Designing a Thin, Tuneable Focal Length Lens

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1.Introduction

Variable focal length lenses have practical applications. A new design for such a lens was investigated, inspired by some of the examples below.

“Adlens” - https://adlens.com/shop/uzoom-screen-protect/ [1][2]

“Eyejusters”- https://newatlas.com/eyejusters-adjustable-glasses-developing-world/22734/ [1][3]

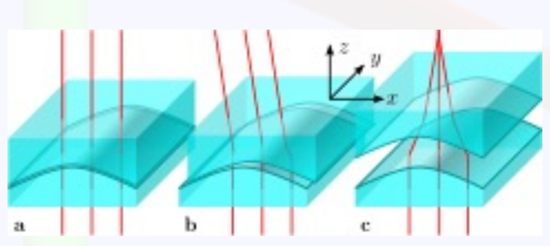
“Tamron Zoom Lens: 150-600mm” - https://www.the-digital-picture.com/Reviews/Tamron-150-600mm-f-5-6.3-Di-VC-USD-Lens.aspx

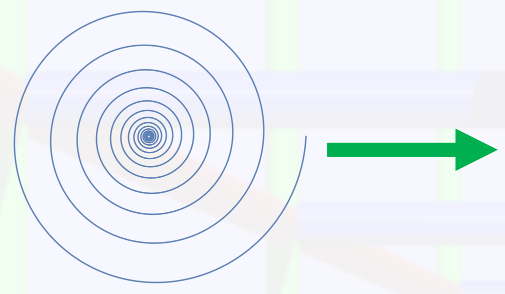
“Optutune- Fluidic Lens”- https://www.youtube.com/watch?v=u6cdLYoZNgc [4][5]

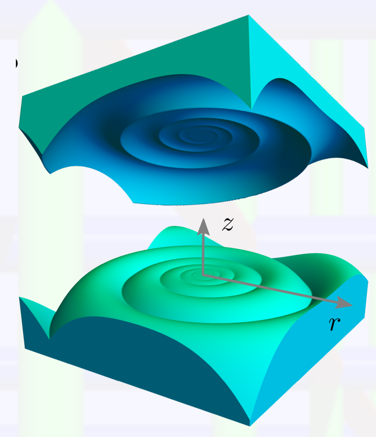
2.Lens Design

- Two complementary lenses
- Focal lengths of equal magnitude and opposite sign: f,-f
- Pitch wound into the shape of a logarithmic spiral
- Rotation and separation between the two lenslets gives rise to a change in focal length and focusing power.

$$r = ae^{b\varphi}$$



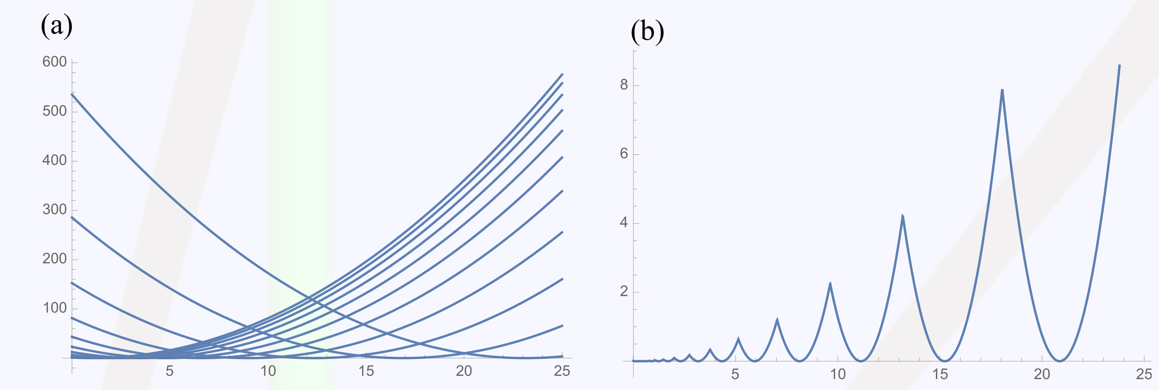




3.Lens Construction

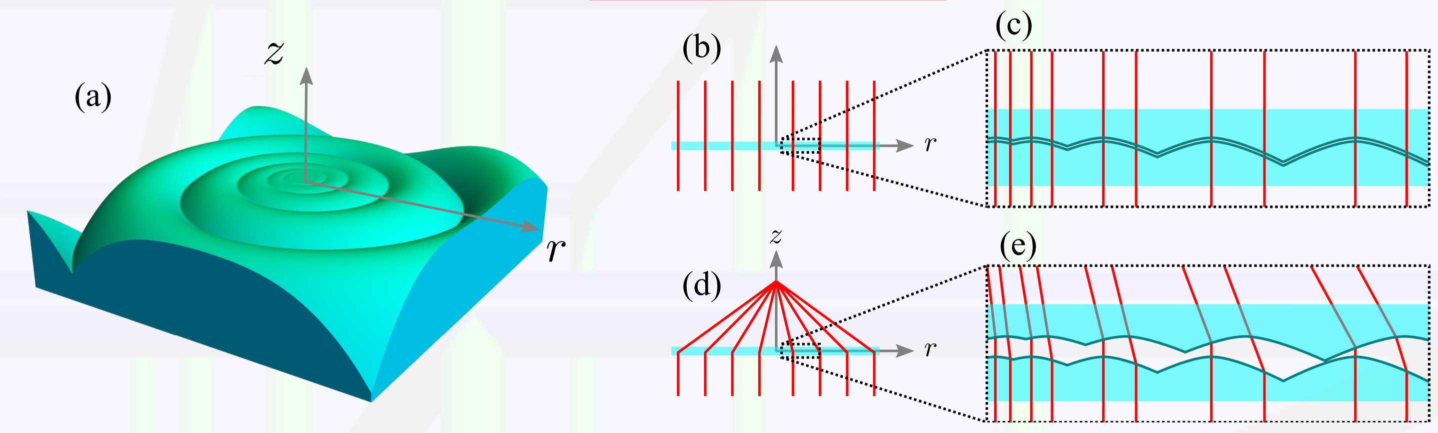
3-D model created using Mathematica:

- Function plots a parabola at each point the logarithmic spiral intersects the x-axis
- Taking the minimum value of the multi-parabola plot gives the appropriate projection.



Obtaining this function allowed two complementary lenses to be created. Change in focal length due to rotation about a common axis given as:

$$\frac{\Delta r}{r} = \frac{f}{F}$$



4.Focusing

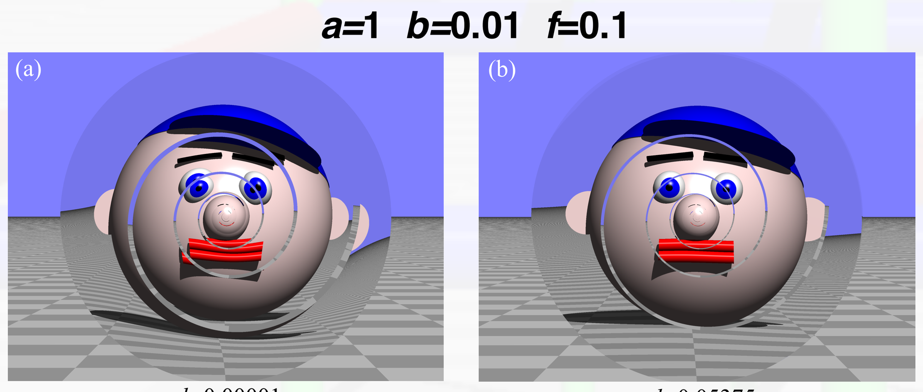
Separation between the two lenses changes the focusing power of the arrangement. This is drawn from the expression for a combination of lenses,

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}.$$

In this case, $f_2 = -f_1$, hence this reduces to:

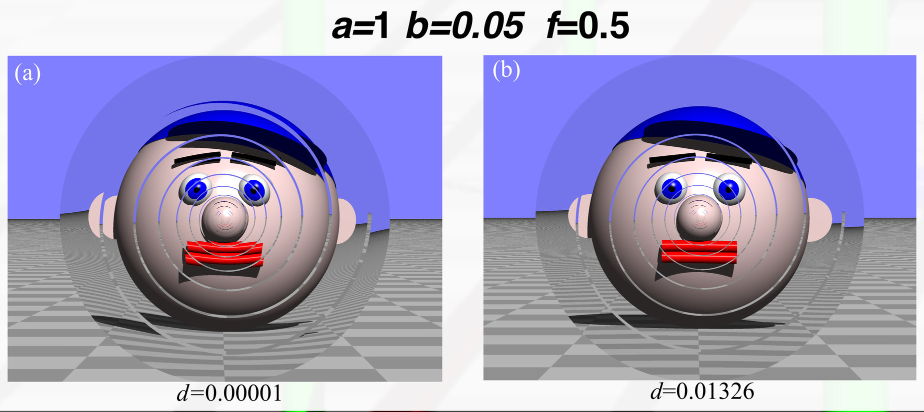
$$d = \frac{f^2}{F}$$

***a*=1 *b*=0.01 *f*=0.1**



(a) d=0.00001 (b) d=0.05375

***a*=1 *b*=0.05 *f*=0.5**

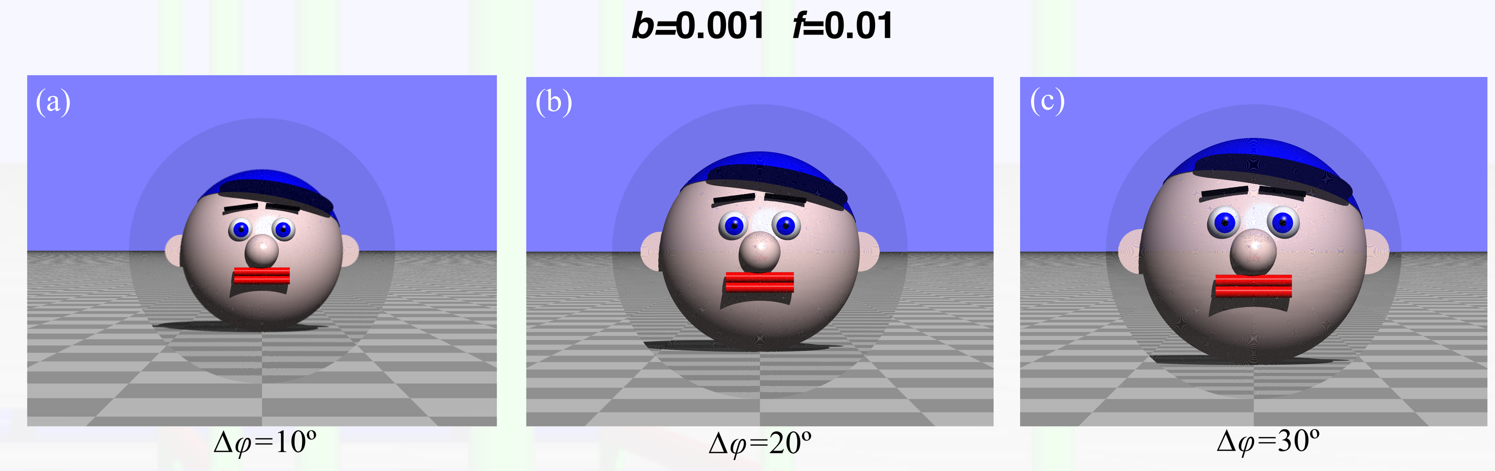


(a) d=0.00001 (b) d=0.01326

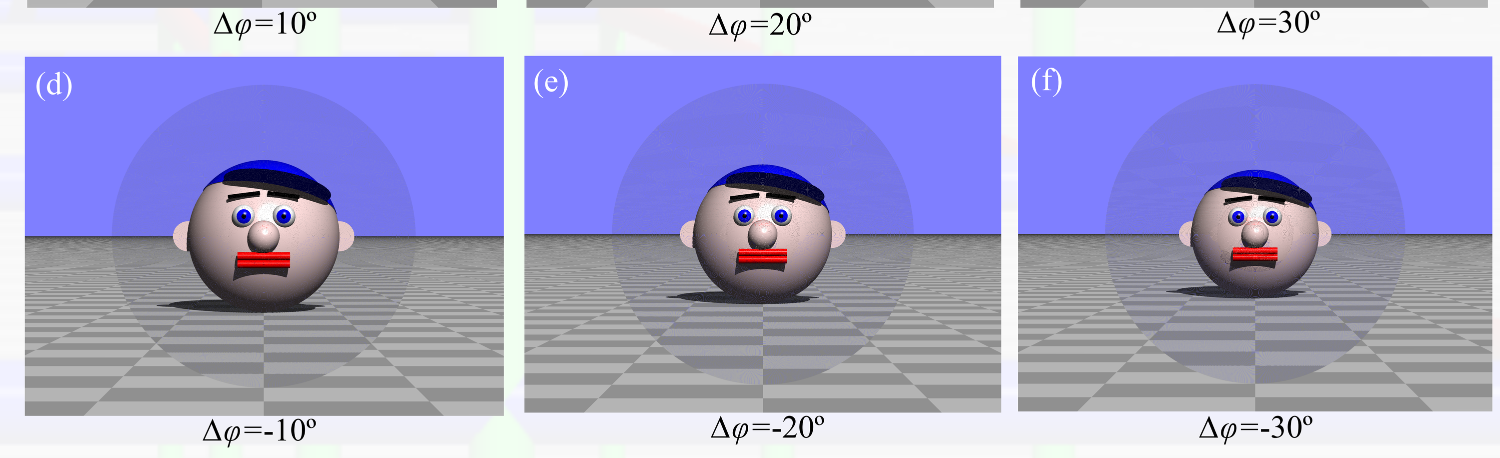
5.Lens Visualising Software Examples

Once constructed, this plot could be coded into lens visualising software, and the total focal length of the arrangement could be seen when one of the spirals was rotated relative to the other.

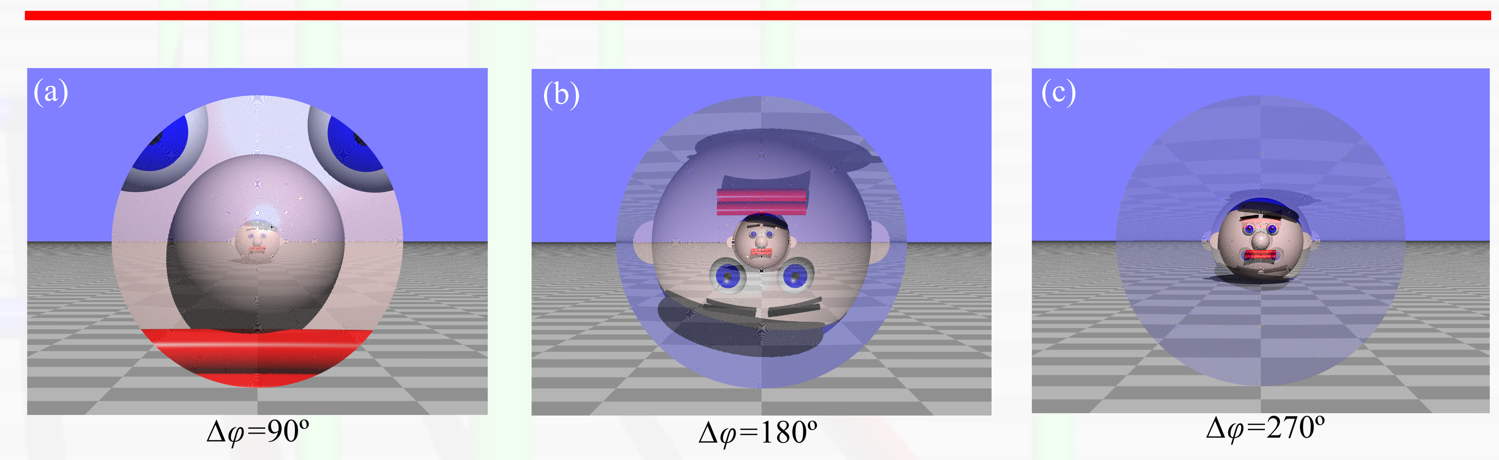
***b*=0.001 *f*=0.01**



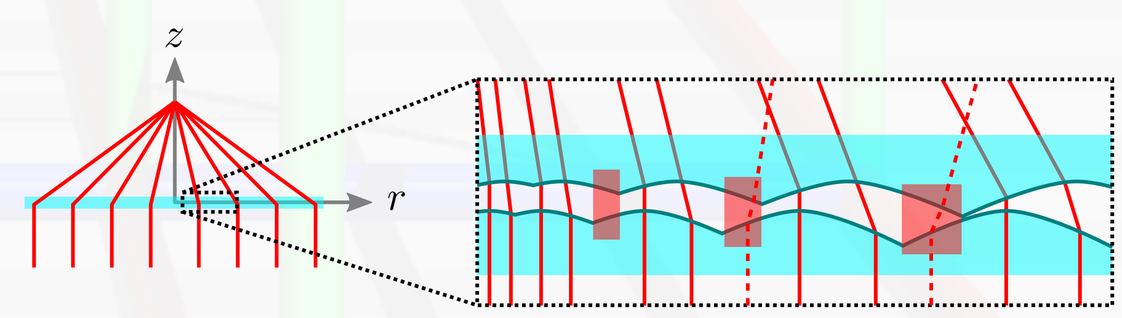
(a) $\Delta\varphi$=10º (b) $\Delta\varphi$=20º (c) $\Delta\varphi$=30º



(d) $\Delta\varphi$=-10º (e) $\Delta\varphi$=-20º (f) $\Delta\varphi$=-30º



(a) $\Delta\varphi$=90º (b) $\Delta\varphi$=180º (c) $\Delta\varphi$=270º

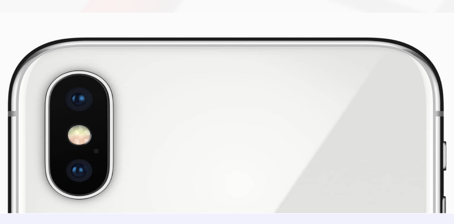


6.Conclusions and Further Work

The design has been tested successfully, but only computationally. It would be useful to have this type of lens manufactured, and its success analysed physically.

Once physically tested, suitable practical applications and commercial scope could be investigated. Potential applications such as:

- Another pair of adjustable glasses as seen above
- Providing smart phone/digital cameras with optical zoom



iPhone X- Latest model of which advertises 2x Optical Zoom on its camera. Released 3rd November 2017

https://www.macobserver.com/news/new-camera-features-in-iphone-8-8-plus-and-iphone-x/

References

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[2] Adlens, “Adjustable Lens Glasses: How They Work” https://adlens.com/how-it-works/ (2017)
[3] Eyejusters, “Eye just… Use one pair of glasses for everything,” https://www.eyejusters.com (2018)
[4] K. Mishra, C. Murade, B. Carreel, I. Roghair, J. M. Oh, G. Manukyan, D. van den Ende, and F. Mugele, “Optofluidic lens with tunable focal length and asphericity,” Scientific Reports, vol. 4, pp. 6378 EP –, 09 2014.
[5] Optotune, “Focus Tunable Lenses”, http://www.optotune.com/technology/focus-tunable-lenses (2016)
[6] S. Bernet and M. Ritsch-Marte, “Adjustable refractive power from diffractive moiré elements,” Appl. Opt., vol. 47, pp. 3722–3730, 2008.