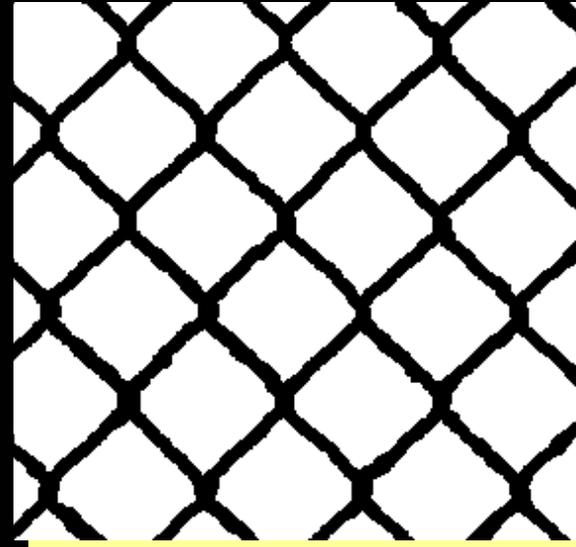


Refocused Image on Person

Deblurring in presence of partial occluders



Captured Photo



Mask for occluders



Least Squares
Deblurring



Weighted Least
Squares Deblurring

Comparison with Small Aperture Image



Small Aperture
Image



Captured
Blurred Image



Deblurred
Image

Comparison with Traditional Camera

Encoded Blur Camera



Traditional Camera



← Captured →
Blurred Image



← Deblurred →
Image