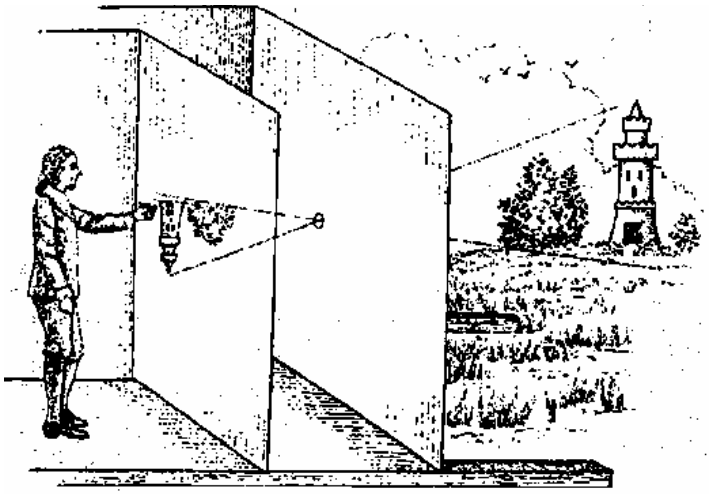
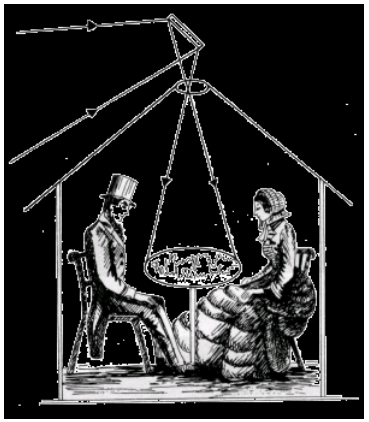
Kapitel 9: Geometrische Optik

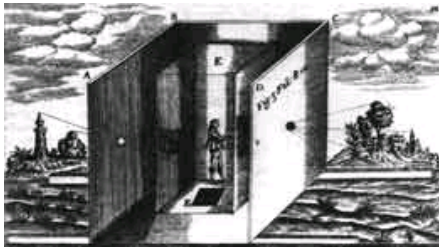
Camera obscura

- principle known already by Aristotle (c. 300 BC)
- 1st records of use: Leonardo da Vinci (1452-1519)





University of Pretoria's Camera Obscura



Sténopé

1-2min

Vergleich Sphärischer- und Parabolspiegel

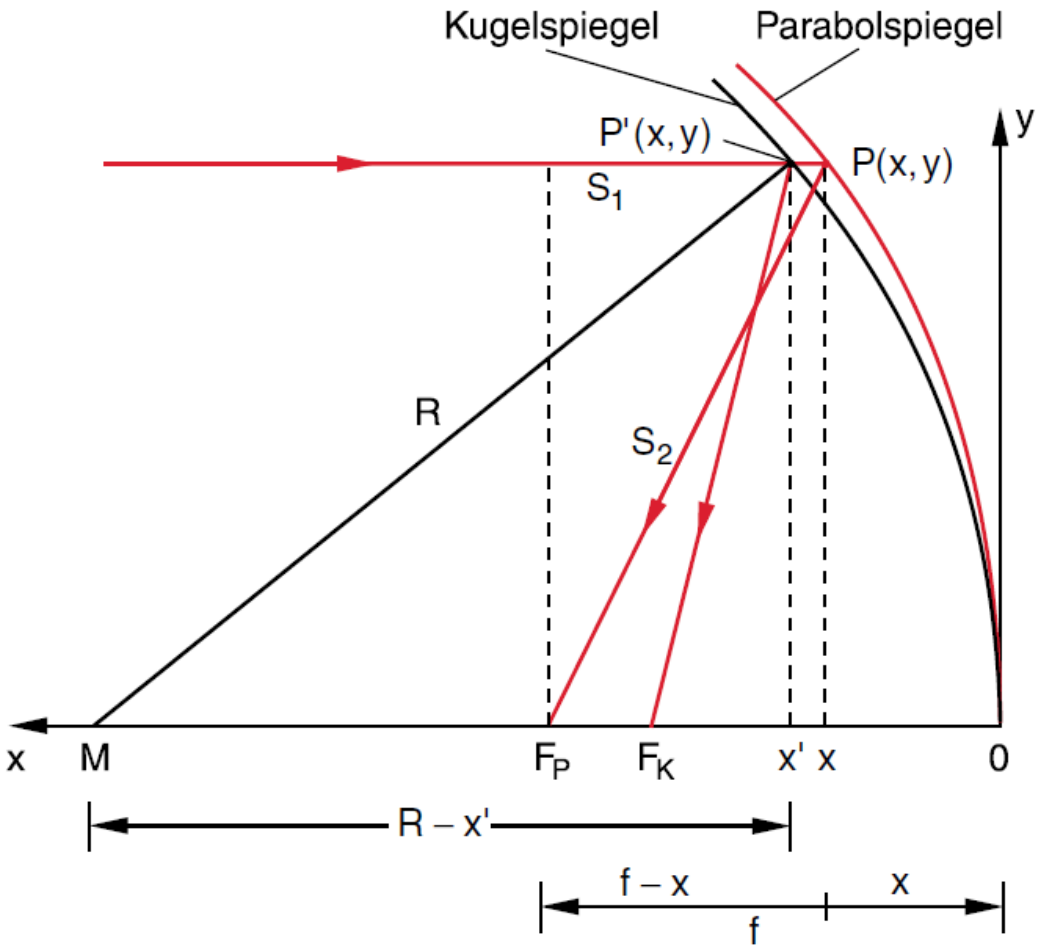
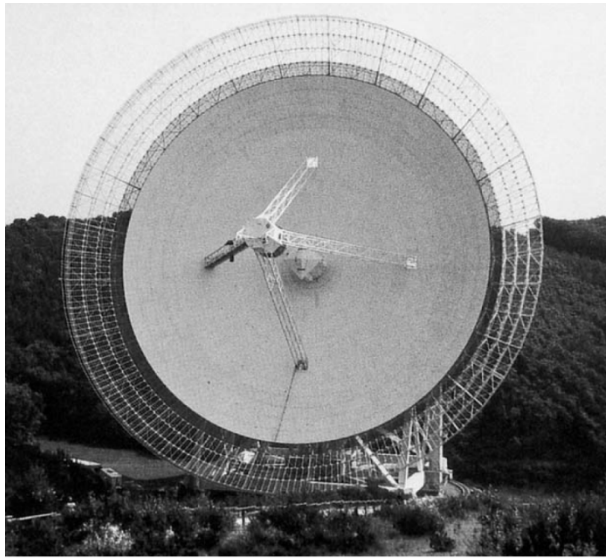


Abb. 9.17. Vergleich des Strahlenganges bei sphärischem Spiegel und Parabolspiegel mit Brennweite $f = R/2$. Für $y \ll R$ wandert F_K gegen F_p nach $x = R/2$



Radioteleskop des Max-Planck-Instituts für Radioastronomie in Effelsberg, DE

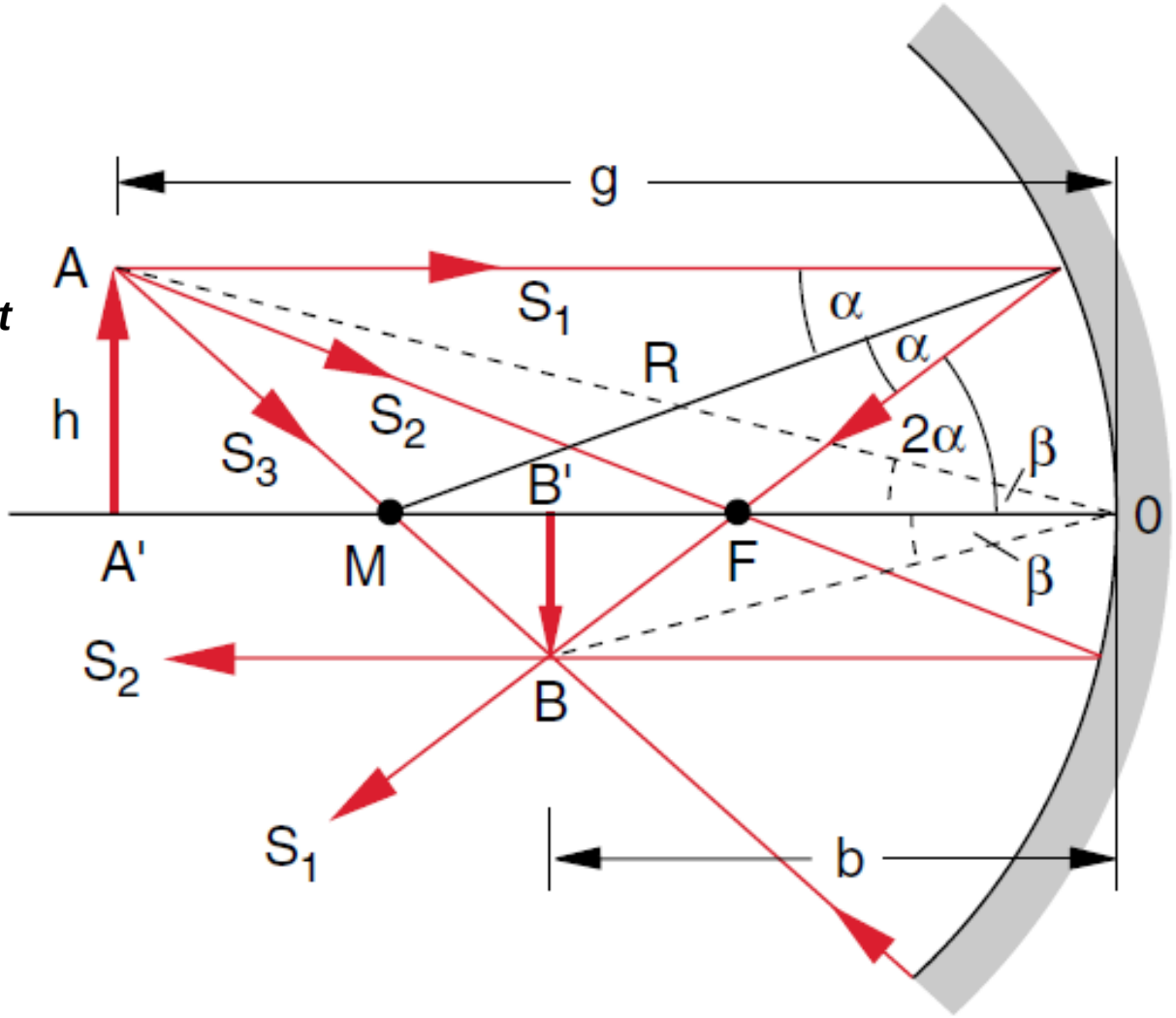
Geometrische Konstruktion des Bildes eines achsennahen Punktes

3 Strahlen zeichnen

S1: parallel zur Achse
S2: durch Brennpunkt
S3: durch Kugelmittelpunkt

Abbildung Massstab

$$\frac{\overline{BB'}}{\overline{AA'}} = \frac{b}{g}$$



Entstehung eines virtuellen Bildes

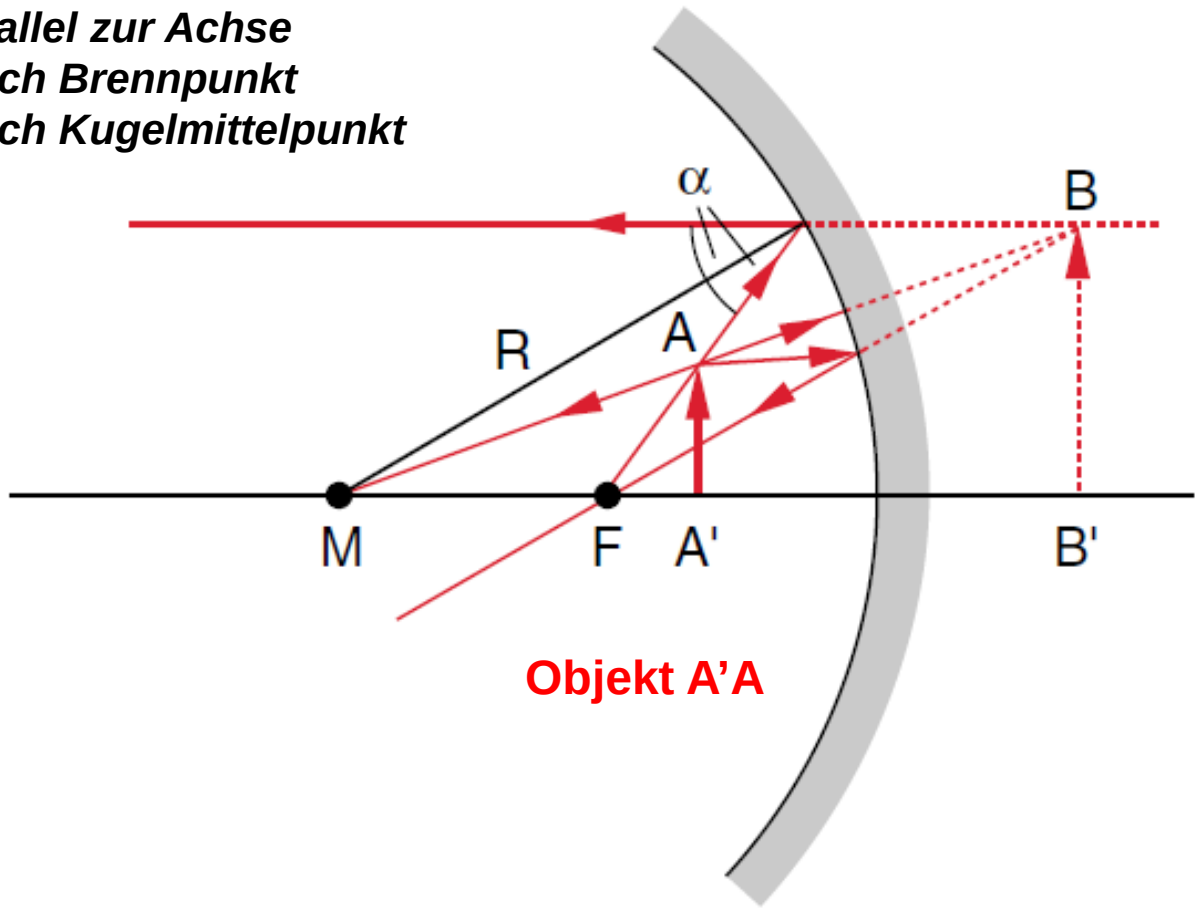
Objekt (Schweinchen) zwischen Spiegel und Brennpunkt

3 Strahlen zeichnen

S1: parallel zur Achse

S2: durch Brennpunkt

S3: durch Kugelmittelpunkt



Virtuelles Bild B'B

(keine Projektion auf einem Schirm)

Objekt A'A

Konkaver und konvexer Spiegel

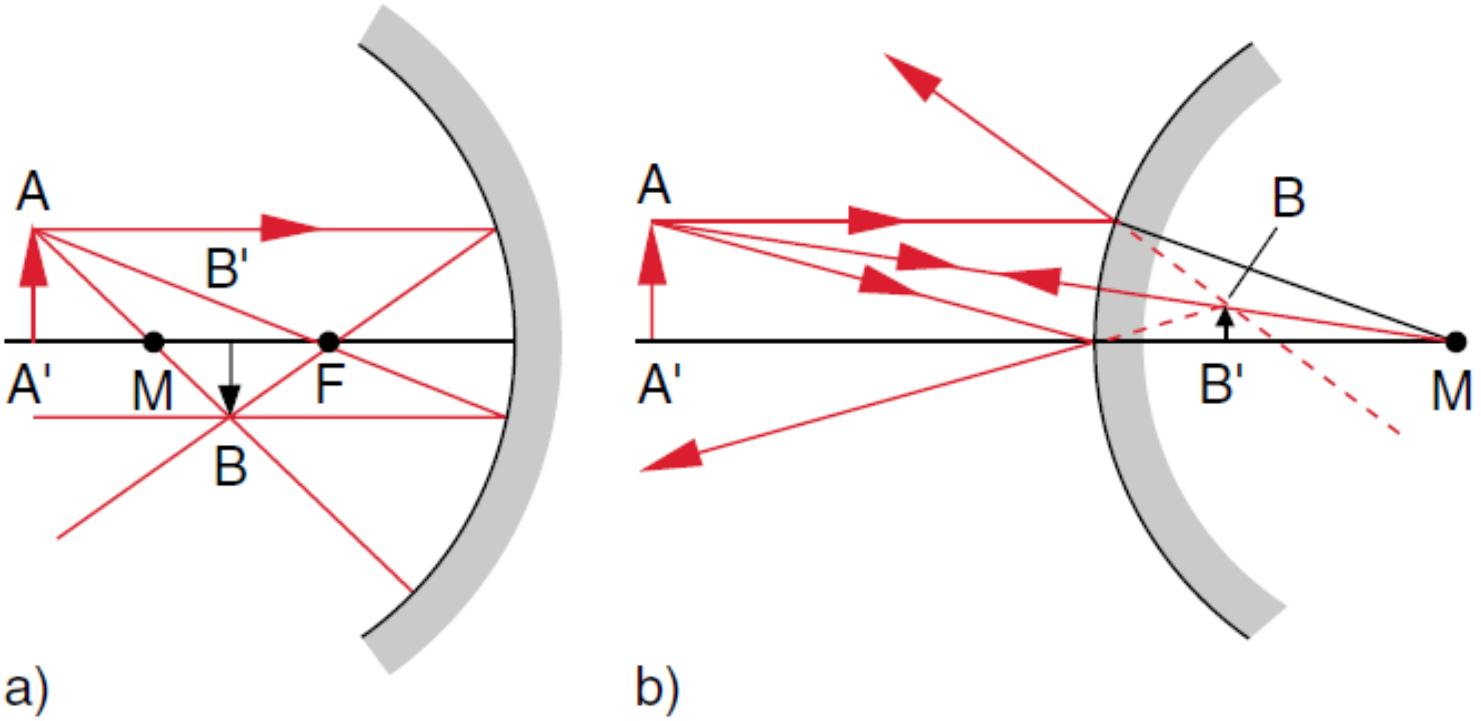
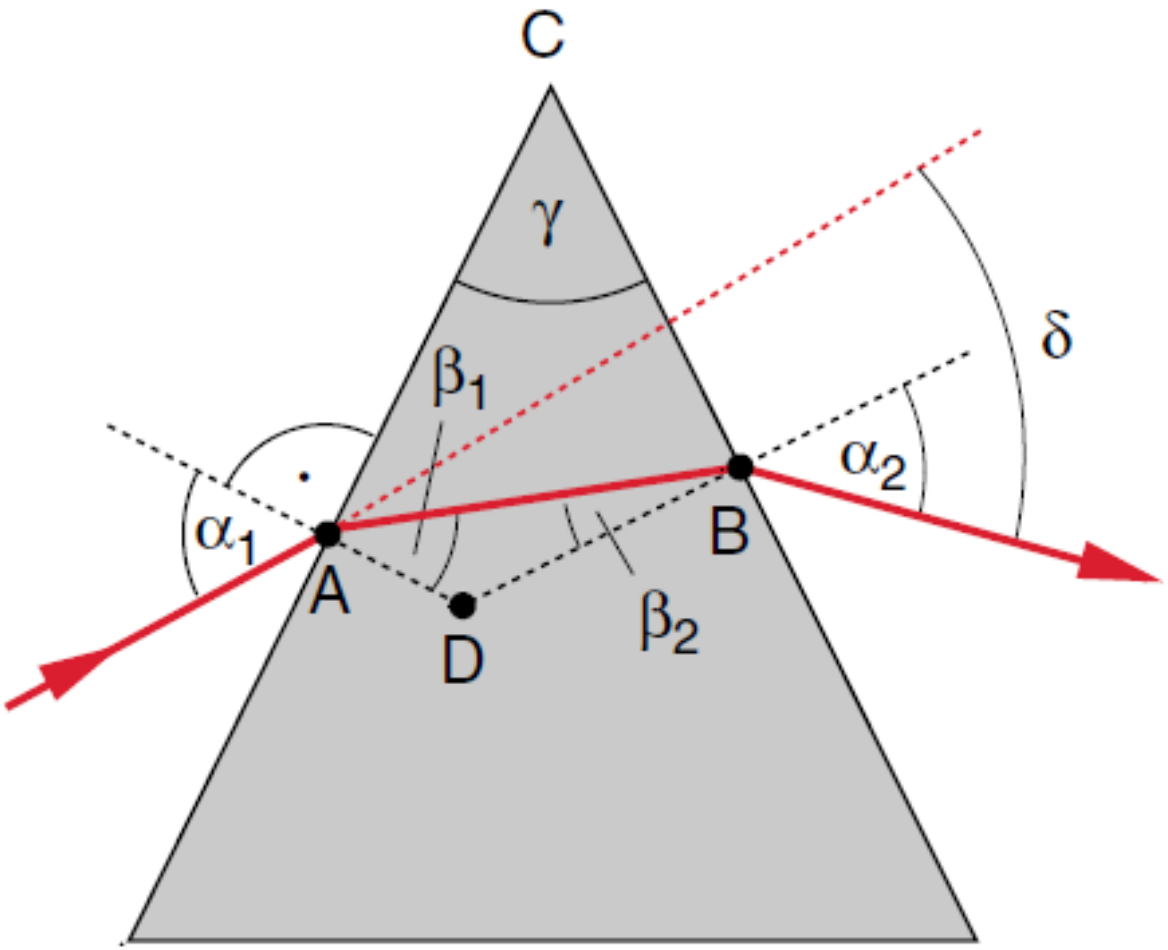


Abb. 9.14. (**a**) Konkaver und (**b**) konvexer Hohlspiegel

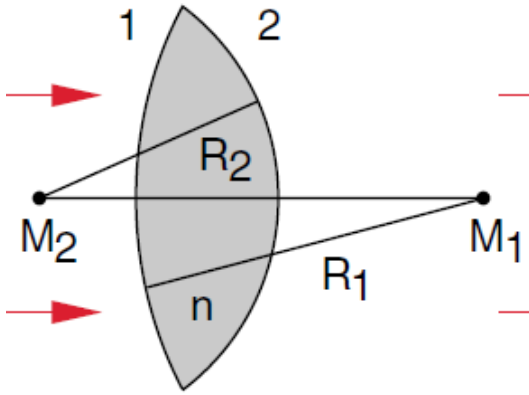
Prisma



Ablenkung vom Lichtstrahl

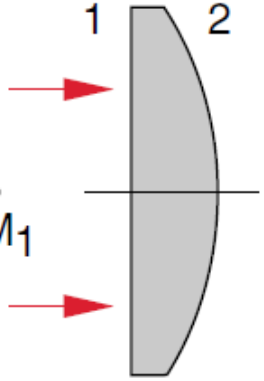
Linsen

bikonvex



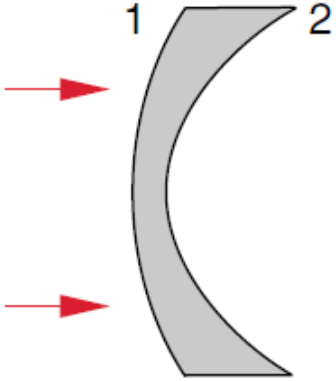
a) $R_1 > 0$
$R_2 < 0$

plan-konvex



b) $R_1 = \infty$
$R_2 < 0$

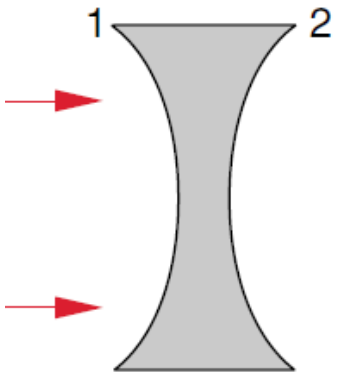
konvex-konkav



c) $R_1 > 0$
$R_1 \neq R_2 > 0$

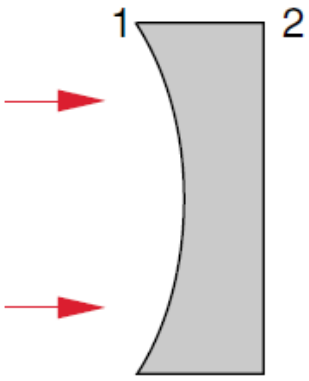
Zeichen Konvention

bikonkav



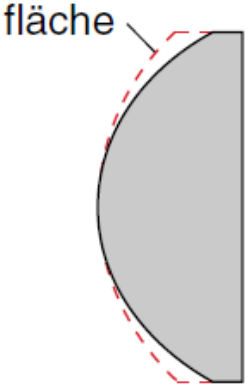
d) $R_1 < 0$
$R_2 > 0$

plan-konkav



e) $R_1 < 0$
$R_2 = \infty$

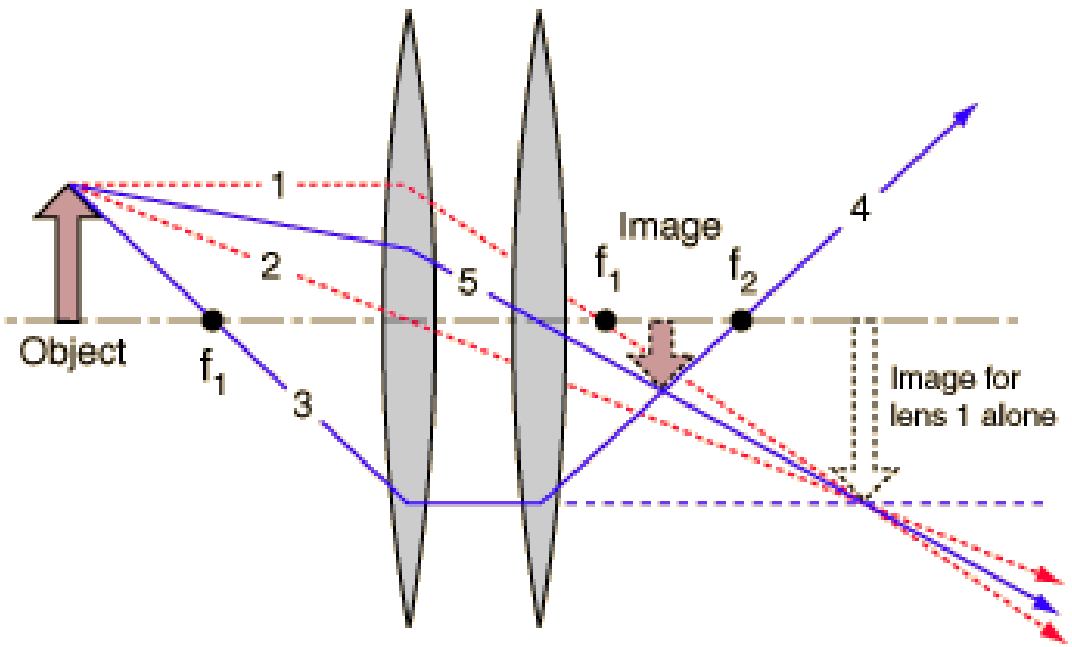
asphärisch



f) nicht-
sphärisch

image formation: 2 lenses

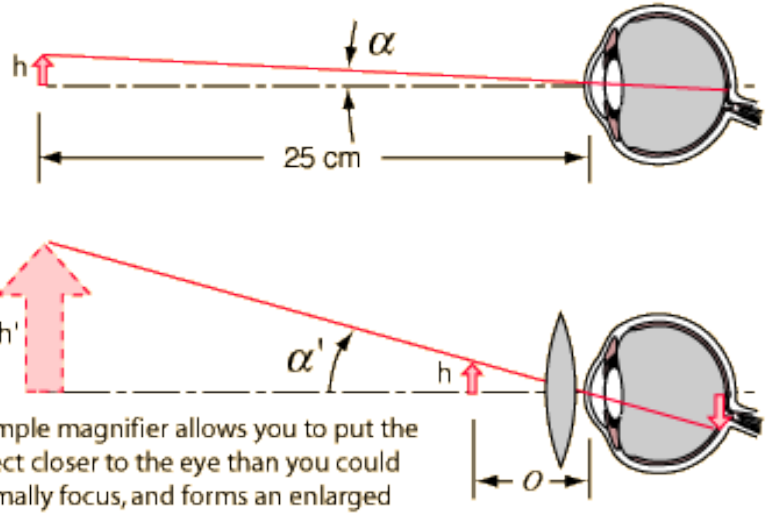
1. The principal rays 1 and 2 are used to determine the location of the of the image for lens 1 alone.



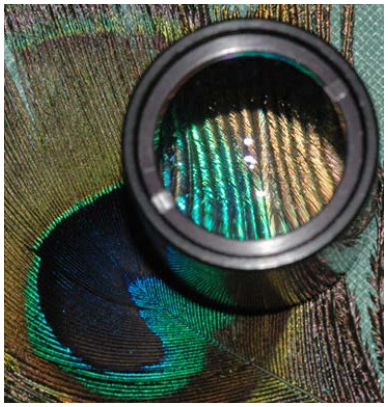
2. Ray 3 through f_1 will approach lens 2 parallel to the axis and will project through focal point f_2, forming one principal ray (4) for the final image.

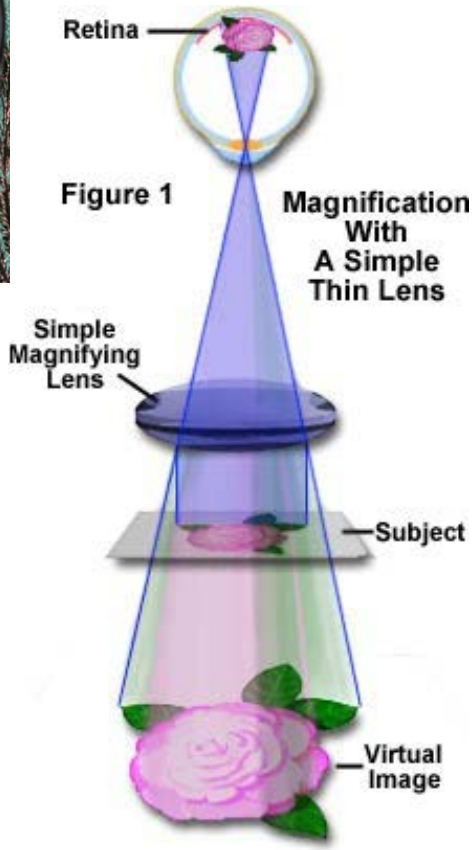
3. Back projecting from the single lens image through the center of lens 2 will define the second needed ray (5) since that ray will be undeflected.

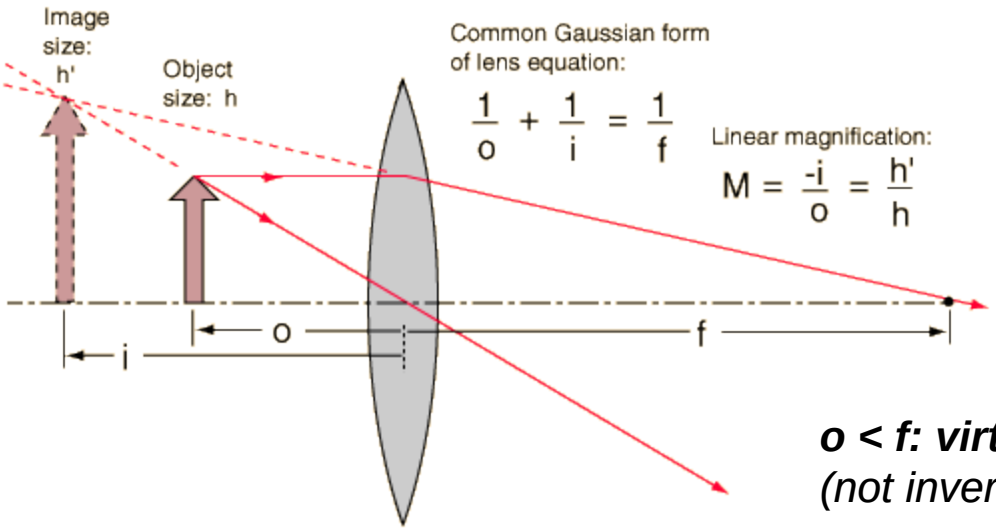
Lupe



A simple magnifier allows you to put the object closer to the eye than you could normally focus, and forms an enlarged virtual image.

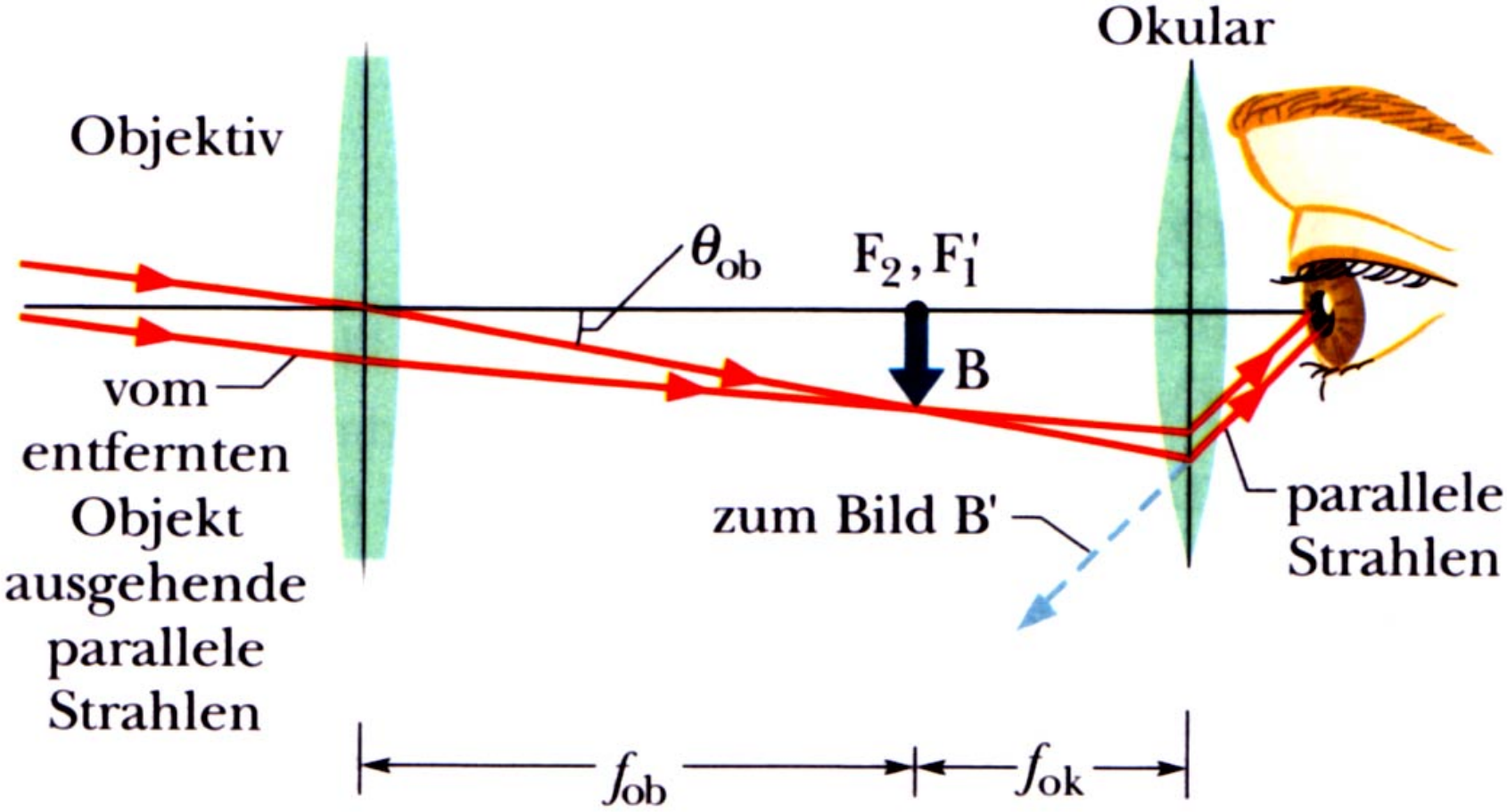




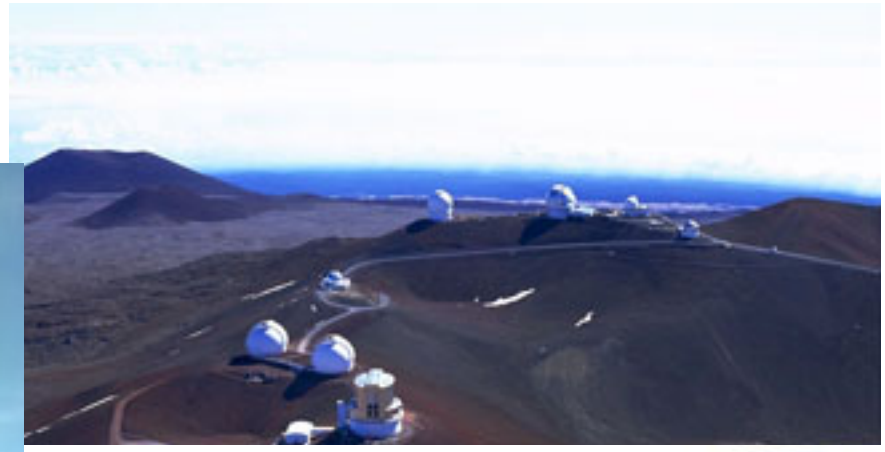


o < f: virtual image
(not inverted)

Fernrohr / Teleskop



Kek Teleskope (10 Meter)



ESO La Silla (NTT)

3.58m Durchmesser (1989)

"flexibel" Spiegel: 78 Kontrol Aktuatoren *(active optics)*

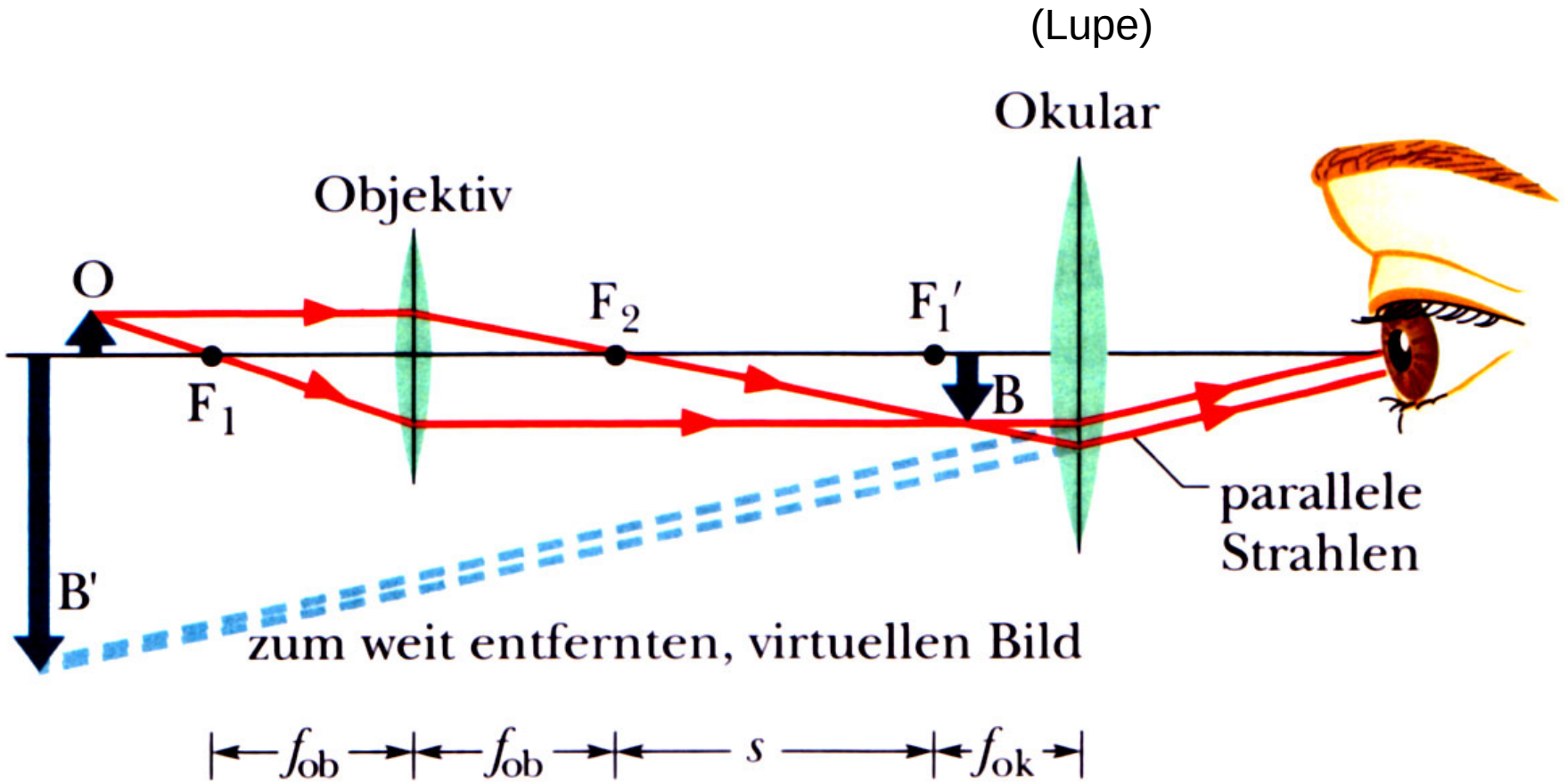
ESO.org

ESO Paranal (VLT)

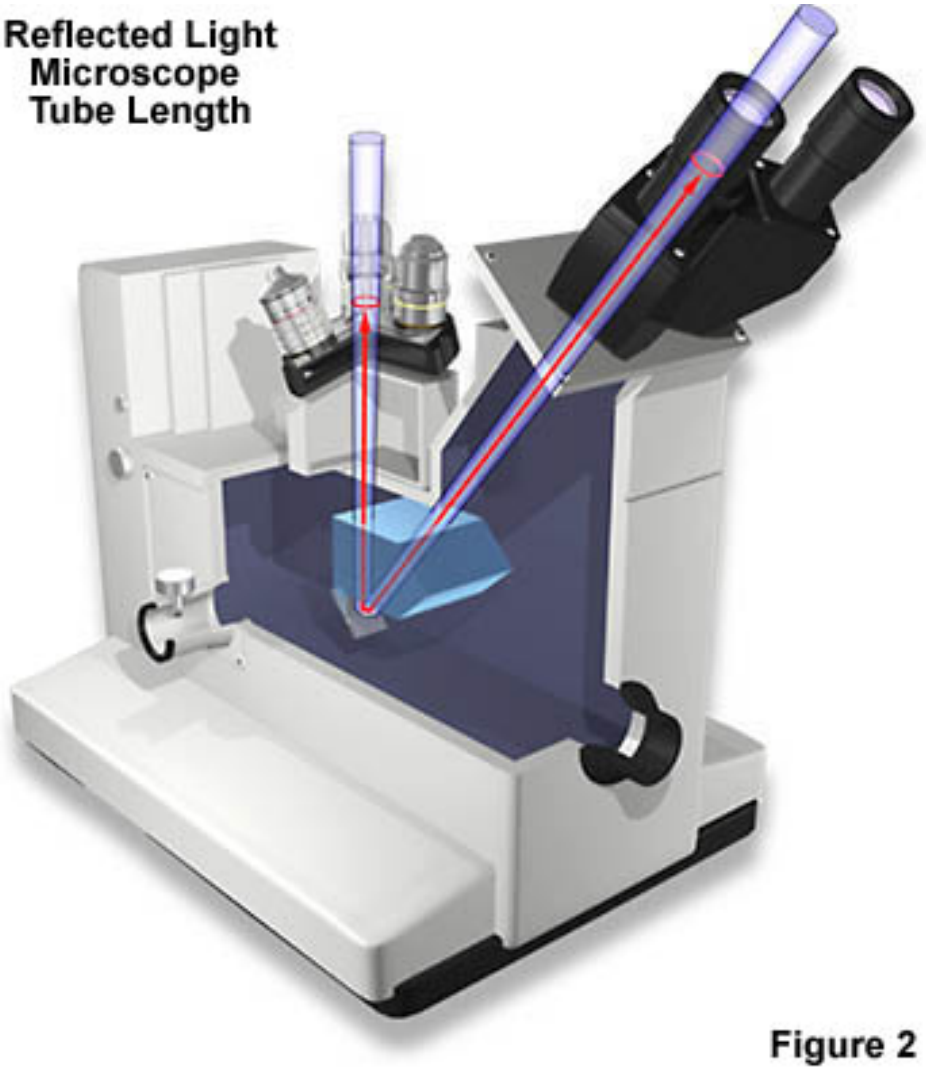
4 x 8.2m (17.5cm thick!), adaptative optics (laser star calibration) + auxiliary telescopes, interferometric operation

ESO.org

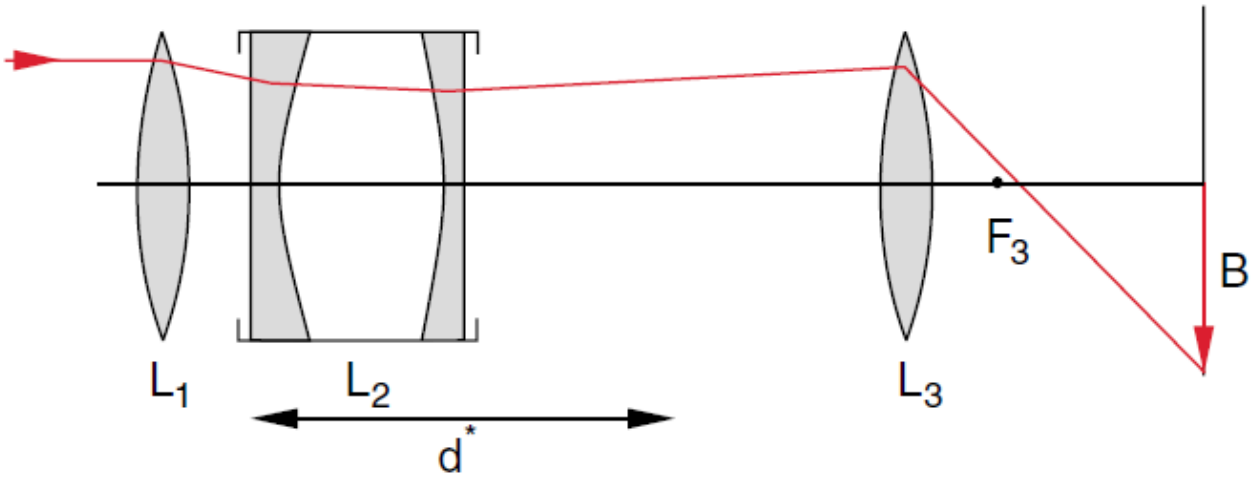
Mikroskop


(Lupe)
Okular
Objektiv
O
F2
F1′
F1
B
parallele
Strahlen
B'
zum weit entfernten, virtuellen Bild
fob
fob
s
fok

Mikroskoptypen



Zoom Linsensystem (Variabel Vergrösserung M)



M variiert, Abbildungs Ebene fix

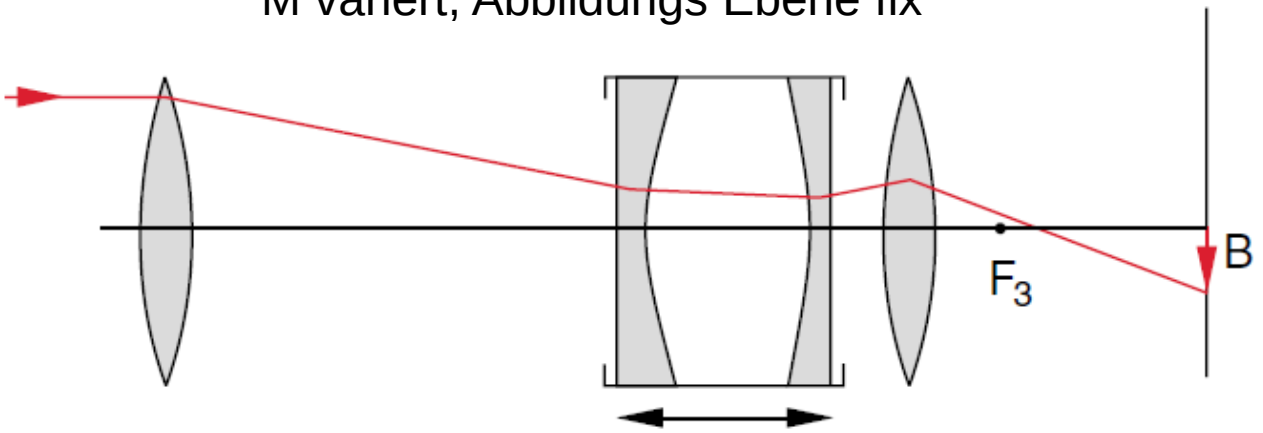


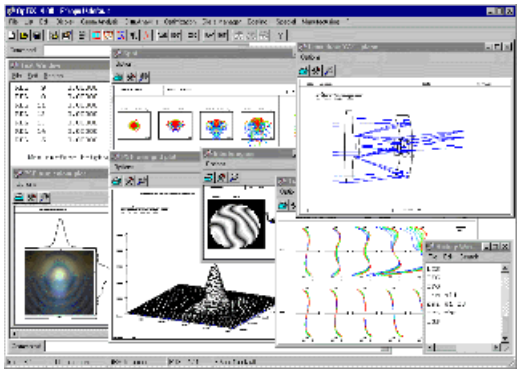
Abb. 9.35. Veränderung der Vergrößerung M eines Zoom-Linsensystems durch Verschieben des Linsenpaares L_2 innerhalb der Strecke d^*

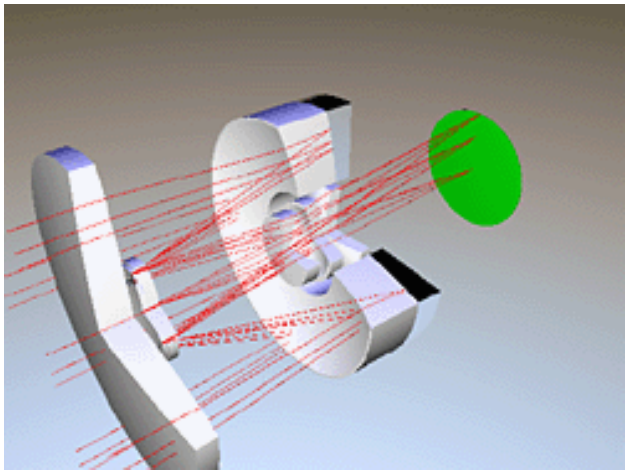
ray tracing

computer ray tracing

- ***lens design and optimization***

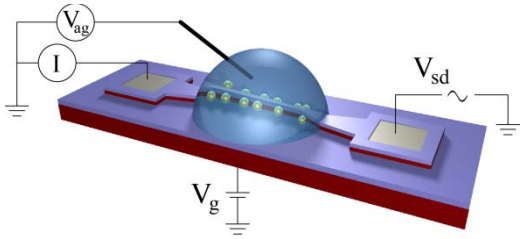
  e.g.: OpTalix

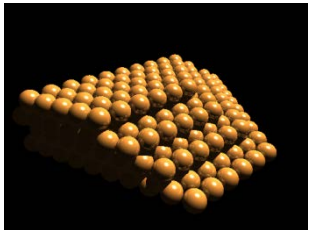


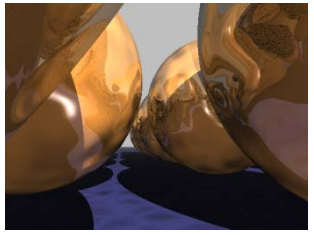


- ***image rendering***

  e.g.: pov ray



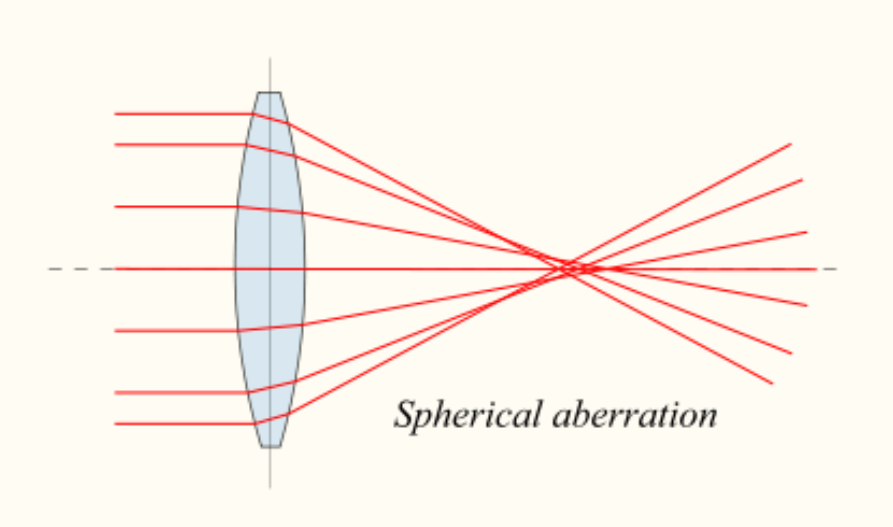


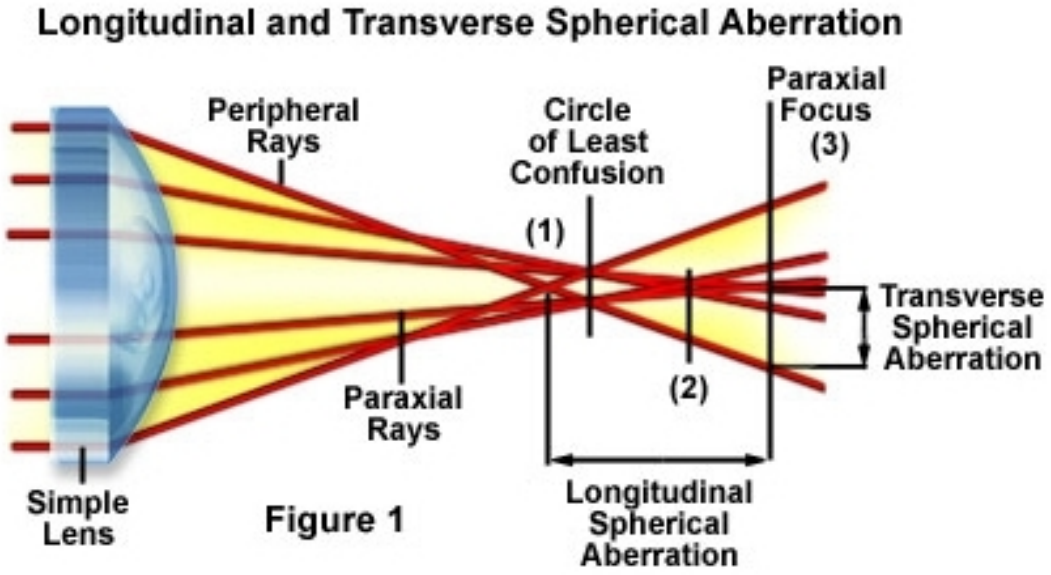


ray tracing

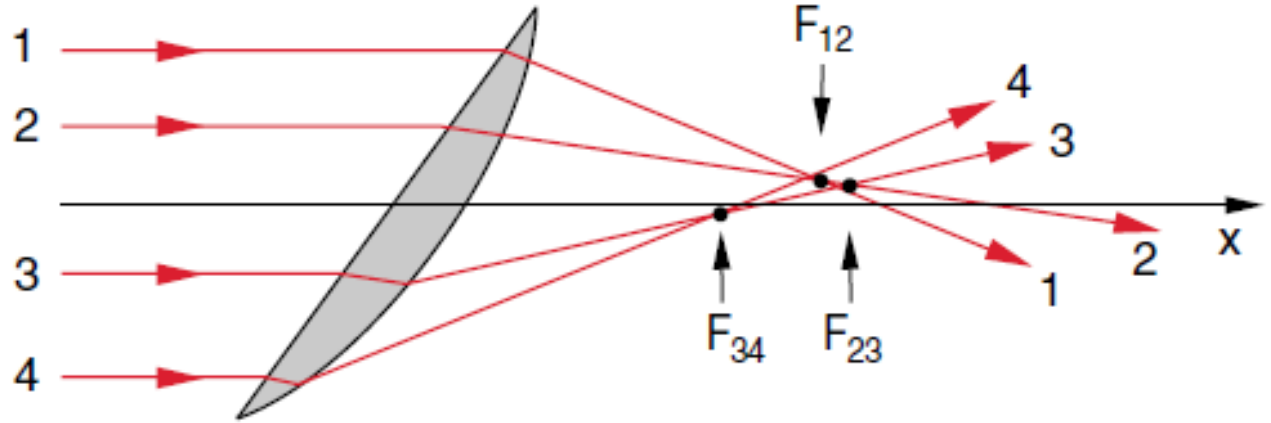
hof.povray.org

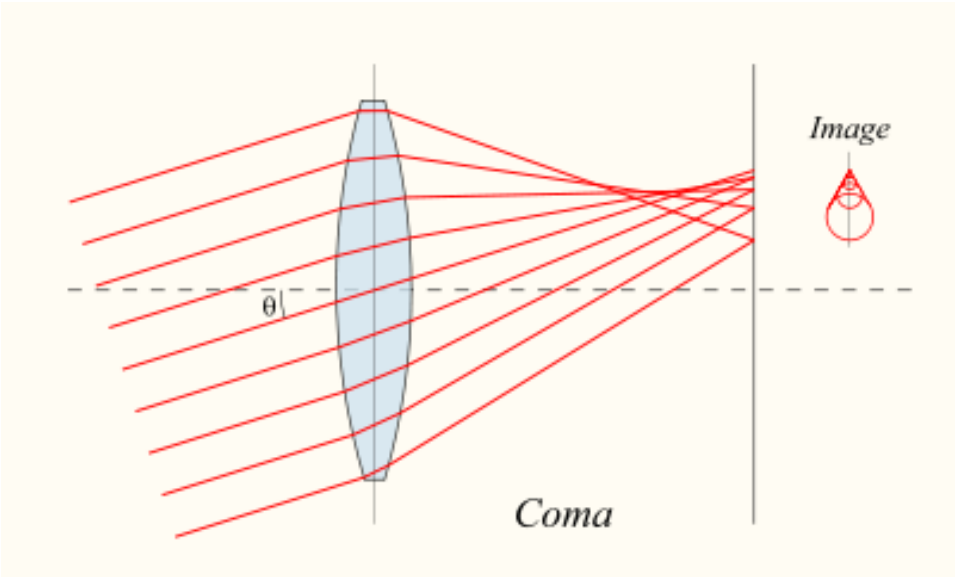
sphärische Aberration





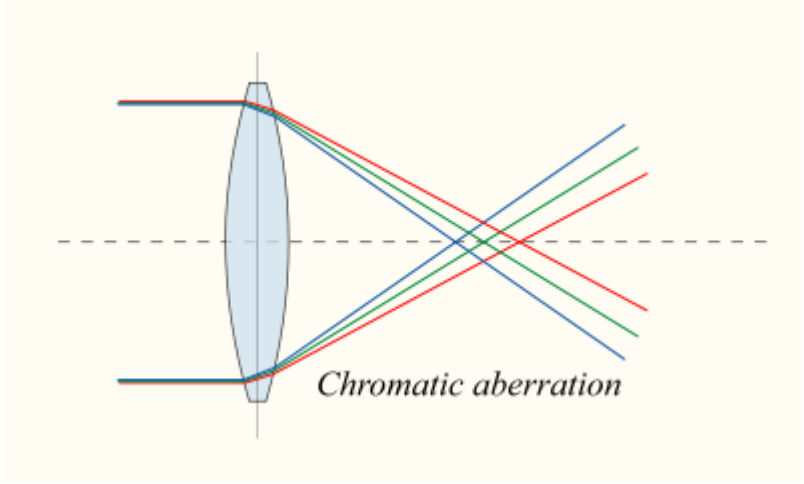
Koma

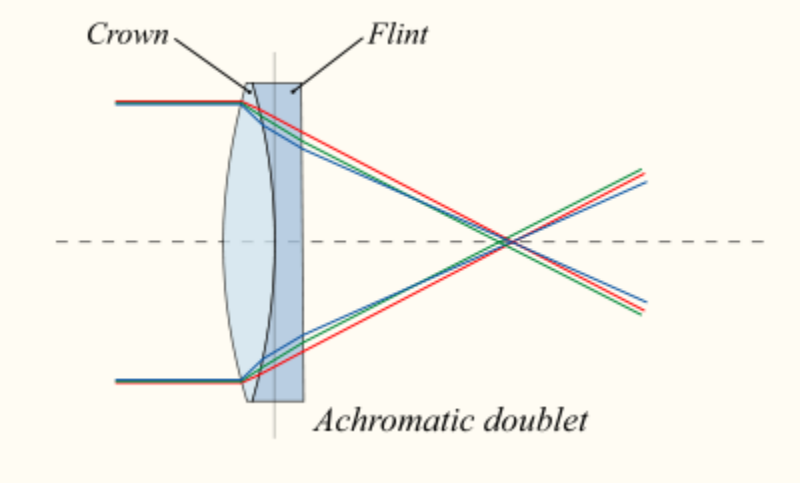




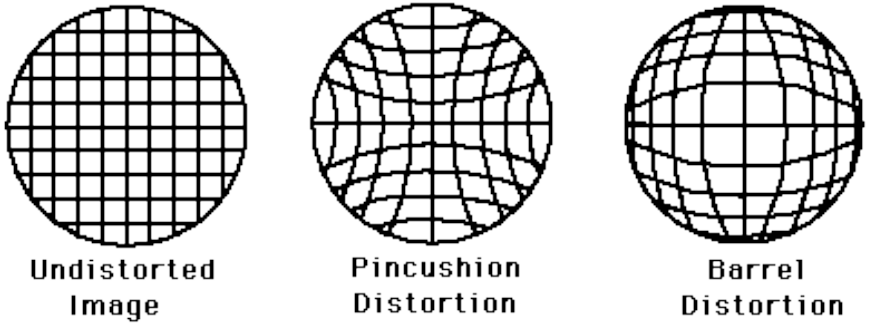
principal plane ≠ plane

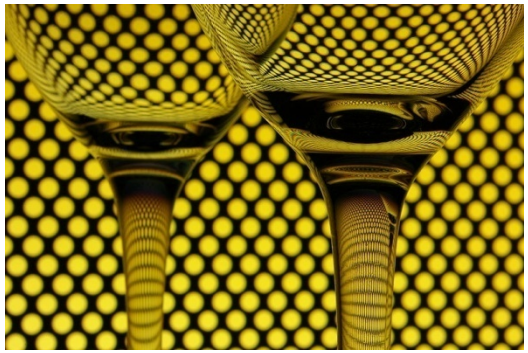
chromatische Aberration





distortions
(geometry of lens; lens imperfections)





Astigmatismus

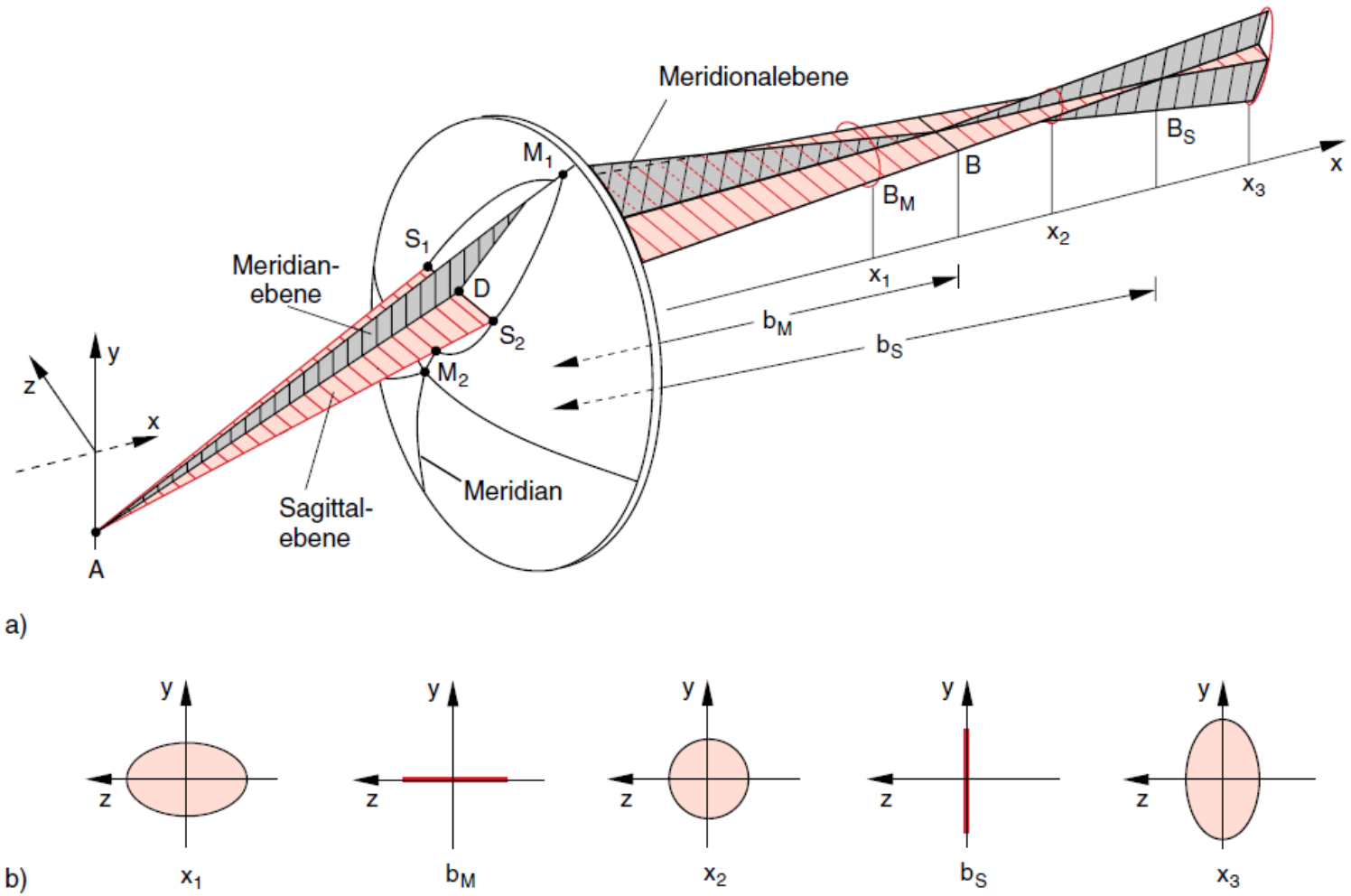


Abb. 9.45a,b. Astigmatismus bei der Abbildung eines schrägen Lichtbündels. (**a**) Perspektivische Ansicht; (**b**) Lichtbündelquerschnitt in den Ebenen im Abstand x_1, b_M, x_2, b_S, x_3

eye image formation

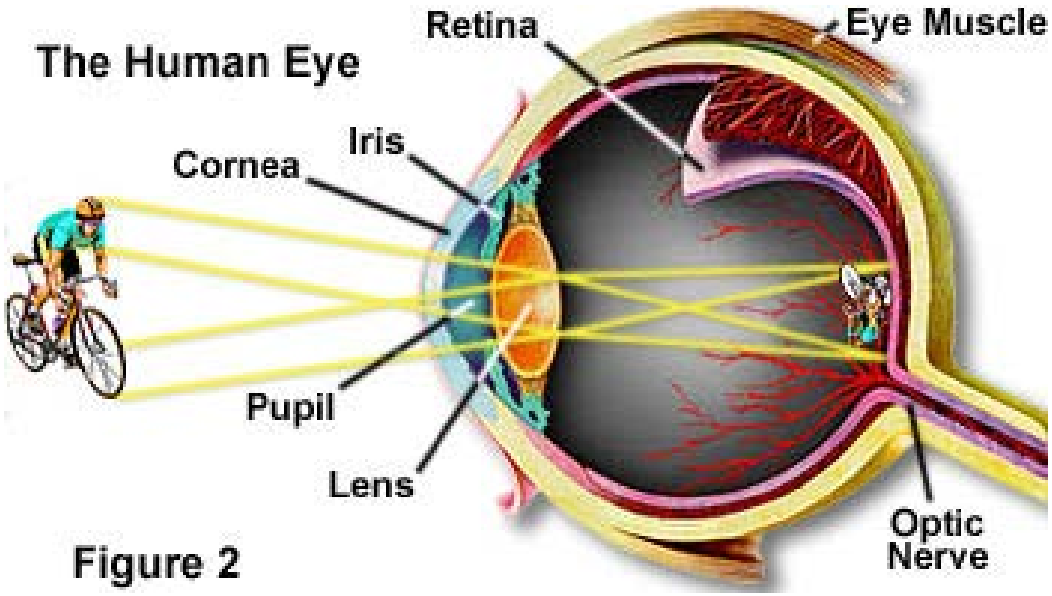
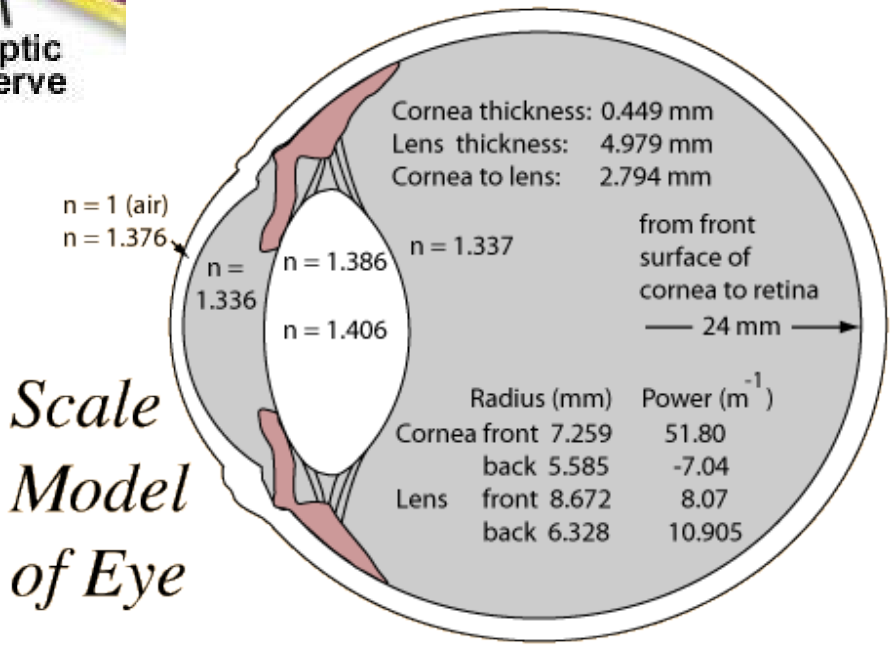


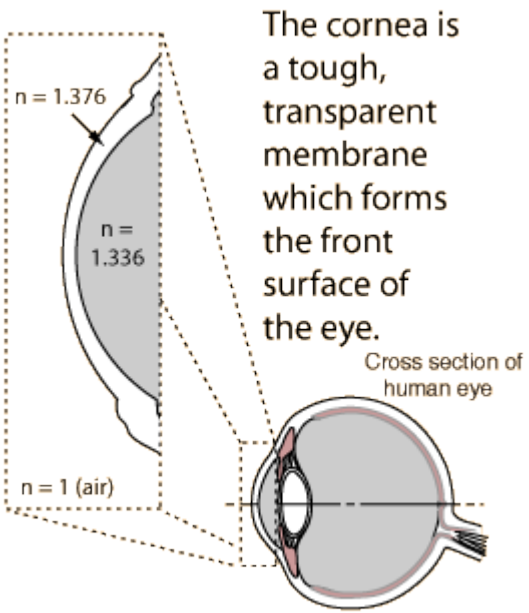
Figure 2



Scale Model of Eye

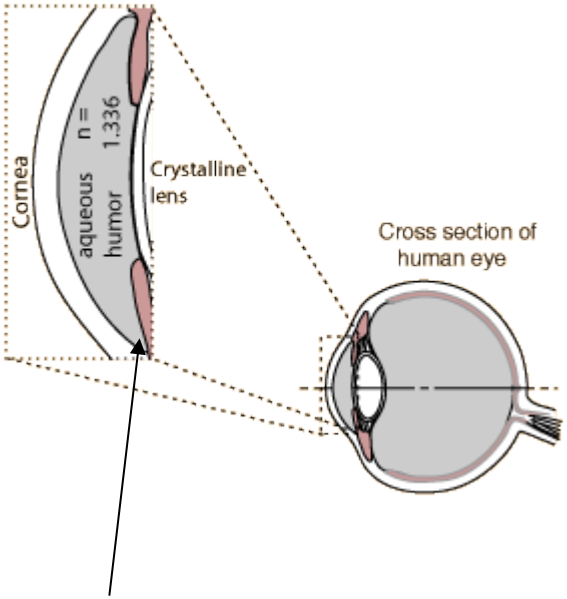
eye image formation

cornea



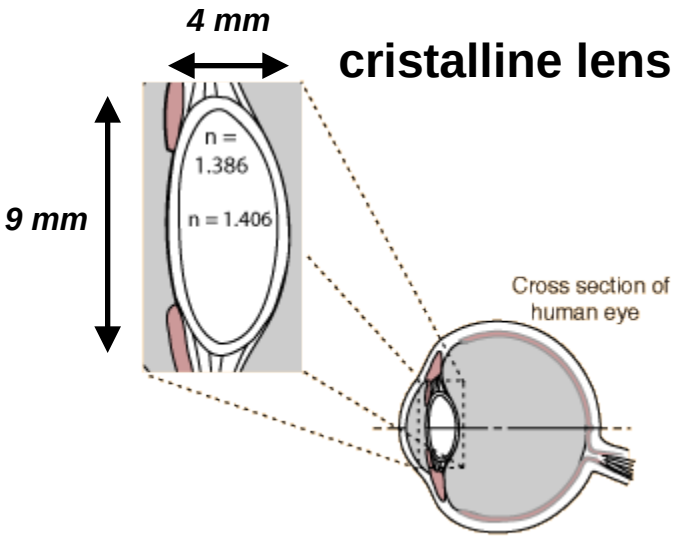
strong refraction (n~1.376)

aqueous humor

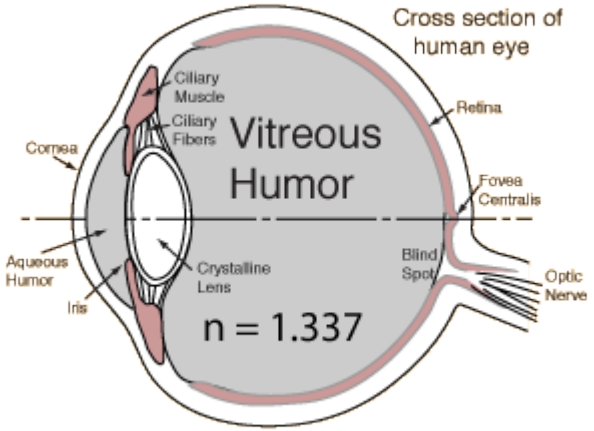


iris (diaphragm)

eye image formation

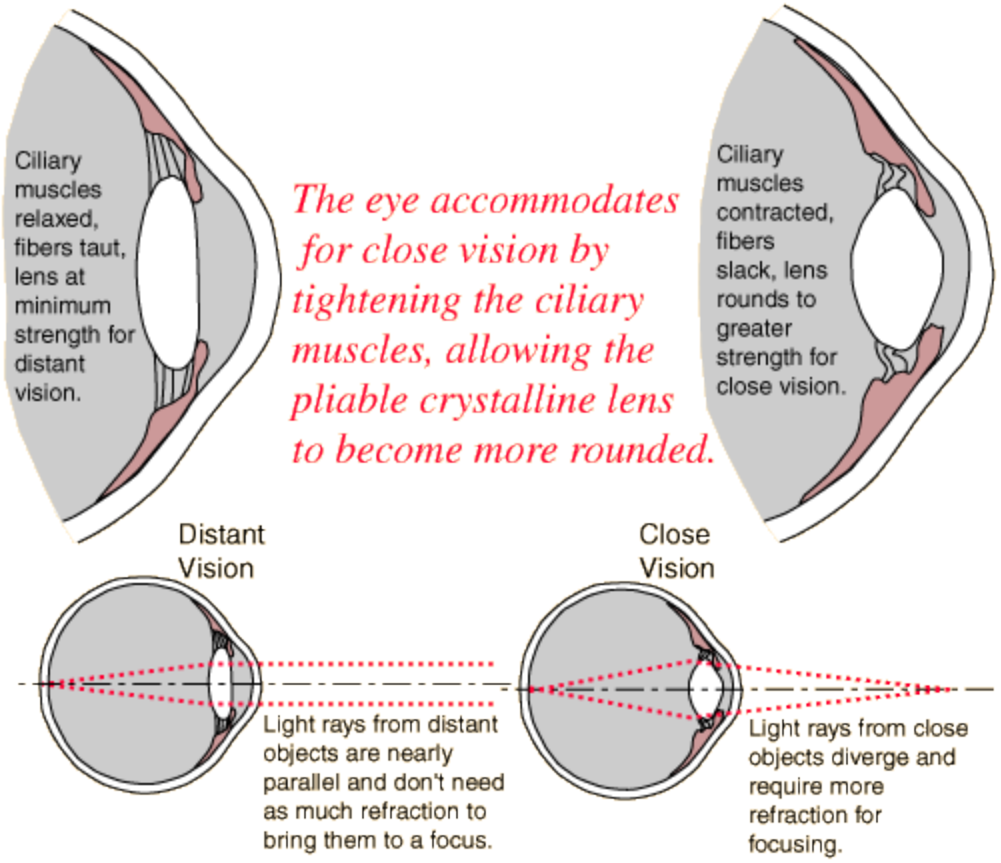


cristalline lens

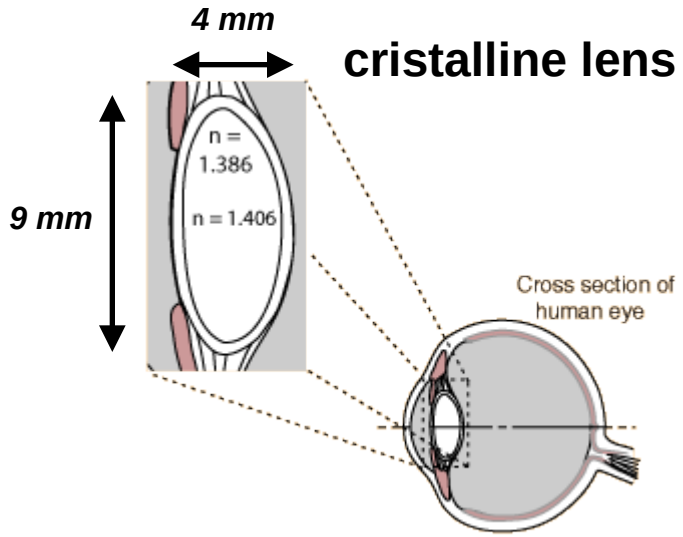


water: n ~1.33

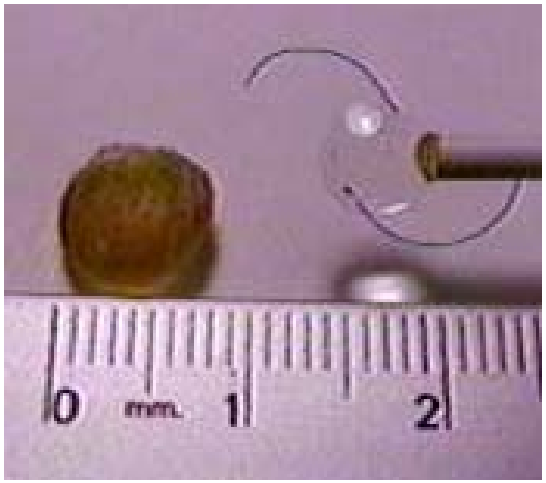
wie fokusiert die Auge?



eye image formation

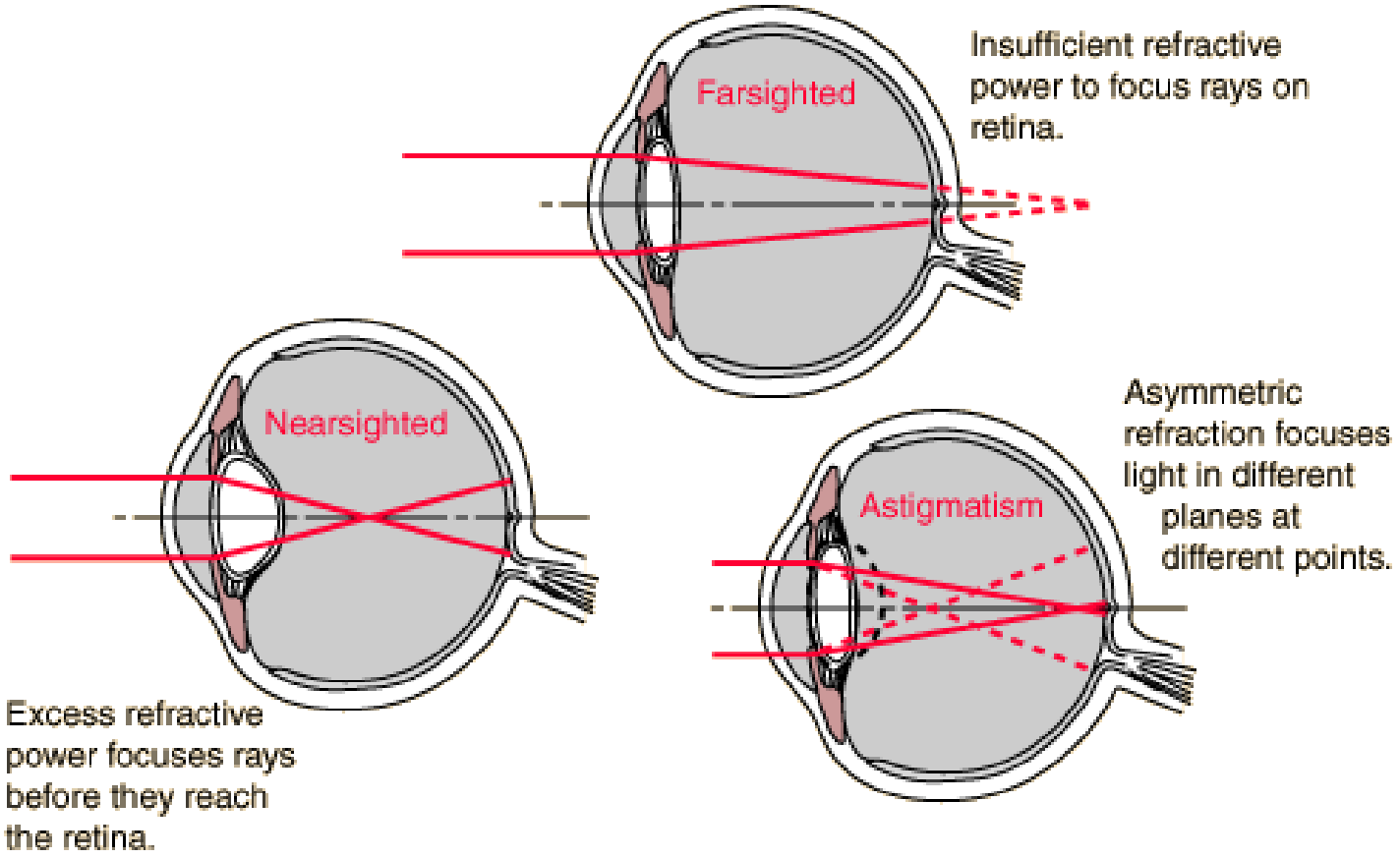


cataracts: *opacification of lens*



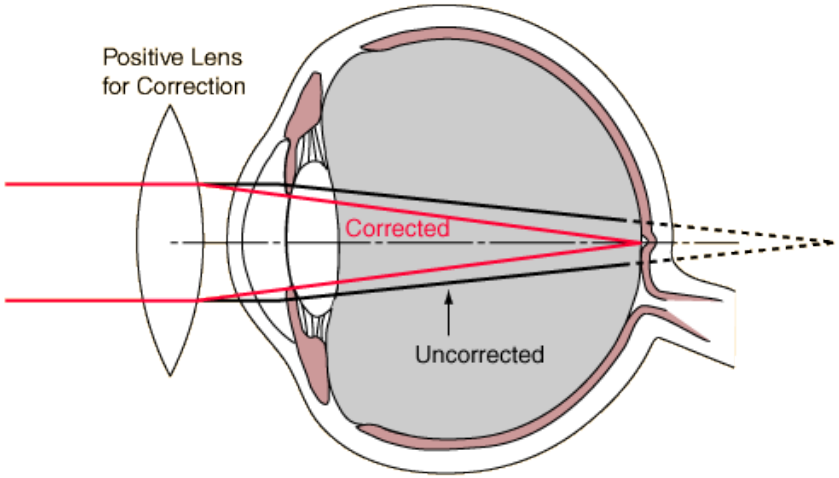
glaucome: *aqueous humor degradation*
pressure increase, perturbation of "optical" system

vision defects

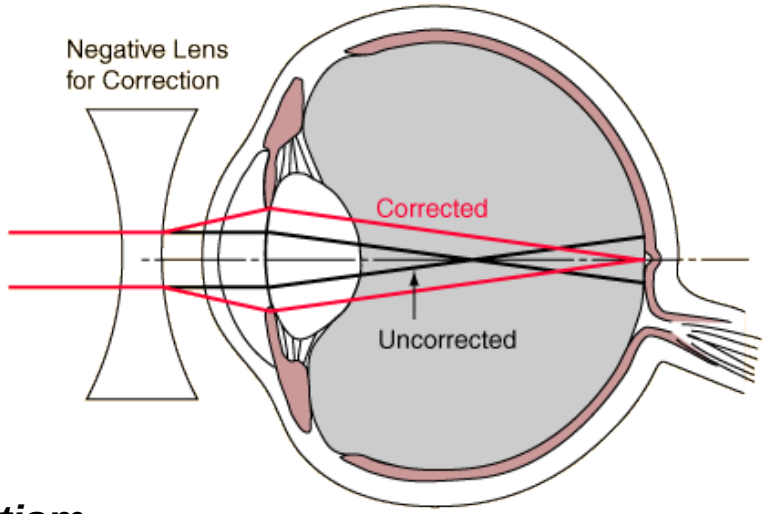


vision defects

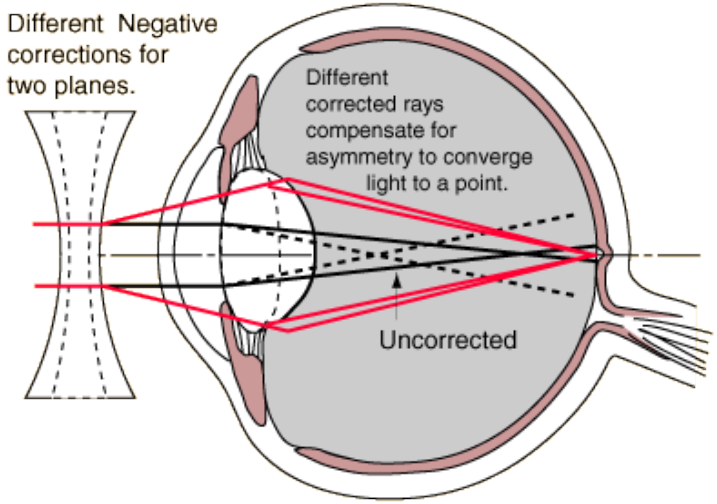
hyperopia (farsighted)



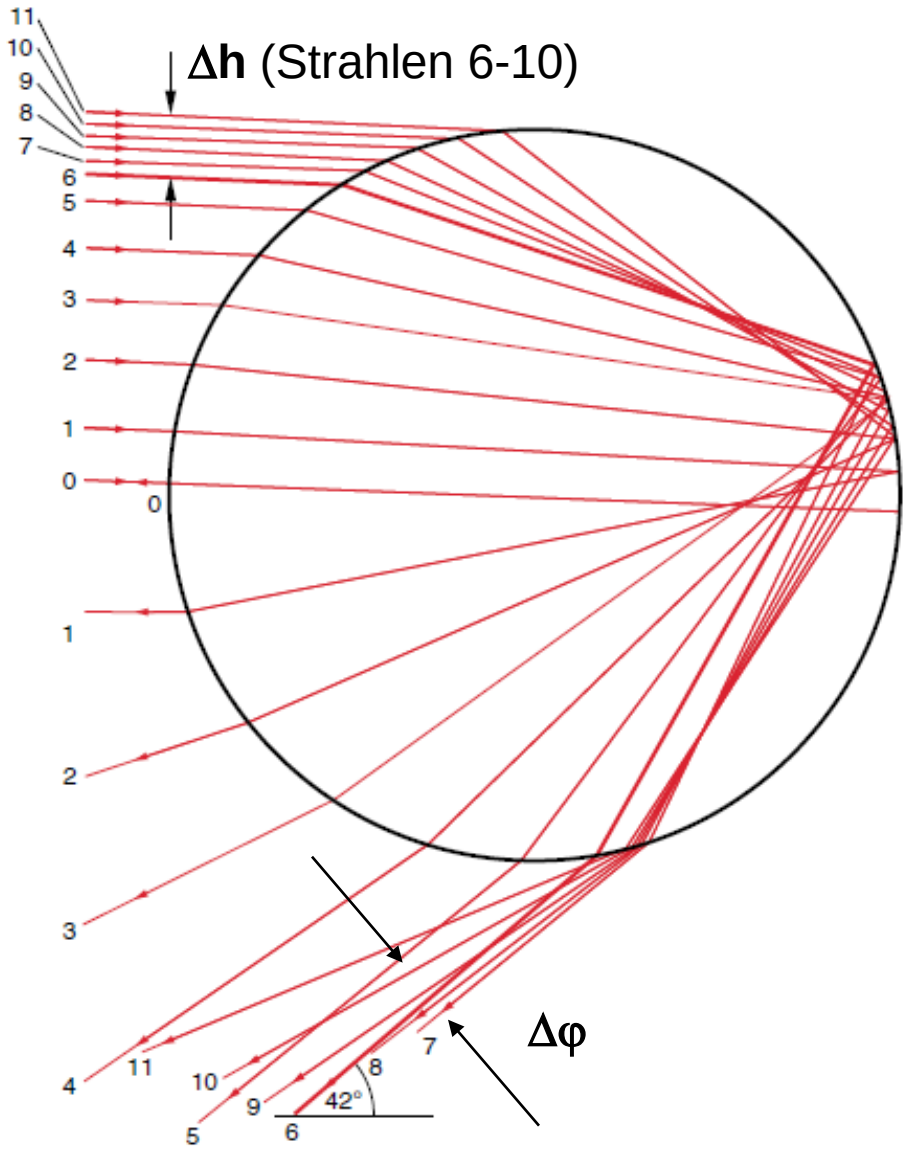
myopia (nearsighted)



astigmatism



Regenbogen



Haupt- & Nebenregenbogen

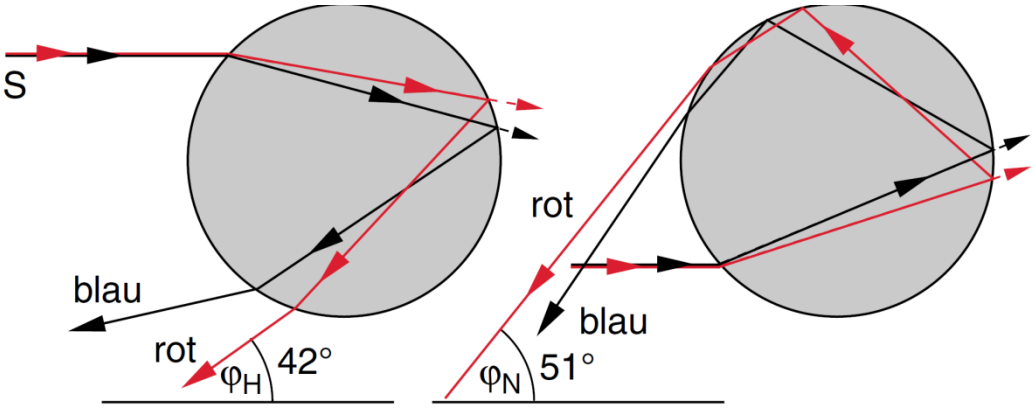


Abb. 9.68a,b. Erklärung der Entstehung von (**a**) Haupt- und (**b**) Nebenregenbogen

22° Halo und Sundogs

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