ECE 278C **IMAGING SYSTEMS** **Winter 2021**

ASSIGNMENT 1: Fourier Spectrum of Coherent Wavefield

Due: Tuesday, January 26

Name: ______________________________

Objective: The main objective of this homework assignment is to visualize the spectral distribution of *2-D* coherent wavefield patterns. This leads you to

(i) the generation of the coherent wavefield,
(ii) observations of the spectral distribution of coherent wavefield,
(iii) understanding of the phase-only concept, and
(iv) observations of changes due to the variation of wavelength, sample spacing, and aperture size.

(1) Consider a point source at the origin, $(x_o, y_o) = (0, 0)$. This centered point source produces a *2-D* coherent wavefield pattern in the form of

$$h(x,y) = (j\lambda_o r)^{-1/2} \exp(j2\pi r/\lambda_o)$$

where $r = (x^2 + y^2)^{1/2}$ and λ_o is the operating wavelength. Generate the resultant *2-D* wave-field pattern for a region within the radius of $30\lambda_o$. For simplicity, sample the *2-D* wave-field uniformly, in both directions, with the sample spacing

$$\Delta x = \Delta y = \lambda_o /4.$$

Evaluate the *2-D* Fourier spectrum of the coherent wave-field with a 512×512 *FFT*, and plot the amplitude of the *2-D* spectrum. (Remember to zero out the data points around $r = 0$.)

(2) Repeat Part (1) with 6 active point sources, located at (x_n, y_n), $n = 1, 2,.. 6$.

	scatters	*scatter locations*
1	(x_1, y_1)	$(0, +10\ \lambda_o)$
2	(x_2, y_2)	$(+10\ \lambda_o, 0)$
3	(x_3, y_3)	$(0, -10\ \lambda_o)$
4	(x_4, y_4)	$(-10\ \lambda_o, 0)$
5	(x_5, y_5)	$(-8\ \lambda_o, -6\ \lambda_o)$
6	(x_6, y_6)	$(+8\ \lambda_o, -6\ \lambda_o)$

The resultant wavefield pattern over the aperture region is the superposition of 6 coherent waveform patterns.

(3) Now consider a different case that each of these 6 active sources is a generating independent coherent wavefield pattern, with a different operating wavelength λ_n, where

$$\lambda_n = n\,\lambda_o$$

	scatters	*scatter locations*	*wavelength*
1	(x_1, y_1)	$(0, +10\ \lambda_o)$	λ_o
2	(x_2, y_2)	$(+10\ \lambda_o, 0)$	$2\ \lambda_o$
3	(x_3, y_3)	$(0, -10\ \lambda_o)$	$3\ \lambda_o$
4	(x_4, y_4)	$(-10\ \lambda_o, 0)$	$4\ \lambda_o$
5	(x_5, y_5)	$(-\ 8\ \lambda_o, -6\ \lambda_o)$	$5\ \lambda_o$
6	(x_6, y_6)	$(+8\ \lambda_o, -6\ \lambda_o)$	$6\ \lambda_o$

Again, the overall wavefield pattern over the aperture is the superposition of 6 waveform patterns. Sample the composite waveform in both directions, with the same sample spacing $\Delta x = \Delta y = \lambda_o/4$. Evaluate the *2-D* Fourier spectrum of the composite waveform with a *512 x 512 FFT*, and plot the amplitude of the spectrum.

(4) Repeat the exercise by using a modified version of the Green's function

$$h'(x,y) = A \exp(j2\pi r/\lambda)$$

(This is to replace the amplitude portion of the Green's function with a constant *A*, which is known as the *phase-only* version.)

(5) The sample spacing was set to $\lambda_o/4$ for simplicity. Examine the change of the spectral distribution as you vary the sample spacing of the array.

(6) The radius of the circular aperture was set to $30\lambda_o$ for simplicity. Examine the change of the spectral distribution as you vary the aperture size.

Report format:

1. Cover page
2. Figures
3. Summary: (comments based on your observations)
4. Appendix: (computer code)