Astronomical Telescopes and Instruments 2017: Exercises on Adaptive Optics (Due on 8 November 2017 at 13:30)

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1 Simulating Kolmogorov Turbulence

Write a python program that can produce wavefronts corresponding to Kolmogorov turbulence spectrum with a given r_0. Start with a two-dimensional array of random numbers with a normal distribution. Calculate the Fourier transform of this array and multiply it in the radial direction such that its amplitude as a function of radius is proprtional to $r^{-11/6}$ and then take the real part of the inverse Fourier transform. Normalize the resulting wavefront such that its *variance* is $1.02\left(\frac{D}{r_0}\right)^{\frac{5}{3}}$ rad^2.

2 Zernike Polynomials

Write a python program that can generate Zernike polynomials.
Hint: `en.wikipedia.org/wiki/Zernike_polynomials`.

3 Simple Adaptive Optics System

Write a python program that takes a wavefront corresponding to Kolmogorov turbulence and remove the first n Zernike modes. Plot the variance of the remaining wavefront error as a function of n where n goes from 1 to 10.

4 Adaptive Optics System Design

The final performance of an AO system depends on many sources of errors. How many actuators would be needed for the 4.2-m William Herschel Telescope to achieve a Strehl ratio of 67% at 800 nm assuming $r_0 = 0.25$ m at 550 nm, a wind speed of 5m/s, a time lag in the AO control system of 5 ms and other errors producing 40 nm rms wavefront aberrations.