Homework 3: Airy puzzler

Purpose:
A) Practice using the UPPE simulator: Basic simulation execution, work with the parameters that control the temporal computational domain and chromatic dispersion of the modeled medium.
B) Physics: Appreciate the effects of chromatic dispersion in the propagation of ultra-short optical pulses

Description:

This homework assignment is based on the work package for the UPPElab simulation template illustrating the deviation form the Gaussian pulse propagation in a realistic medium with chromatic dispersion.

There are three simulation templates included in this assignment. The first two are identical to those we worked with in the class. The simulation run with the base name A sets up an initial Gaussian pulse that propagates in water (which is idealized, without absorption). The initial condition is chosen as to make diffraction effects less important (due to large waist) than the chromatic dispersion. The comparative run with the base name Acmp is there only to save the Gaussian pulse that would evolve from that used as the initial condition in run A after the same propagation length as in simulation A. This is to underline the drastic difference in the pulse evolution you will see: The result of propagation in run A is very far from being Gaussian...

Your task:

A) Execute simulation A.

B) Execute simulation Acmp.

C) Plot in the same graph the intensity profile of the initial condition in run A, the final intensity profile in run A, and the initial intensity profile in run Acmp. Here we refer to the intensity profiles as function of the (local pulse) time which are stored in files that have _T_ in their names. The initial conditions are stored with the index _0 at the end of the file name; this number is an index corresponding to the propagation distance at which the file was saved.

   Here you should reproduce what we have observed in the class: There is a drastic change in the temporal intensity shape of the propagating pulse. Instead of maintaining a Gaussian envelope (as we most often expect from Gaussian pulses), the resulting shape resembles the square of a special function, namely the Airy function Ai

D) Look up the basic properties of Airy functions, in particular find out how $Ai(-x)^2$ looks and how similar (or different) it is to the intensity profile you obtained.

E) Execute the simulation in template with the base name B. Identify the differences from the run A. You should see that the propagated pulse remains (roughly) Gaussian.

F) Experiment with the parameters in inputB in order to find out how the resulting temporal shape "warps" into Airy Ai as the wavelength of the initial condition approaches that in the input A. One or two runs with different initial wavelengths should be sufficient to document this.

G) Find out an explanation for why the simulation A produces a temporal pulse with the shape of an Airy function. As a hint, a file with the group velocity dispersion data for water is included with this exercise.