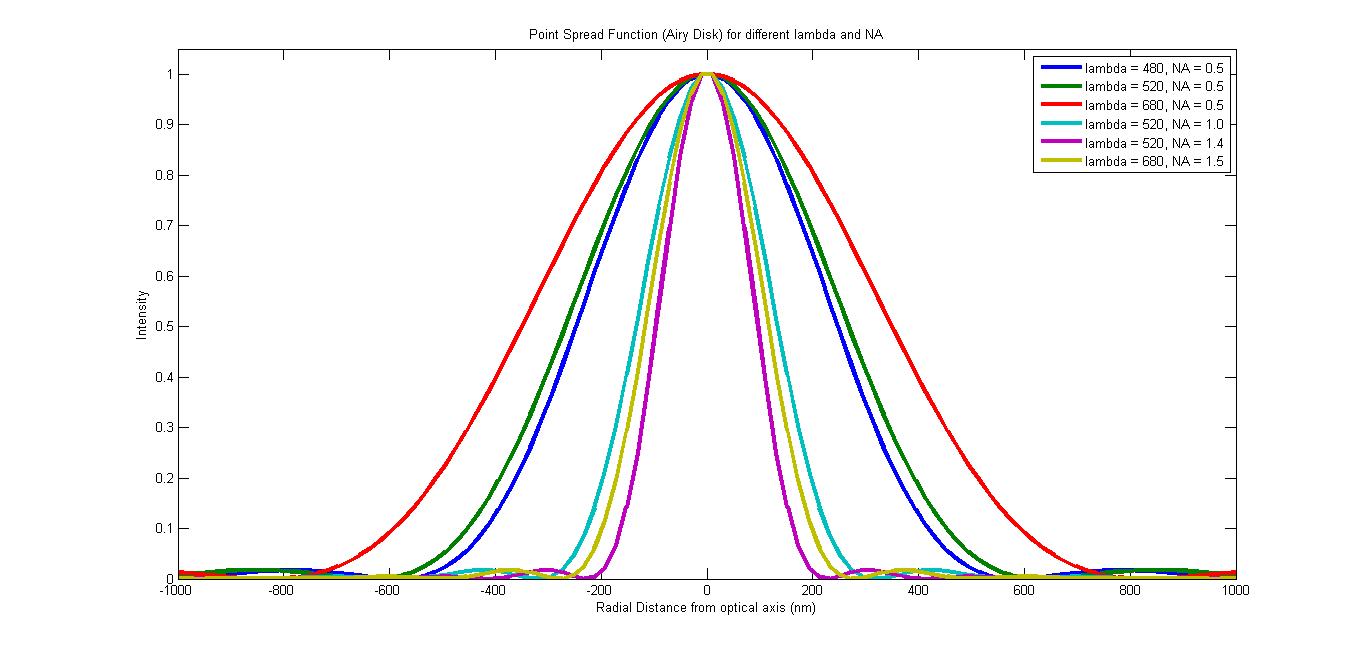
1. The plot showing the airy disk for all combinations of and NA is shown below:



Formula used for calculation of airy disk function at a given distance from optical axis:

where is a Bessel function of first kind with order .

**PART 1:**

Table showing variation of airy disk radius corresponding to the wavelength and NA given:

|  |  |  |  |
| --- | --- | --- | --- |
| **S.No.** | **(nm)** | **NA** | **Approximate Airy Disk radius (nm)** |
| 1 | 480 | 0.5 | 586 |
| 2 | 520 | 0.5 | 635 |
| 3 | 680 | 0.5 | 830 |
| 4 | 520 | 1.0 | 317 |
| 5 | 520 | 1.4 | 227 |
| 6 | 680 | 1.5 | 277 |

**NOTE:** The approximate airy disk radius was found out by trying to find the lowest at which the airy disk function was close to . This was done in MATLAB and the approximate airy disk radii given are our best guesses from the data we had.

We can see that for a fixed NA, the radius of the airy disk is directly proportional to the wavelength. This can be seen from observations 1-3 in the table where the NA is fixed at 0.5 and is increasing. As we increase , we see that the radius increases proportionally.

We can also see that for a fixed , the radius of the airy disk is inversely proportional to the numerical aperture NA. This can be seen from observations 2,4 and 5 where is fixed at 520 nm and NA is increasing. We see in this case that the airy disk radius is inversely proportional to NA and decreases with increasing NA.

From the plot below we can see that is fully correlated with the airy disk radius.

The slope of the line is approximately 0.61 and this follows the Rayleigh limit which says that the Airy disk radius

**Summary:** The airy disk radius increases through observations 1-3 as the wavelength increases at fixed NA. The airy disk radius decreases through observations 2 and 4-5 as the NA increases at fixed . In observation 6, although the NA increases compared to observation 5, the huge increase in wavelength from 520 nm to 680 nm makes the radius slightly larger than for observation 5.

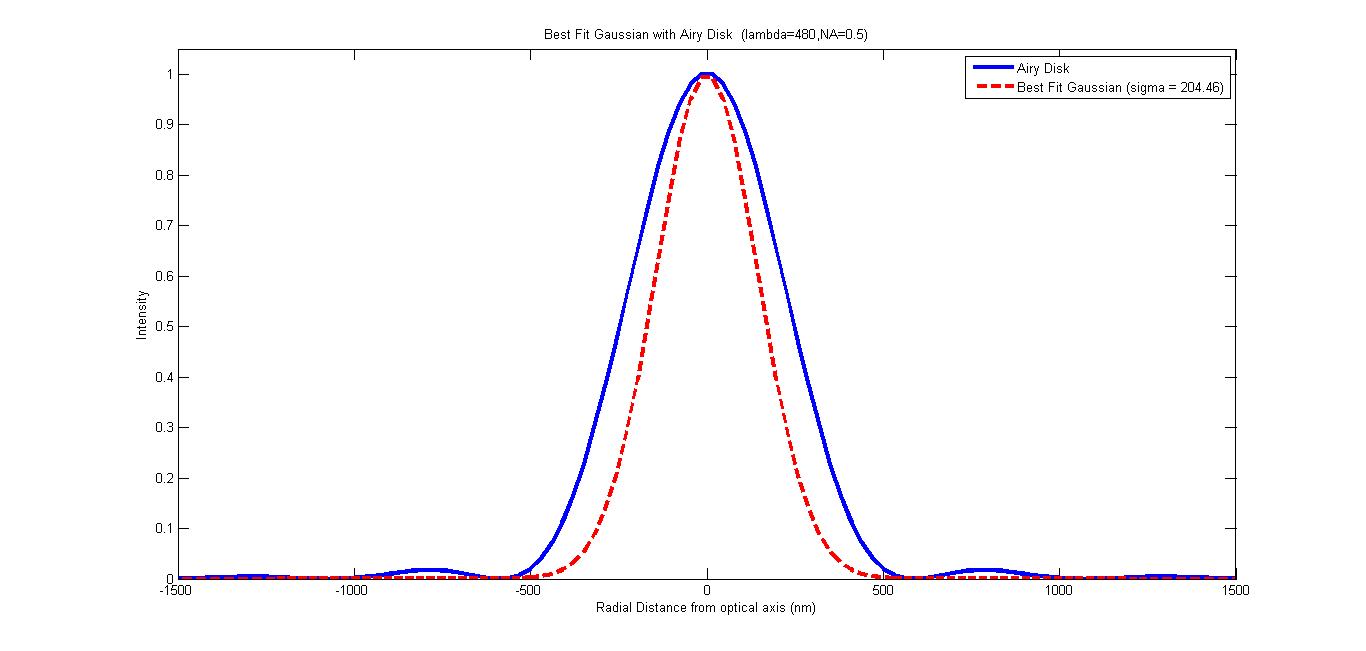
**NOTE:** Code submitted in file: q3\_plotAiryDisk.m. This code generates the individual point spread function plots for a particular given and NA. This contains a function that also takes as input whether to fit a Gaussian or not as the third argument (required for part 2).

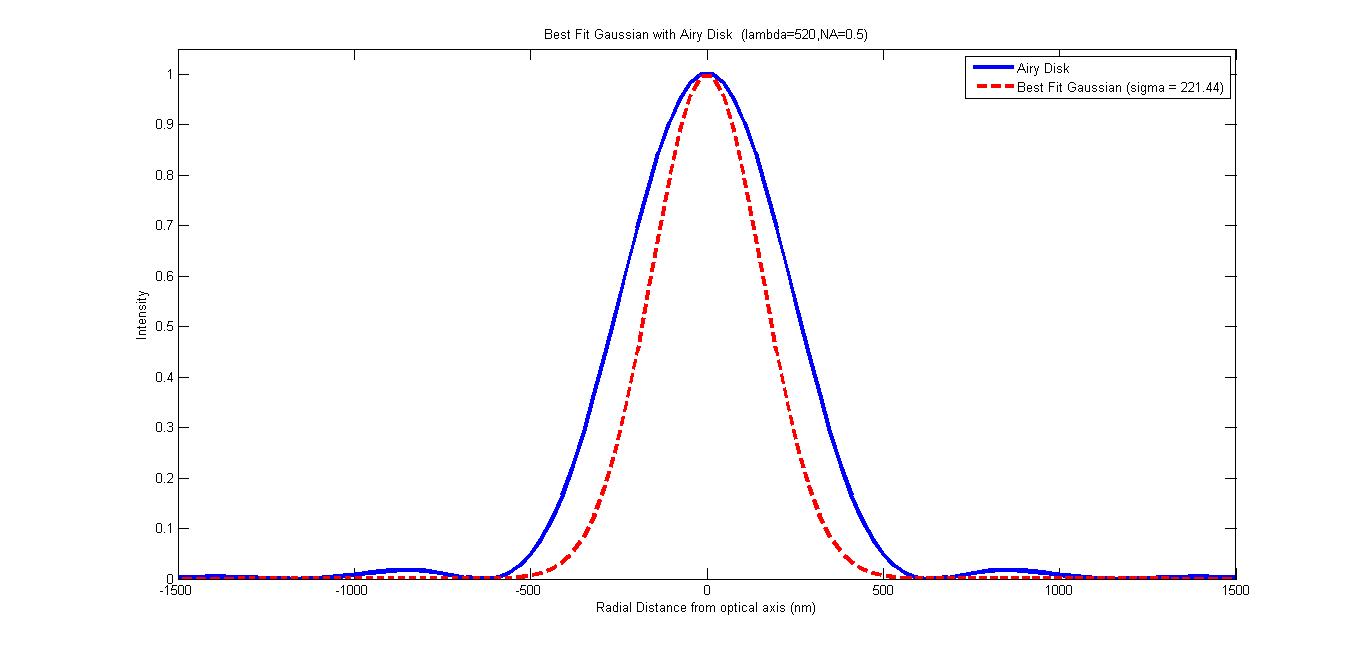
Figure showing all 6 airy disks in one graph submitted in file: q3part1plot.fig and q3part1plot.jpg. This figure is also shown above.

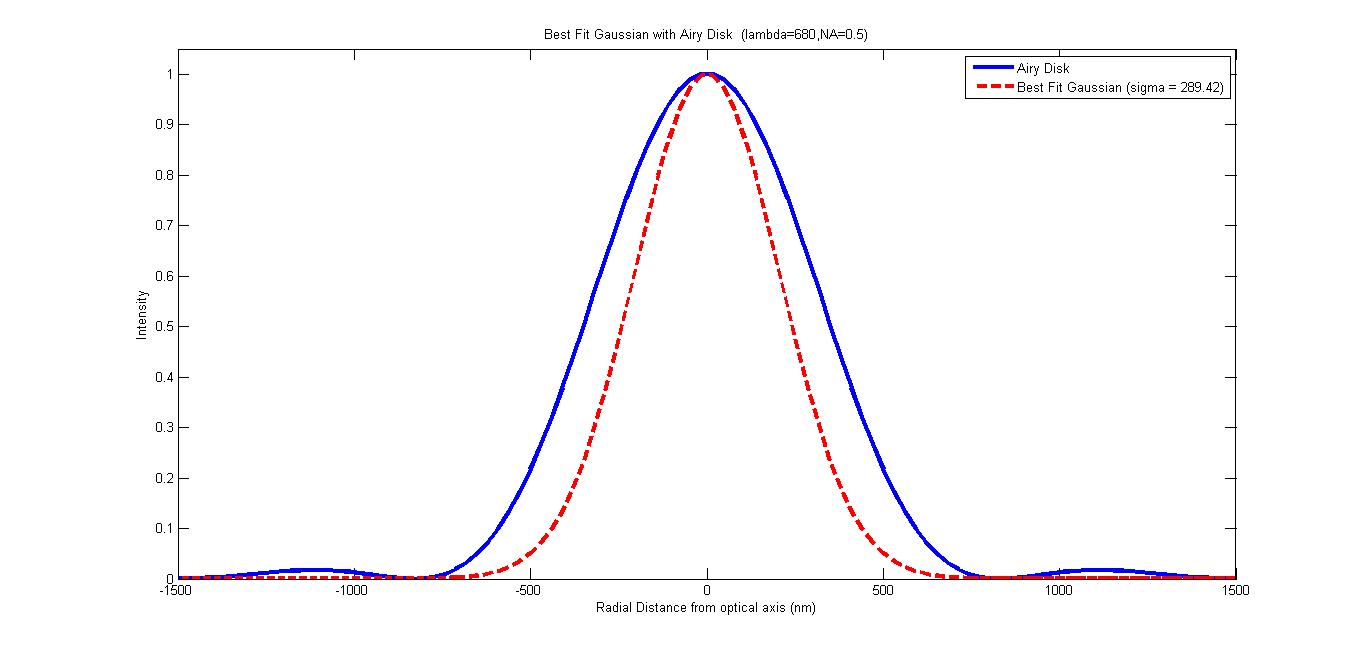
**SIDE NOTE:** Code to generate the combined airy disk plots (shown above) for the 6 observations is submitted in files: q3part1\_makeFigure.m and q3part1\_getAiryDiskFunction.m

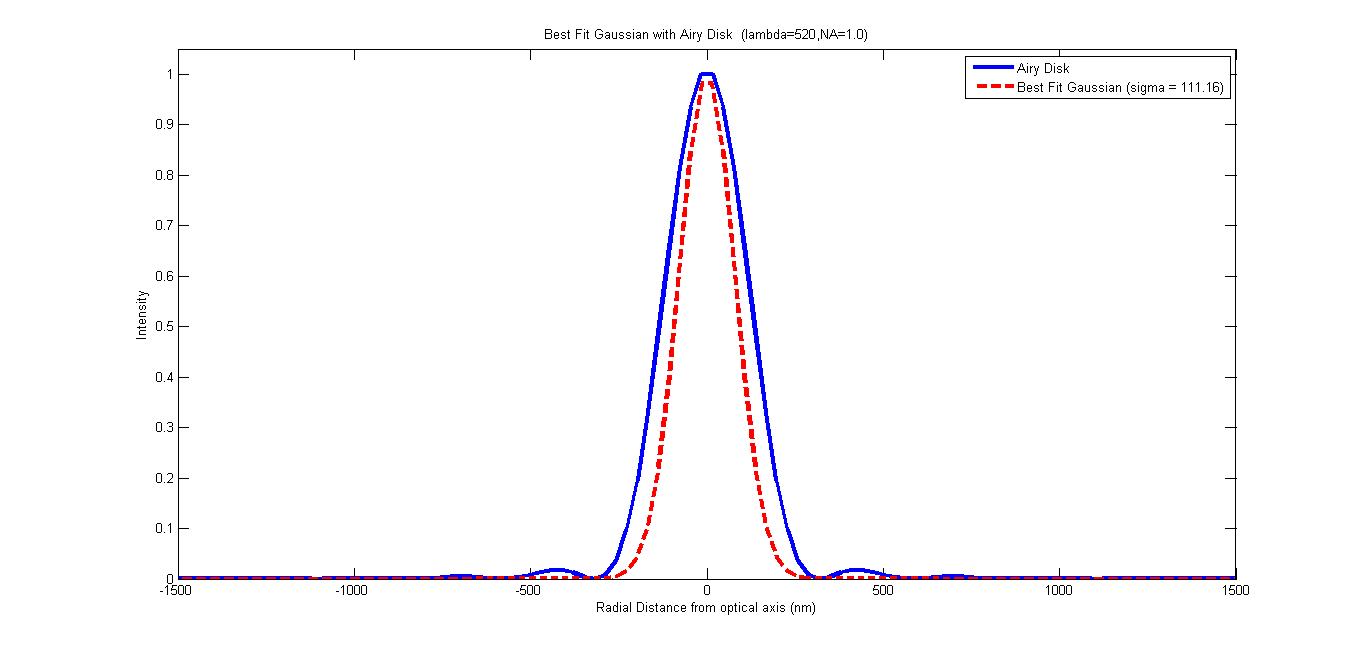
**PART 2:**

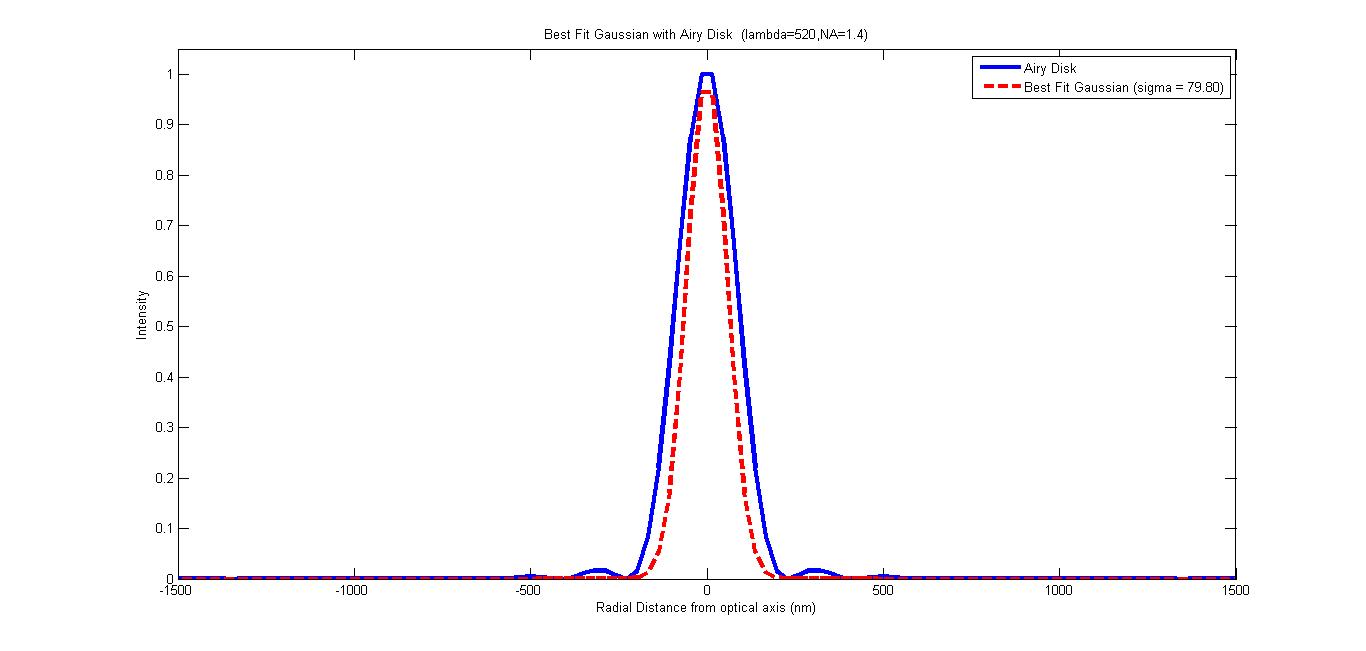
Individual plots showing fitted Gaussians for all 6 observations are shown below in order. The and NA used are mentioned in the title of the figures. The standard deviation of the fitted Gaussian is mentioned in the figure legend.











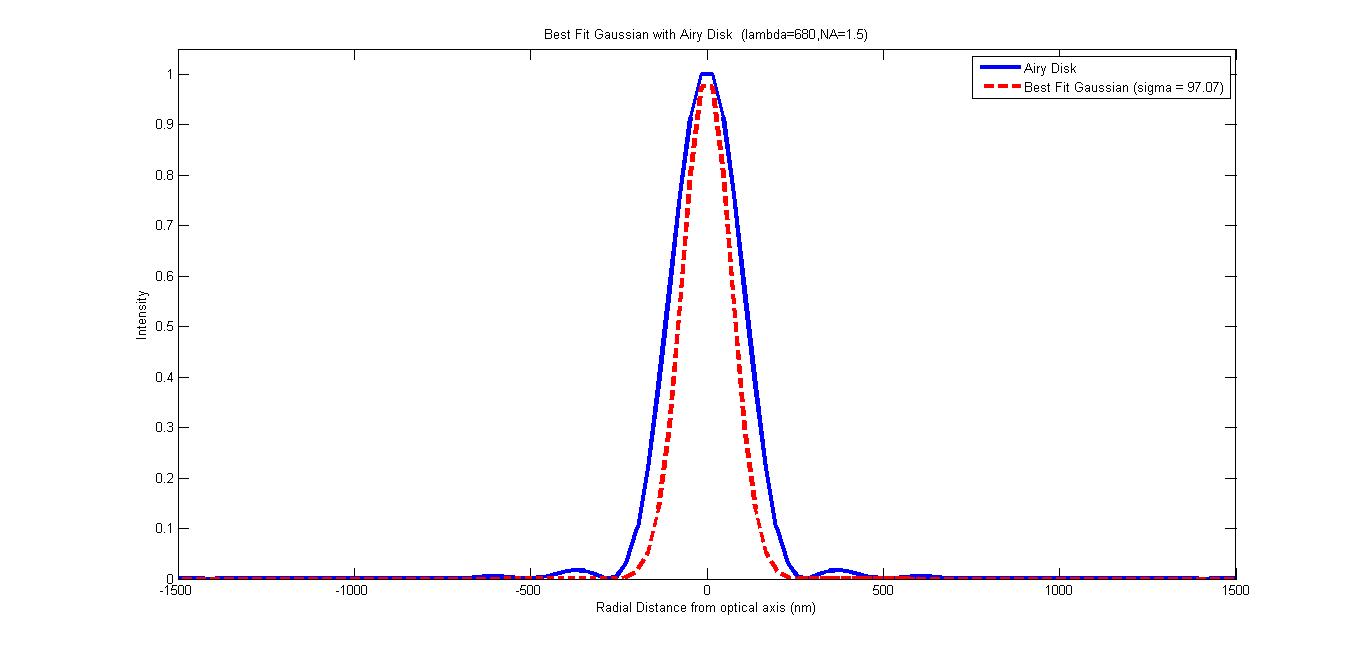


Table summarizing the gaussian standard deviation values found after fitting the Gaussians:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **S.No.** | **(nm)** | **NA** | **Approximate Airy Disk radius (nm)** | **Gaussian (nm)** |  |
| 1 | 480 | 0.5 | 586 | 204.46 | 2.866086 |
| 2 | 520 | 0.5 | 635 | 221.44 | 2.867594 |
| 3 | 680 | 0.5 | 830 | 289.42 | 2.867805 |
| 4 | 520 | 1.0 | 317 | 111.16 | 2.851745 |
| 5 | 520 | 1.4 | 227 | 79.80 | 2.844612 |
| 6 | 680 | 1.5 | 277 | 97.07 | 2.853611 |

We can see that the ratio remains almost constant at around 2.86.

The airy disk radius and the gaussian are completely correlated as can be seen from the plot below:

We observe that the airy disk radius is approximately times the standard deviation of the fitted Gaussian i.e . The fact that we can fit a Gaussian to all these airy disks makes us come to the conclusion that the airy disk can be suitably approximated using a Gaussian kernel with where is the airy disk radius.

**NOTE:** It was assumed that the magnitude of the Gaussian was since the airy disk was normalized before plotting. The Gaussian was fitted using the MATLAB function that minimizes the least square difference between the gaussian kernel and the point spread function (airy disk).