August 2, 2014

I have redone the plots from the previous post, since there were some mistakes in my code. First here are the Fourier coefficient plots for a beam radius of $r_0 = 1$ mm and $W = L = H = 4$ cm. Figure 1 indicates how many terms are necessary to keep in the Fourier series.

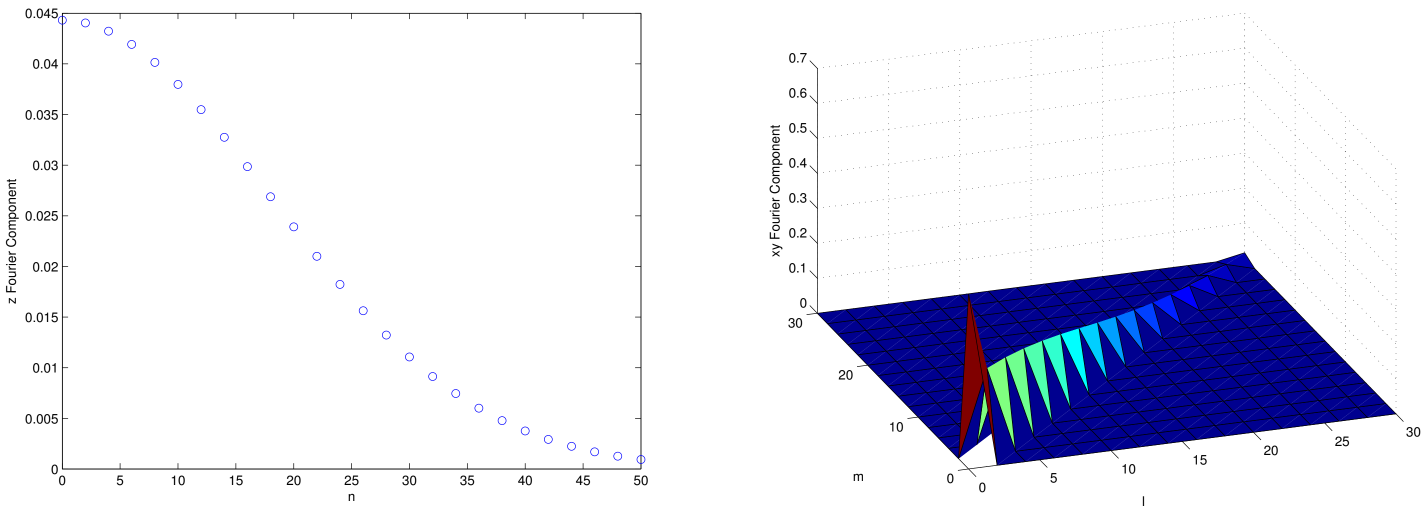

Figure 1: The z-component should go out to about 50 terms, while the xy components should go out to about 50 terms. Moreover, the diagonal $m = l$ only contributes to the Fourier series, allowing us to neglect many terms.

Here are the analytical-numerical comparisons for a uniform, finer mesh. Last time, I neglected the zeroth Fourier series term, which was definitely wrong to do!

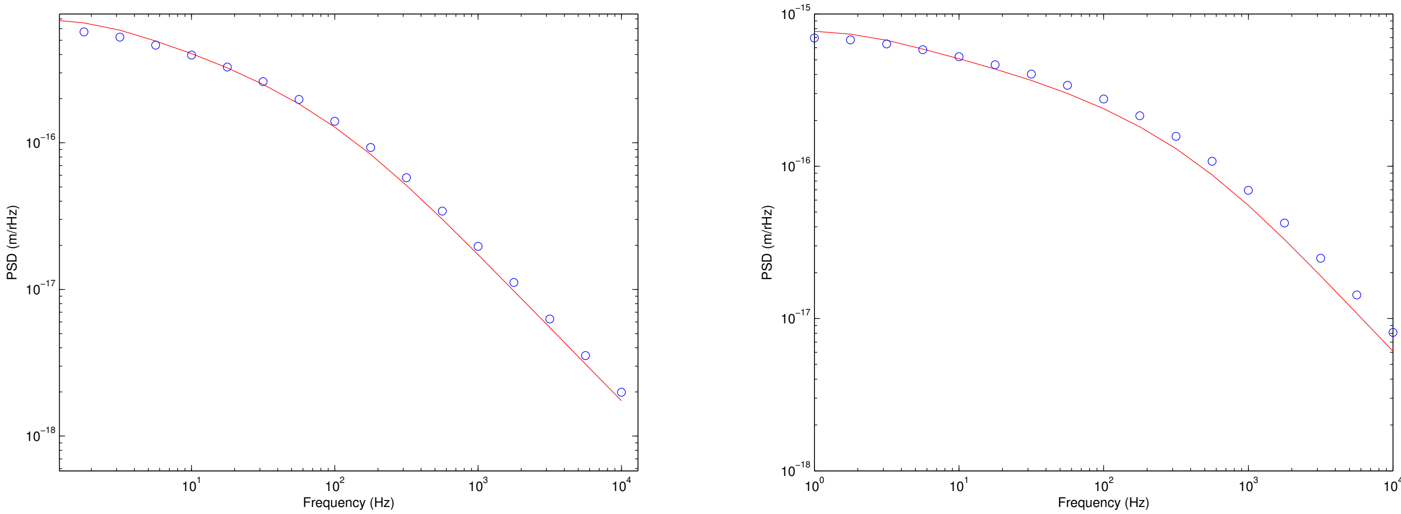

Figure 2: $r_0 = 2$ mm (left), $r_0 = 1$ mm (right)

As expected, figure 2 shows that reducing the beam radius causes the numerical-analytical error to increase. A smaller beam size requires more terms, and the meshing loses accuracy. For reference, figure 3 shows what the fourier coefficient plots look like for $r_0 = 49/\sqrt{2}$ μm

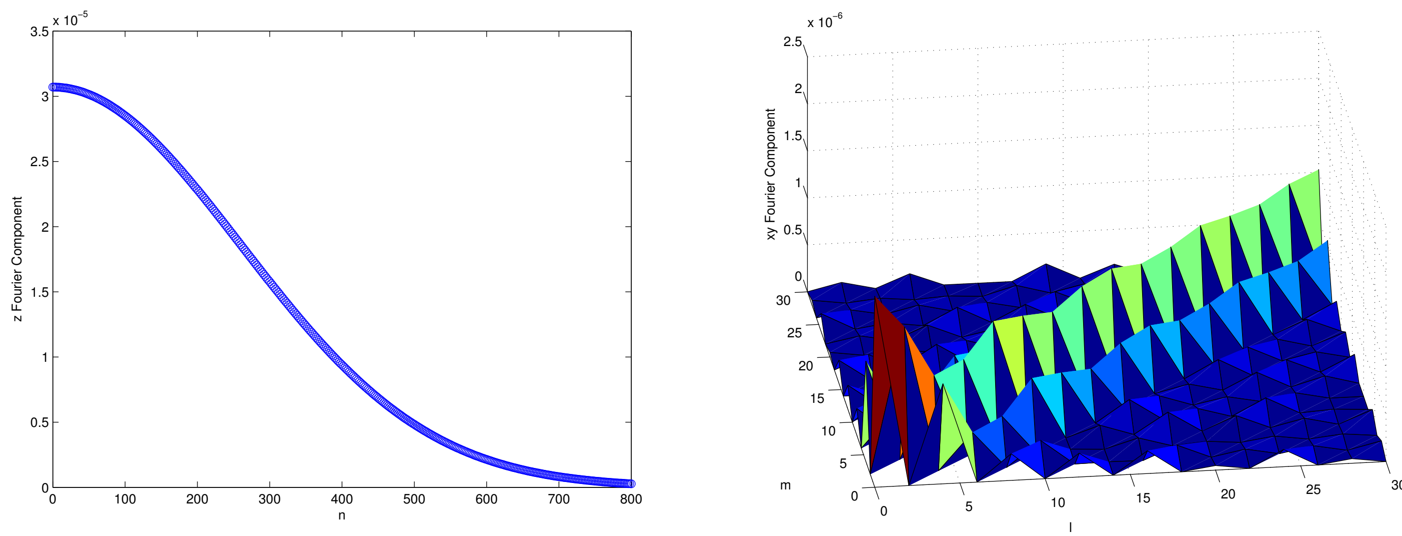

Figure 3: This plot was done for $L = W = H = 2$ cm. The z-component needs about 800 terms, while the xy components also need more than 30. Moreover, off diagonal terms start to become important here. These plots show that it is not easy to obtain a good analytical solution when the beam radius is small.

The plots in figure 2 were obtained from the 'inefficient' method of a triple for loop through 34 terms each. The following plots show them for the improved code. It turns out that the plots don't look much different, but they are generated much faster. The Fourier coefficient plots give us more confidence in the accuracy of the analytical model, allowing us to attribute error to the meshing.

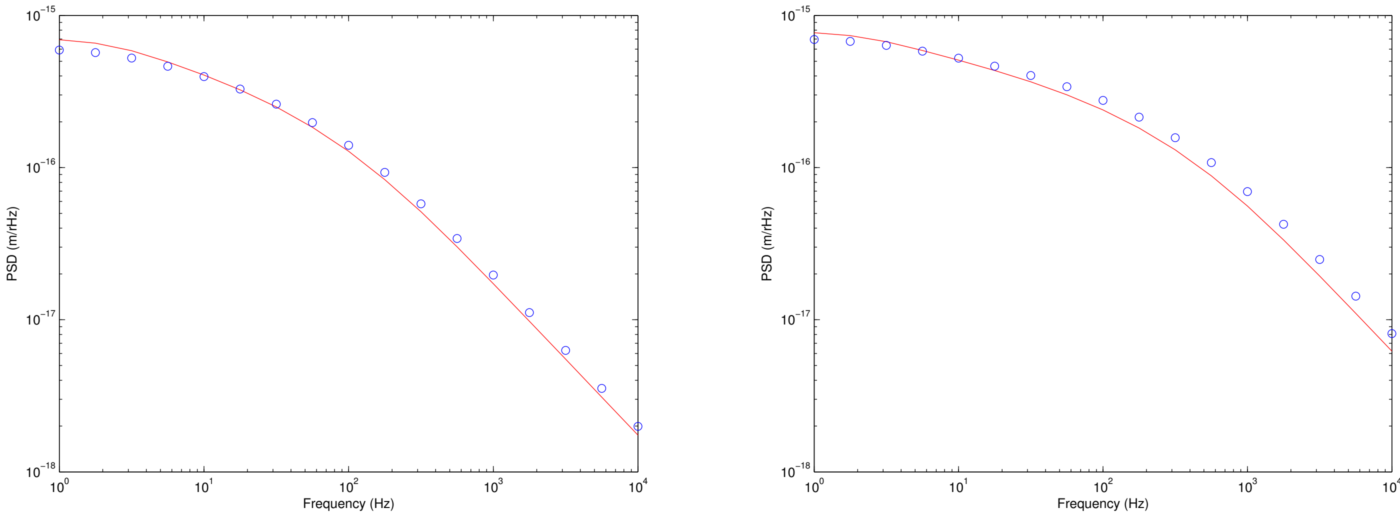

Figure 4: The optimized plots ($r_0 = 2$ mm, $r_0 = 1$ mm) don't look much different than before, but they do run faster.