

Knife Fit; Steck Section 6.6

Gaussian Fit to Beam (10 pts) Watch the video `Lab4bHeNeLaserCavity_BeamProfile.mov` in the OpticsLab2021 Google Drive. Direct link: <https://drive.google.com/file/d/1is-JH-bAUDqZ9K6NLT1b2jNuAYyUjfuz/view?usp=sharing>

Download the data that I took and recorded in the CSV file:
`Lab4bHeNeLaserCavity_BeamProfile_Data.csv`.

From the section problem, you should have an expression for the power that makes it past a knife in various positions. Do a fit to determine w at the location of the knife edge along with any other “nuisance parameters” like an arbitrary position offset and power-meter offset. It will be your first non-linear fit and your first with more than two parameters. Non-linear fits often require an initial guess for the parameters, which you can specify as the `p0` parameter of `curve_fit`.

Be sure to show Residuals, Normalized Residuals, and calculate χ^2 , χ^2 per degree of freedom taking into account the number of fit parameters, and the probability-to-exceed (PTE).

When I did the fit, it looked good, but had awful χ^2 and PTE values. Unless I screwed up, this tells me that my errors are not statistical, but systematic. Perhaps the razor wasn’t vertical or completely straight; perhaps there was a lot of scattered light that changed in a repeatable way as I moved the laser; or perhaps the beam wasn’t Gaussian at the level of accuracy that the micrometer and power meter can measure.

Assume that I was close enough to the focus of the laser to treat w as w_0 . Calculate z_0 from this. Based on the video, was that a reasonable assumption to make?

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Steck Section 6.6 (10 pts) For a HeNe laser with $w_0 = 0.5$ mm, reproduce the intensity plots in the figures in section 6.6 along with colorized phase plots for

- Hermite-Gaussian modes (p104)
- Doughnut mode (page 105) and
- Laguerre-Gaussian Modes for a few of your favorite l and m (page 105 not shown)

Ignore overall constant amplitudes—just scale things so that the plots look reasonable. You will need to choose reasonable parameters for z and the size of your screen. Be sure to indicate units on your plot and the location z in the title along with what you’re plotting. I’ll just be looking at your plots and their titles, not code or comments.

Motivation: Watch the video `Lab4aHeNeLaserCavity_SpatialModes.mp4` Direct link: <https://drive.google.com/file/d/18ADlwecpoW-YqBNyISwMZ7UVTrAuQgjF/view?usp=sharing>

Hint: You can use `Plane Waves Real` and `Complex.ipynb` as a template and just copy the `colorize` function directly to help plot complex functions.

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