

Assignment #2

Applying Geometrical Optics, Building the Rochester Cloak

Schedule:

Jan 11: Lecture

Jan 13: Building cloak with simple lenses

Jan 11-15: Work on assignment

Jan 27: Assignment due

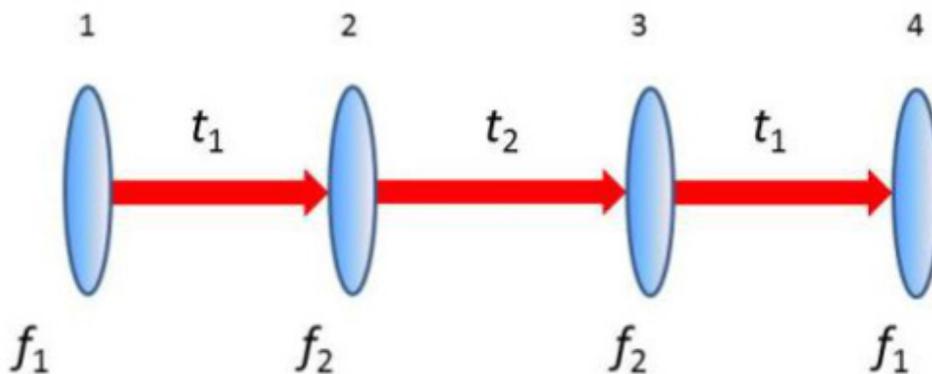
Goals for this week

- Build an invisibility cloak using simple lenses.
- Continue working on Assignment 1.

Instructions:

Building a 4 lens optical cloak (From University of Rochester web site, see link below).

1. Purchase 2 sets of 2 lenses with different focal lengths f_1 and f_2 (4 lenses total, 2 with f_1 focal length, and 2 with f_2 focal length)
2. Separate the first 2 lenses by the sum of their focal lengths (So f_1 lens is the first lens, f_2 is the 2nd lens, and they are separated by $t_1 = f_1 + f_2$).
3. Do the same in Step 2 for the other two lenses.
4. Separate the two sets by $t_2 = 2 f_2 (f_1 + f_2) / (f_1 - f_2)$ apart, so that the two f_2 lenses are t_2 apart.



For the first and last lenses (1 and 4), we will use 200 mm focal length, 50 mm diameter achromatic doublets composed of BK7 and SF2 glasses. For the center two lenses (2 and 3), we will use 75 mm focal length, 50 mm diameter achromatic doublets composed of SF11 and BAF11 glasses. All doublets were off-the-shelf catalogue optics from Thorlabs (Table 1) and had anti-reflection coating in the visible spectrum. Total length of the system is 910 mm.

Table 1: Components from Thorlabs available

| Part number | | Cost ea. | Number | Totals |
|-------------|--|----------|--------|------------|
| AC508-200-A | | \$101.00 | 2 | \$202.00 |
| LMR2 | | \$24.68 | 4 | \$98.72 |
| AC508-075-A | | \$116.00 | 2 | \$232.00 |
| SM2L10 | | \$28.75 | 2 | \$57.50 |
| SM2RR | | \$6.75 | 4 | \$27.00 |
| SPW604 | | \$43.40 | 1 | \$43.40 |
| TR50/M-P5 | | \$23.36 | 1 | \$23.36 |
| TR100/M-P5 | | \$26.42 | 1 | \$26.42 |
| BA1/M-P5 | | \$25.20 | 1 | \$25.20 |
| BA1S/M-P5 | | \$23.40 | 1 | \$23.40 |
| MB15120/M | | \$306.00 | 1 | \$306.00 |
| | | | | \$1,065.00 |

Questions:

How robust is the optical cloak?

Q1: How much can distance t_1 be increased and decreased before the cloaking effect is eliminated?

Q2: How much can distance t_2 be increased and decreased before the cloaking effect is eliminated?

Q3: If you change both distances t_1 and t_2 does the cloaking effect return?

Switch the order of lenses with focal lengths f_1 and f_2 .

Q4: Does this eliminate the cloaking effect?

Q5: Use ray tracing to plot the region that is cloaked. Make a picture with the lenses. (Can be a rough picture, no measurements required).

This publication by the authors provide some fun views of other simple cloaks:

Howell JC, Howell JB, Choi JS. 2014. Amplitude-only, passive, broadband, optical spatial cloaking of very large objects. Applied Optics 53:1958-1963.

Useful Links for this Lab:

Publication for Building of Optical Cloak

Choi JS, Howell JC. 2014. Paraxial ray optics cloaking. Optics Express 22:29465-29478.

<https://www.osapublishing.org/oe/abstract.cfm?URI=oe-22-24-29465>

University of Rochester newscenter:

<http://www.rochester.edu/newscenter/watch-rochester-cloak-uses-ordinary-lenses-to-hide-objects-across-continuous-range-of-angles-70592/>

Printing colored graph paper:

<http://incompetech.com/graphpaper/multicolor/>