Physics 350 Lab 12: Fourier Transforms with IDL

Objective: In this lab you will learn to Fourier transform a function, to manipulate functions using the Fourier transform, and to perform similar operations on images.

Do this first: Download the supplement to this lab and import the files into your project (you can do this by unzipping the files then dragging and dropping the files or by going to File→Import...).

Do this next: The IDL Workbench needs a little help understanding what folder you are working in. To help it, go to Preferences and set the preference shown in the file `Preferences.jpg` in supplement you just downloaded for this lab.

One dimension: In this first section you will go through some of the steps we did in lecture Monday to filter a function in one dimension. Once you are familiar with the idea of filtering a function you will apply the same ideas to filtering an image. Conceptually, the steps to go from a function $f(x)$, like the one in lecture, to a filtered version of that function, called $f_{\text{filt}}(x)$, are:

1. Fourier transform $f(x)$ to obtain $g(\alpha)$.
2. Multiply $g(\alpha)$ by a *filtering function* (also called a *window function*) that depends on α. In this lab the filtering function will be called $w(\alpha)$.
3. Perform the inverse Fourier transform of the product to obtained the filtered function f_{filt}.

A mathematical summary of these three steps is:

$$f_{\text{filt}} = \int_{-\infty}^{\infty} g(\alpha) w(\alpha) d\alpha. \tag{1}$$

To accomplish these three steps in IDL requires a few things. We need to define the function $f(x)$ in IDL, transform this function, define the filter $w(\alpha)$, multiply w by $g(\alpha)$, and transform back. To be neat and organized about this you are about to get a crash course in functions in IDL.

Do this:

- Open the file `filter_one_dim.pro` and run it (by clicking the green play button on the toolbar).
- Make the changes to `filter_one_dim.pro` indicated in the comments in that file.
- **For this part of the lab you will turn in you modified `filter_one_dim.pro` but not copies of any of the plots.**

Images–2 dimensions : Filtering two dimensional arrays in IDL is no harder (or easier) than filtering one dimensional arrays. In this section you load an image of the Cat's Eye Nebula, NGC 6543, and modify it by filtering out information at either high or low frequencies. In doing so you will learn how to create a blur effect in an image and how to detect edges.The image you will use is part of the lab supplement and is called `hs-2004-27-a-bw.png`

Do This:

- Open the file `filter_two_dim.pro`
- The file contains an outline of the task you are to do; fill in the necessary code.
- Much of what you need can be copied from the one dimensional case.
- Frequency Filtering
  1. **High-pass filter**
     (a) Write the code necessary to remove the low frequencies from the transform and keep only high frequencies. Try a few different filter frequencies until you find one that very, very clearly changes the image.
     (b) What sort of features are the same as in the original image and what are different? Explain why the image looks the way it does.
     (c) Try a couple different limits for high frequency, one above 100, one below, and describe how the images change. Make a printout of one of the images, and label it (by hand after you print) so we know what your limit was.
  2. **Low-pass filter.** Do the same steps as in the high-pass filter, but keep only frequencies *lower* than 100.