ECE 278C Imaging Systems

11. Diffraction tomography

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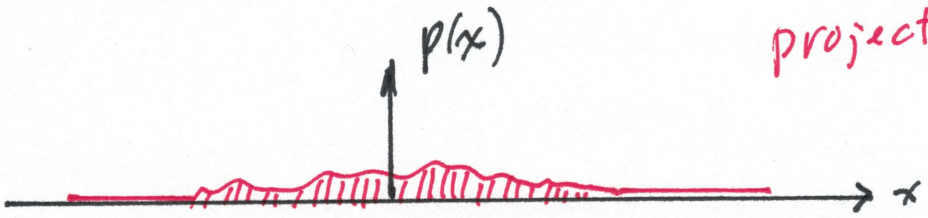
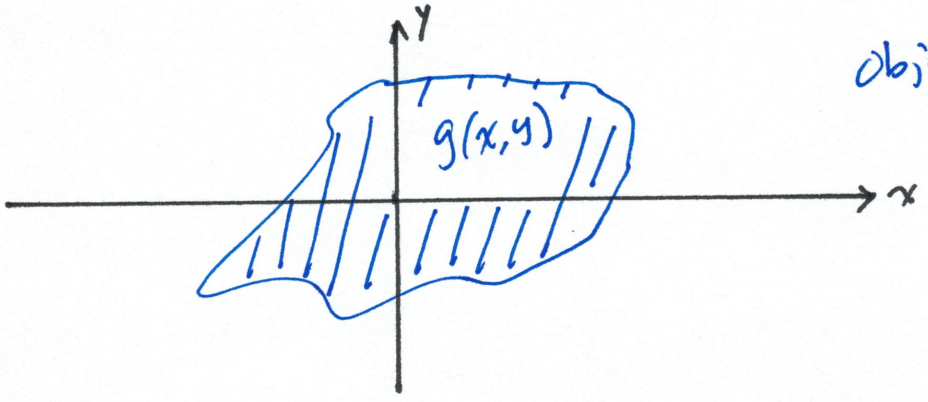
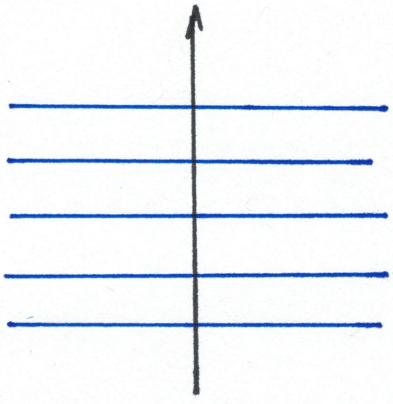
Diffraction tomography



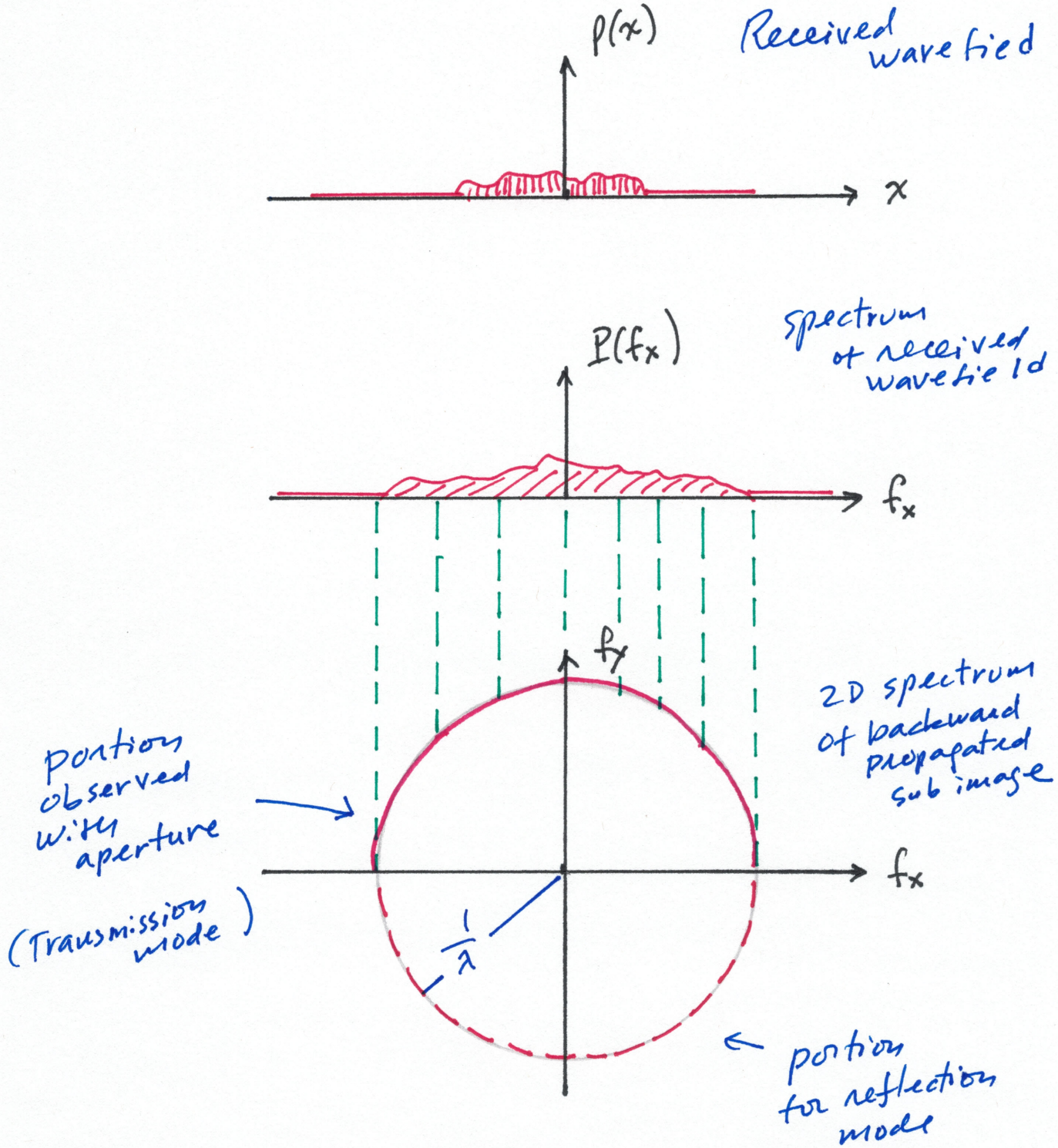
projection p(x)

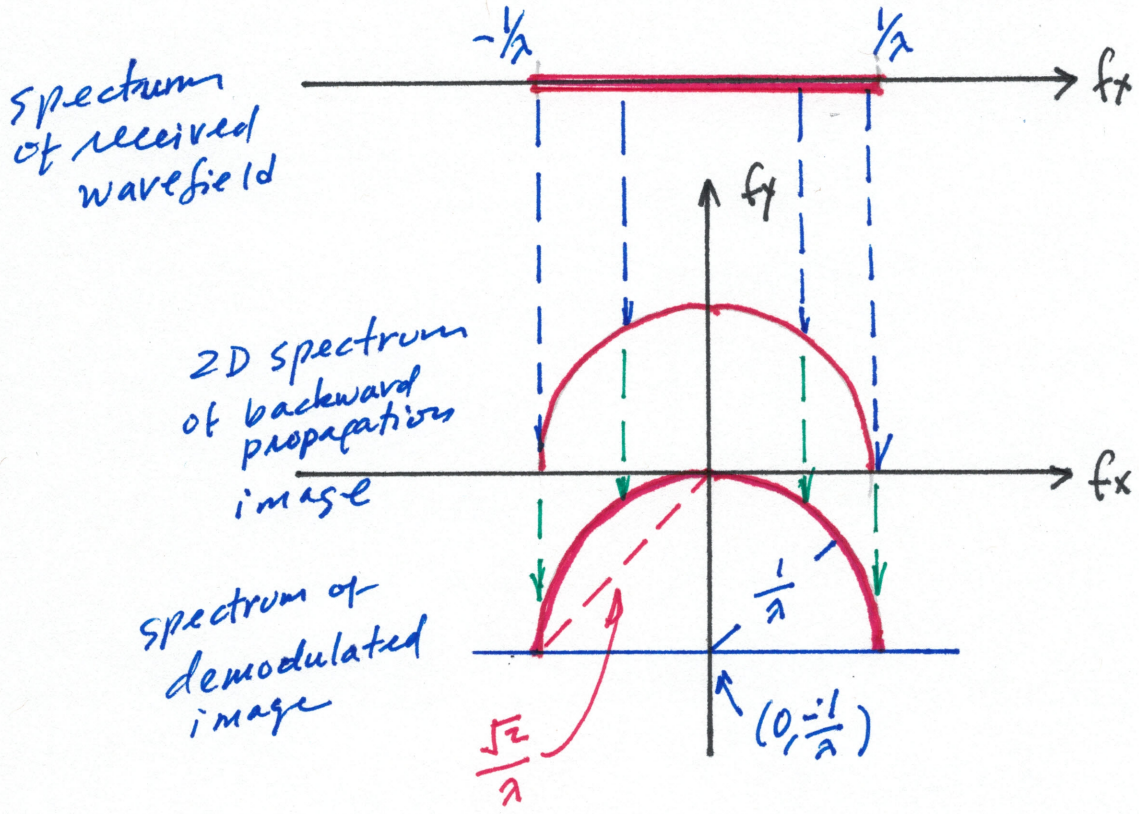


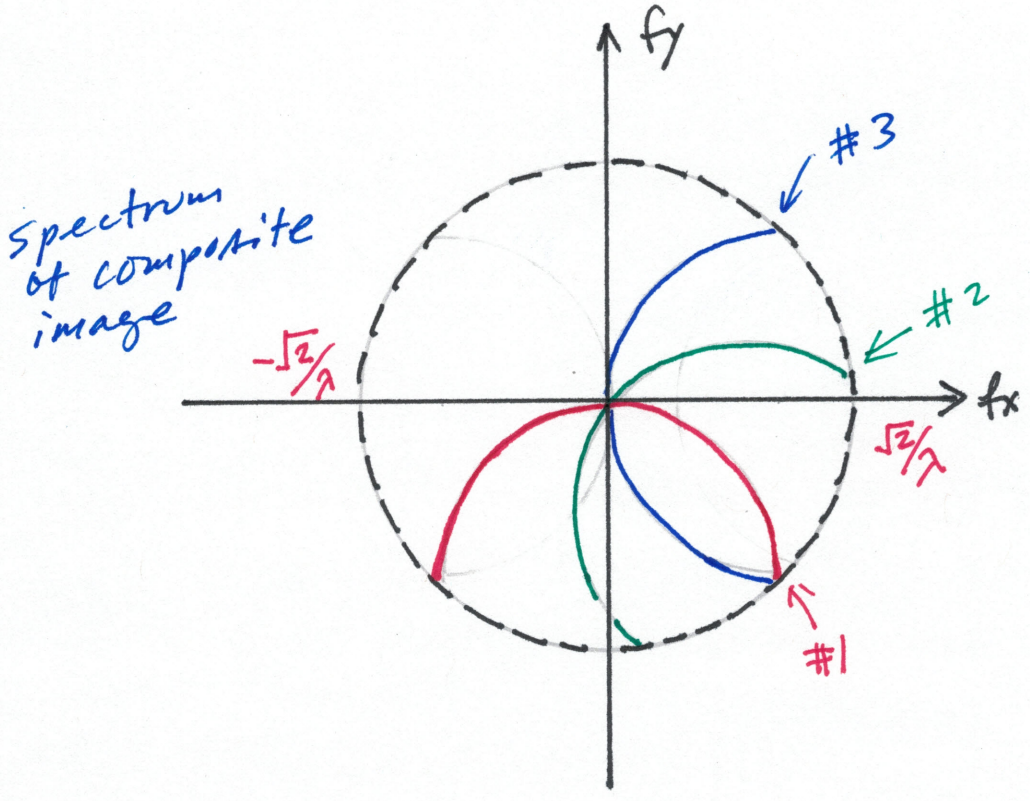
object distribution

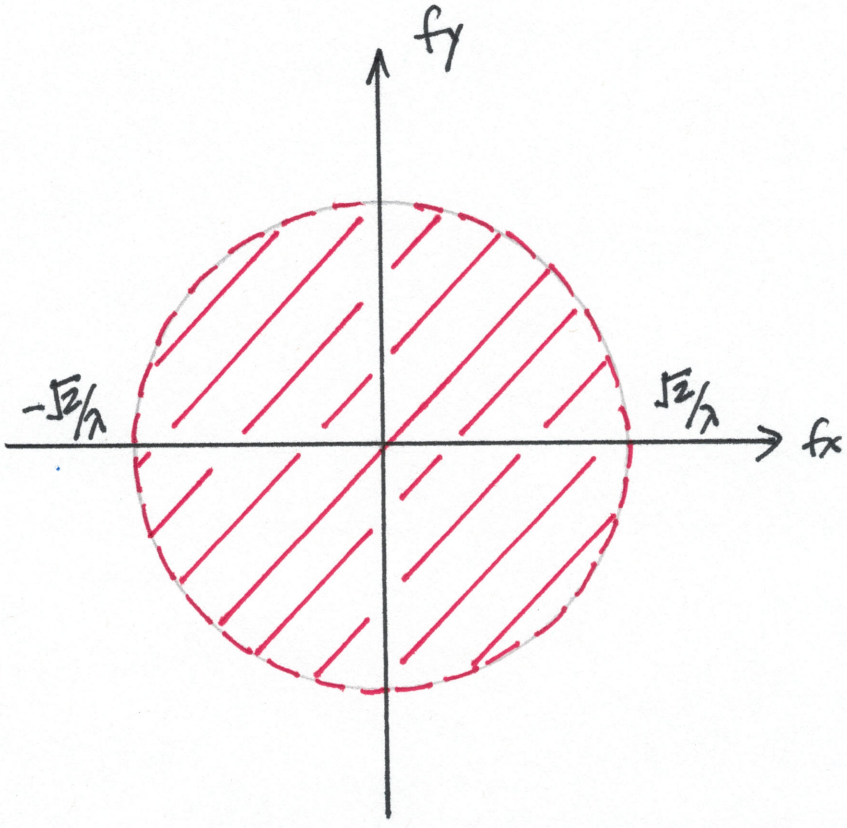


plane wave,
wavelength λ


p(x)
Received wavefield
x
P(fx)
spectrum of received wavefield
fx
fy
2D spectrum of backward propagated sub image
portion observed with aperture
(Transmission mode)
fx
1/λ
portion for reflection mode

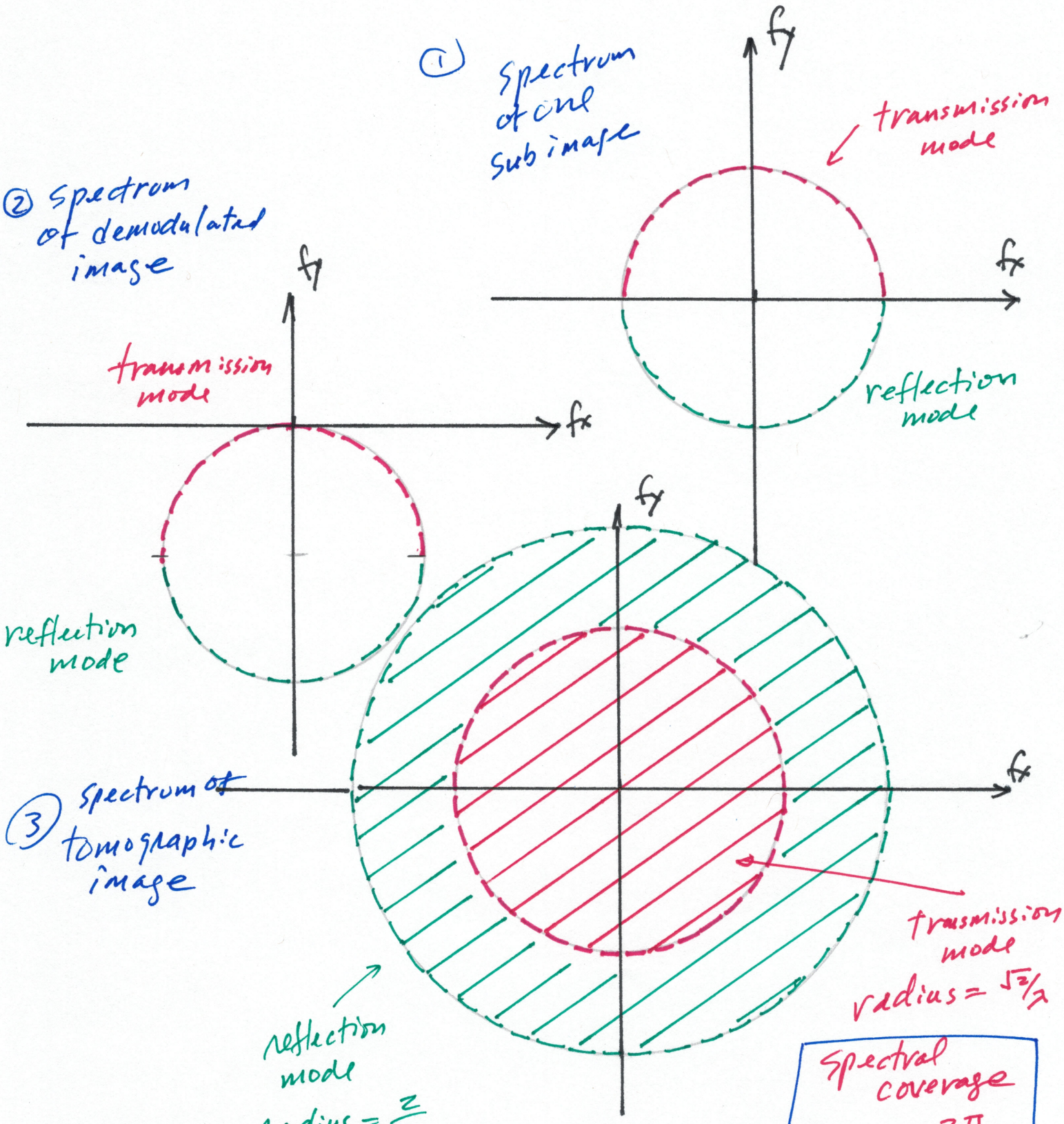

spectrum of received wavefield
$-1/\lambda$
$1/\lambda$
f_x
f_y
2D spectrum of backward propagation image
f_x
spectrum of demodulated image
$\frac{1}{\lambda}$
$(0, \frac{-1}{\lambda})$
$\frac{\sqrt{2}}{\lambda}$


spectrum of composite image
f_y
#3
#2
$-\sqrt{2}/\lambda$
f_x
$\sqrt{2}/\lambda$
#1



Spectrum of tomographic image after superposition and enhancement

radius = $\sqrt{2}/\lambda$ (Transmission mode)


① Spectrum of one sub image
fy
fx
transmission mode
reflection mode
② Spectrum of demodulated image
fy
fx
transmission mode
reflection mode
③ Spectrum of tomographic image
fy
fx
transmission mode
radius = √2/λ
reflection mode
radius = 2/λ
Spectral coverage = 2π/λ²
Spectral coverage = 2π/λ²

Imaging procedure:

1. Illuminate the object region with a plane wave
2. Perform data acquisition over the receiving aperture
3. Perform image reconstruction by backward propagation
4. Demodulate the complex sub-image to remove the plane-wave component
5. Rotate and repeat the process
6. Superimpose the sub-images to form the composite image
7. Conduct image enhancement with the highpass filter

Special notes:

1. The spatial-frequency bands of transmission-mode and reflection-mode images are orthogonal without any overlapping.
2. The transmission-mode image gives the lowpass component of the object distribution.
3. The reflection-mode image gives the bandpass component of the object distribution.
4. The 2D spatial-frequency coverage is the same, at the level of $2\pi/\lambda^2$.