Protar Lens

Lens Design OPTI 517

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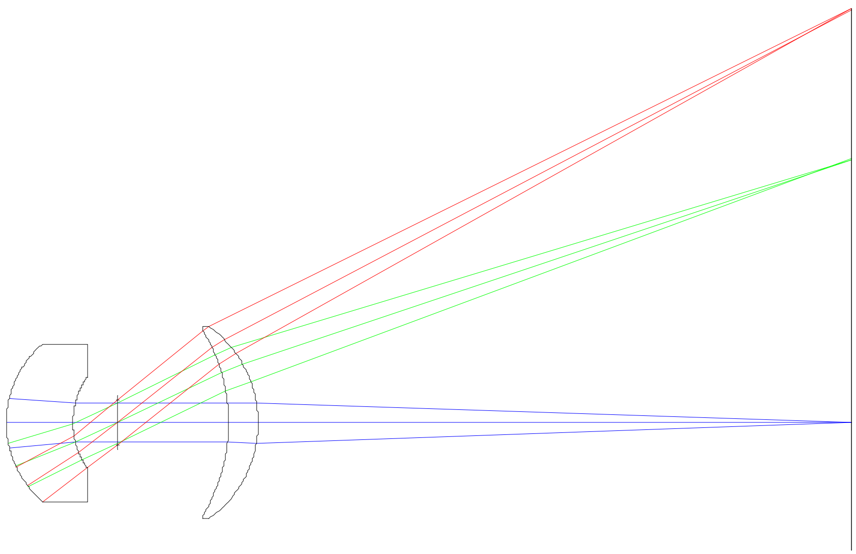
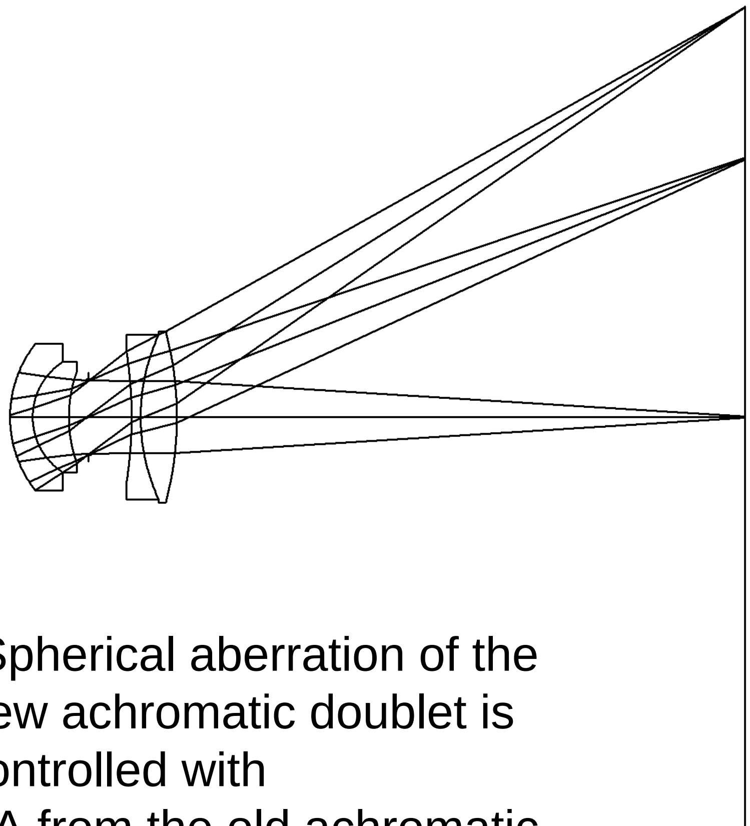
Thick and thin meniscus



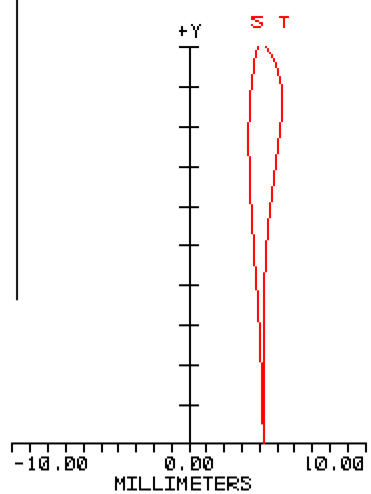
- Thick meniscus lens corrects field curvature of the thin meniscus
- Thick meniscus is afocal
- Thick lens likely unconventional prior to 1890
- Concept of an afocal corrector

Protar or anastigmatic lens



- Flat field
- Use of a ‘new achromat’ and an old achromat
- Use of a thick meniscus
- Protar or anastigmatic lens
- 1890, Paul Rudolph (1858-1935)
- Correcting all aberrations?

“Spherical aberration of the new achromatic doublet is controlled with
SA from the old achromatic doublet.”



Strong curvatures at faster speed

Wave coefficients

Seidel Aberration Coefficients in Waves:

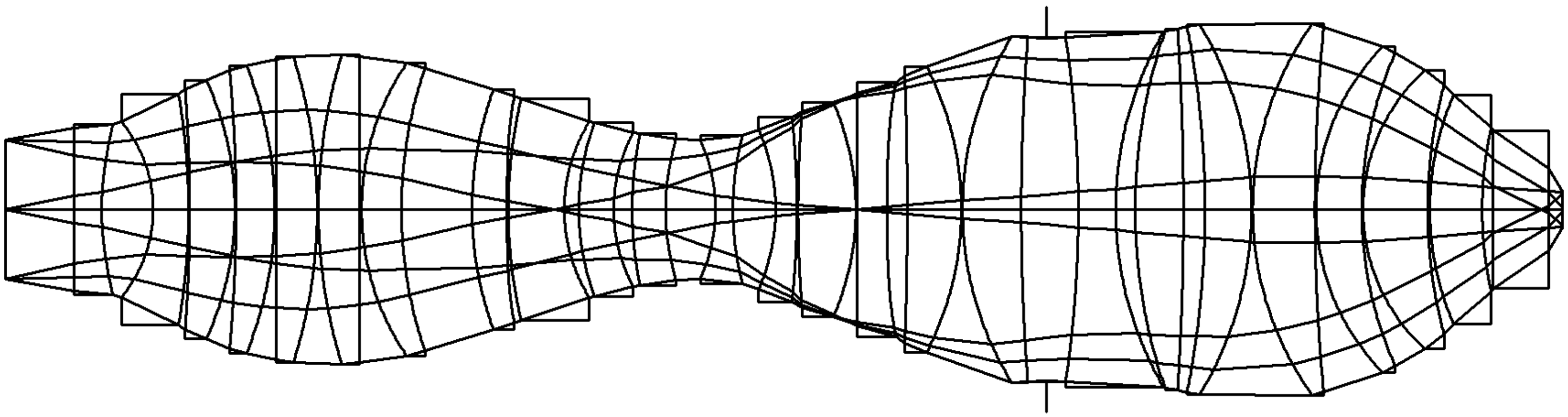
Surf	W040	W131	W222	W220	W311	W020	W111
1	16.902694	38.266476	21.658134	128.082455	157.242819	-0.000000	-0.000000
2	-12.124128	-1.009712	-0.021022	-25.385127	-1.057489	-0.000000	-0.000000
3	-3.328583	-31.697977	-75.464679	-99.914030	-655.400755	-0.000000	-0.000000
STO	-0.000000	0.000000	-0.000000	-0.000000	0.000000	0.000000	-0.000000
5	-0.438778	9.989364	-56.855230	-32.202146	690.157826	0.000000	-0.000000
6	0.639966	8.672704	29.382730	7.014967	147.080149	-0.000000	-0.000000
7	1.962467	-22.109214	62.270782	44.788843	-427.682450	0.000000	-0.000000
8	-0.000000	0.000000	-0.000000	-0.000000	0.000000	0.000000	-0.000000
IMA	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
TOT	3.613637	2.111642	-19.029286	22.384963	-89.659901	0.000000	0.000000

Fourth and Sixth-order coefficients

TOTALS

3.6136	2.1116	-19.0293	12.8703	-89.6599
92.5579	104.9205	-139.9073	-47.5687	14.1065
0.1503	-10.5189	0.8455	-13.6589	54.8971
-0.9212	1.9873	-0.1704	-5.0329	

Aspect ratio of lenses



Lens from microlithography

~about 1250 mm long
~300 mm in diameter
193 nm
~f/0.64
FOV +/- 13.5 mm @ wafer side
m=-0.25

•Lenses must be manufacturable

Issues on aspect ratio of lenses

- Must preserve structural integrity of lens
- Self-weight deflection should be considered
- Consider type of mounting
- Incorrect mounting may deflect significantly a lens
- Improper thickness can make a lens difficult to manufacture
- Chamfers must be considered
- Lens thickness is not usually an effective design variable: meniscus lenses
- Stress birefringence
- Consider cocking of the lens in cell at insertion
- Consider chemical attack of first surface: crowns more durable than flints
- Lenses have significant sag variation
- Concentric radii in shells
- Light Transmission, light scattering

- Lenses in comparison to mirrors are less sensitive to deflection by factor of (n-1)/2 and by canceling of opposite OPD contributions
- Consider edge and center thickness
- Consider glass homogeneity
- Consider clear aperture
- Consider specifying the lens bigger to insure a good surface
- Weight can be a concern
- Aspect ratio of small lenses (up to 4 inches), thickness to diameter: 1/10 to 1/6
- Couder's law for self weight deflection is: $\delta = Cqr^4/D$ where δ is the axial deflection, C is a support constant, q is the weight per unit of area, r is the mirror radius, D is the flexural rigidity. $D = Eh^3/12(1-\nu^2)$ where E is Young's modulus, ν is the Poisson ratio, and h is the thickness. This equation was developed for mirrors but applies to lenses too. However it does not say anything about OPD canceling due to opposite sign surface effect. HBK of Optomechanical Engineering, Anees Ahmad Ed. Page 116.
- Experience
- Can use lenses from a data base (Lens view)
- Exercise: measure the aspect ratio of several lenses

Summary

- Protar lens
- Fabrication issues