Astronomical Observing Techniques 2014: Exercises on Fourier Transforms (Due on 7 October 2014 at 09:00)

September 29, 2014

1 Diffraction-limited Point-Spread Function

Write a python program that can take a circular aperture function a and calculate the diffraction-limited Point-Spread Function (PSF) as the absolute value squared of the Fourier transform of the aperture, which is defined as being 1 where light is transmitted and 0 everywhere else. If you use an array of e.g. 1024 by 1024 pixels, make sure that the aperture does not extend beyond half the size of the array, i.e. stay within [256:768, 256:768].

Submit the program as well as the result from one example calculation.

2 Speckles

Expand your program such that your aperture function can have a complex value, i.e. $a \cdot e^{i\phi}$. Download the file with 100 phases ϕ (simulating the effect of the Earth atmosphere). The screens are 512 pixels squared.

1. Calculate the 100 PSFs that would correspond to these atmosphere aberrations.
2. Simulate the images of a triple-star system by making a perfect image of three point sources and concolve them with the 100 PSFs to generate 100 images of the triple-star system as it would be seen through the Earth's atmosphere.

   Choose the distance between the stars such that the distance between the stars is significantly smaller than the size of the speckle cloud.

   The convolution is best implemented via Fourier transforms.

Submit the program and the results for the first aberration.

3 Speckle Interferometry

Calculate the average image as well as the average auto-correlation of the 100 images simulating the triple-star system as seen through the atmosphere. Compare the two results and explain the average auto-correlation in terms of the real image of the triple-star system.