PHSX815_Project4:
Determining Binary Separation

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1 Introduction

One of the important problems in modern astronomy is the detection of a binary system. We will not be considering the process of detecting two objects in the field of view. Instead, given multiple images of a binary system taken at similar times, we would like to determine the separation distance between the two stars. By seeing how the separation distance changes in time, we can attempt to determine further orbital parameters, such as the total mass of the system, orbital period, and orbital inclination.

2 Problem Statement

Suppose a sequence of two-dimensional images with two sources on it. If the images are taken in a small period of time, then the source positions are fixed. However, because counting photons on the detector is a stochastic process, as well as atmospheric seeing, the apparent positions of the objects may vary over time. If we wish to determine the separation distance between two stars, this problem reduces to finding the most likely position of each individual star given the data, then determining the distance.

We must have a model of how point sources appear on our detector. For this, we use the Airy disk (Equation 1).

$$I\left(x\right) = I_0 \left(\frac{2J_1\left(x\right)}{2x}\right)^2 \tag{1}$$

In Equation 1, x is proportional to the radial distance from the center of the disk and J_1 is the Bessel function of the first kind. We will simulate each observation by taking samples from this distribution using fixed positions for the two sources. Using this simulated data, we will determine the positions of the sources by maximizing a likelihood.