Discrete Hankel transform and linear optical pulse propagator

This homework assignment concerns the implementation and usage of the discrete Hankel transform and its application to the optical pulse propagation in situations characterized by axial symmetry.

A) Your first task is to implement a discrete Hankel transform function, and test it. As a rudimentary test, show that the transform is its own inverse, i.e. that application twice restores the original input.

B) The second task is to set up a simple pulse propagator based on the spectral method (i.e. Fourier between the time and frequency dimensions and Hankel between the radial and transverse wavenumber dimensions) restricted to axial symmetry. For simplicity we will assume that the propagation medium is vacuum.

C) The third task is to demonstrate that the propagator can simulate the propagation of an optical pulse. For concreteness, take a 35fs duration Gaussian pulse with central wavelength of 800nm, and a beam waist of 100 micron. Demonstrate propagation over one Rayleigh length, showing that the intensity decreases by the expected amount, and that the temporal shape of the pulse remains constant in the frame moving with the pulse group velocity.

Note: It is not necessary to implement calculation of Bessel zeros — one can use the provided tabulation in the file named *J0zeros.dat*.