Optik

Freitag, 17. Juni 2022 10:15

Spektrum

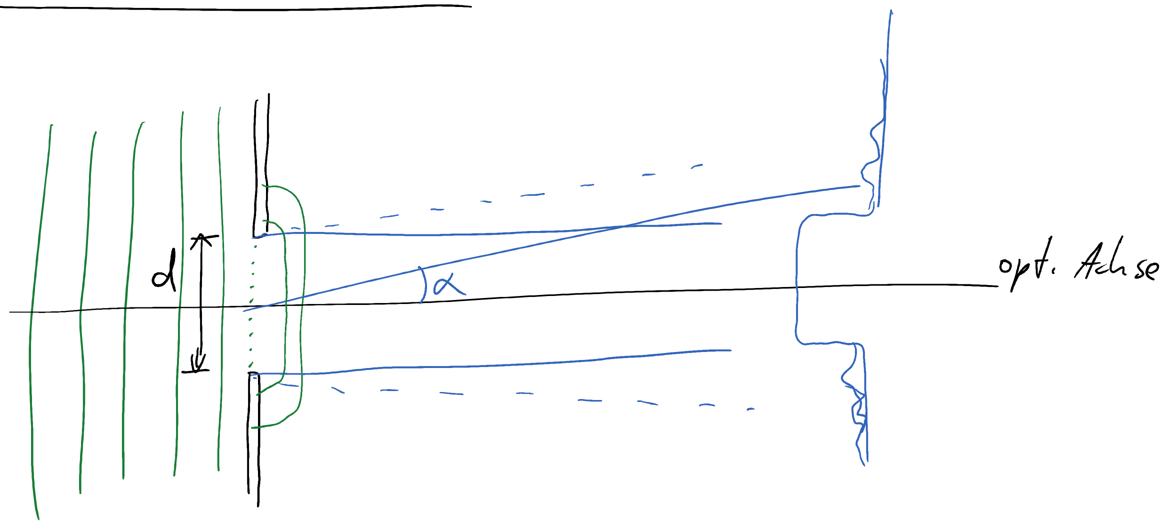
~350nm 500nm ~750nm

γ Röntgen UV | | | IR . . . . . . Radiowellen

ultraviolett $\underbrace{\qquad\qquad}_{\text{sichtbar}}$ infrarot

← E wird größer

Lichtstrahlen /-bündel



$$d = \frac{\lambda}{\sin\alpha} \approx \frac{600\,nm}{10^{-3}} \approx \underline{\underline{0.6\,mm}}$$

$\alpha = 1\,mrad$ $\qquad \frac{1}{2}\,mm$

Brechungsindex n

$c_0 = 299\ 792\ 458\ \frac{m}{s} \pm 0$ Lichtgeschw. im Vakuum

$30\ \frac{cm}{ns}$

↑ fixiert den Meter im SI

Im Medium (Luft, Wasser, Glas, ...):

$c < c_0$ lokale Lichtgeschw. ist kleiner

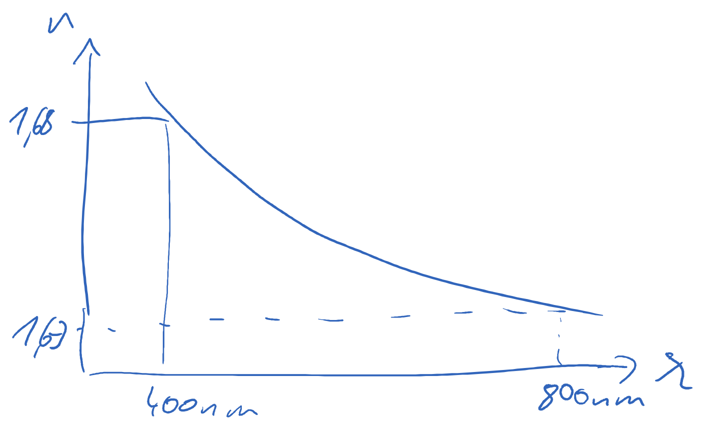
$$\boxed{c = \frac{c_0}{n}}$$

H_2O: $n = 1{,}33$

Brechungsindex n = Materialeigenschaft

Dispersion:

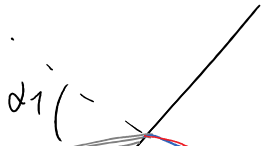
n hängt von λ ab



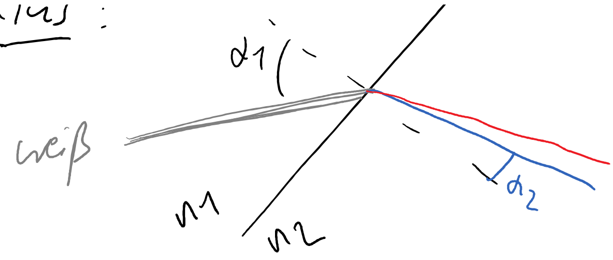
↓

Regenbogen im Prisma wg. Dispersion d. Glases

Snellius:



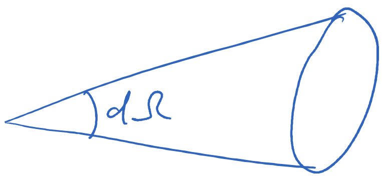
Snellius :



$$n_1 \sin\alpha_1 = n_2 \sin\alpha_2$$

Lichtstrom : Lumen lm

Lichtstärke : Lichtstrom in einen Raumwinkel

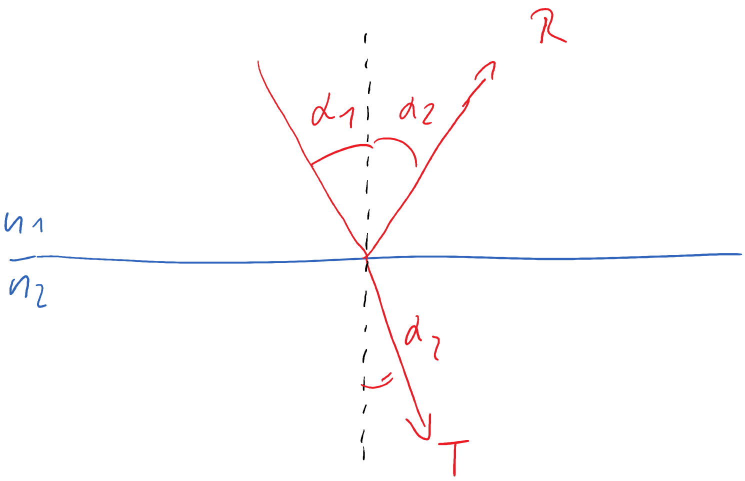


Candela cd

gesamter Raumwinkel (Kugeloberfläche) $= \underline{4\pi \text{ sr}}$

($\neq$ Winkel im Kreis (2D): $360° = \underline{2\pi}$ rad)

Reflexion & Transmission



$$n_1 \sin\alpha_1 = n_2 \sin\alpha_2$$

Fresnel'sche Formeln

Fresnel'sche Formeln

für $\alpha = 0$ (senkrecht Einfall):

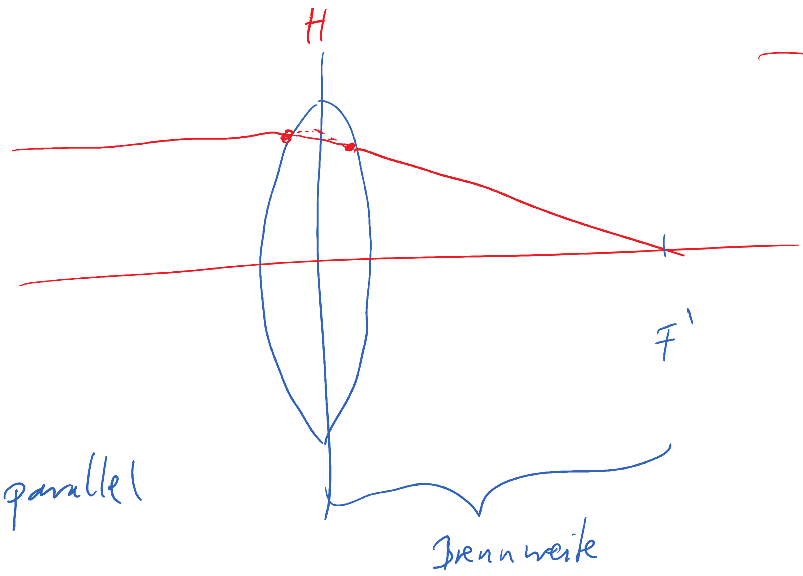
$$R = \frac{I_{refl.}}{I_{ein}} = \frac{(n_2 - n_1)^2}{(n_1 + n_2)^2} \qquad \text{f. Luft-Glas: } 4\%$$

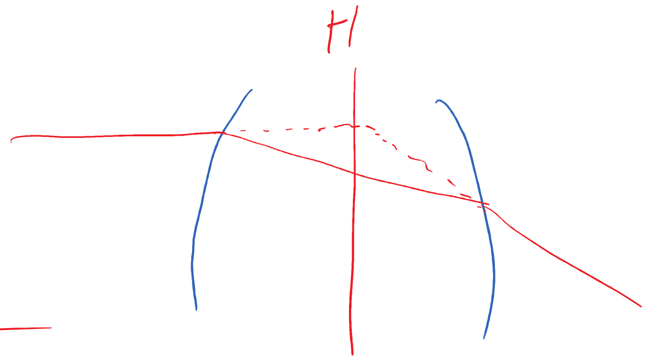
$$T = \frac{I_{trans}}{I_{ein}} = \frac{4 n_1 n_2}{(n_1 + n_2)^2}$$

$$R + T = 1 \qquad \text{(falls keine Absorption, Streuung)}$$

Totalreflexion ✓

Abbildung v. Linsen

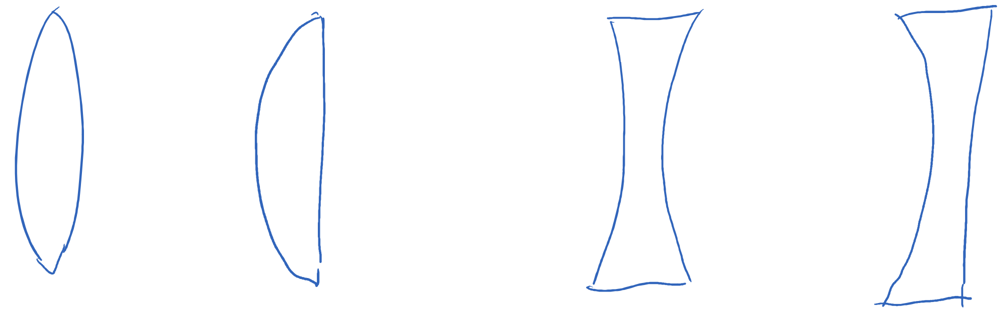




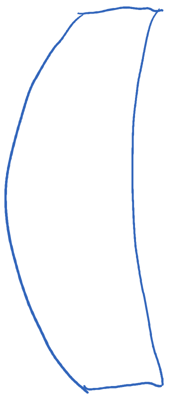
Näherung: 1 Brechung an Hauptebene

statt 2x an den Grenzflächen (= phys.!)

bikonvex plankonvex bikonkav plankonkav

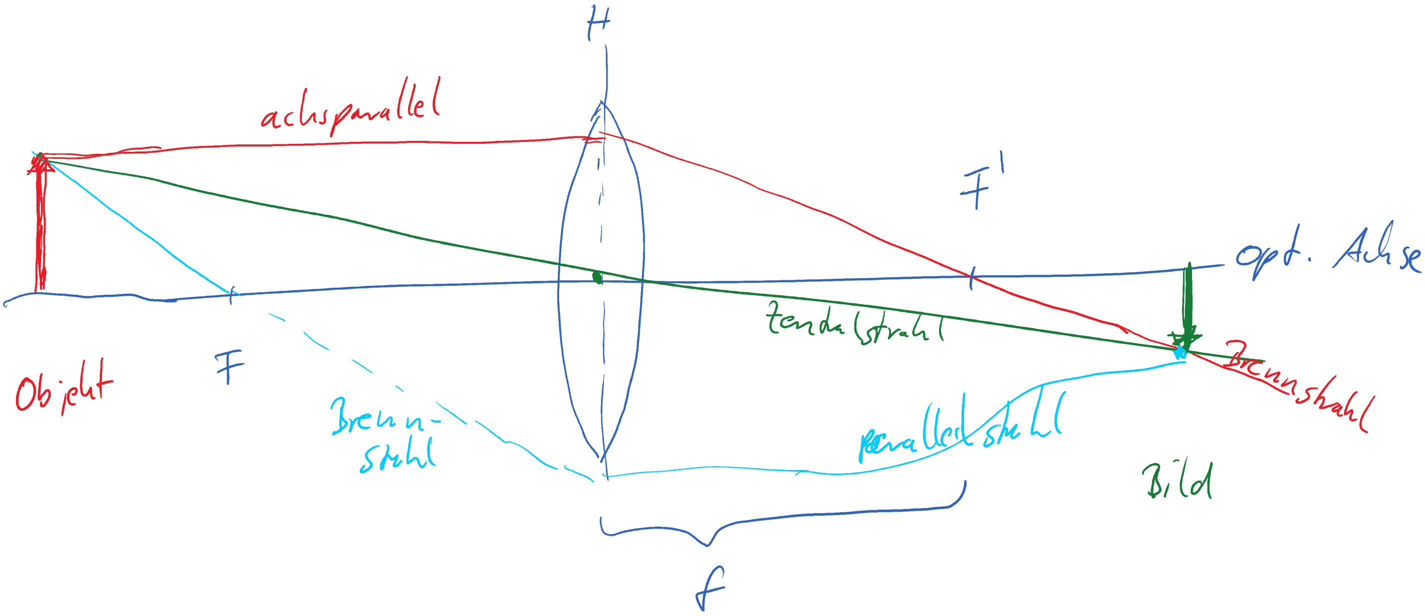


konvex-konkav



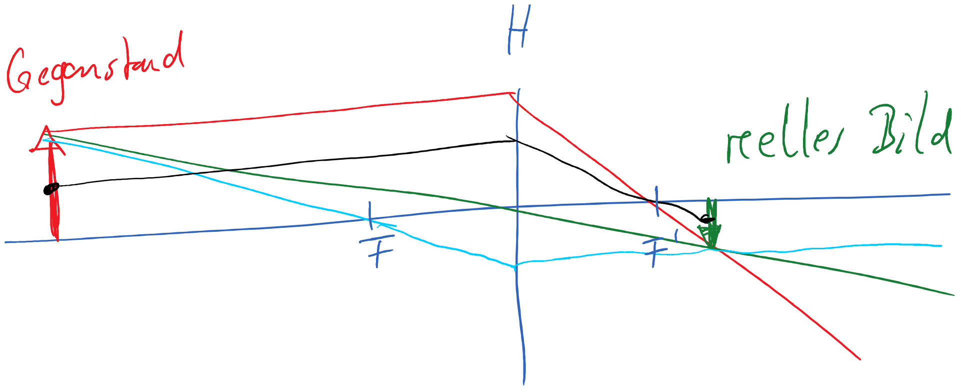
= physikalische Realisierung

<u>Näherung</u> : Hauptebene + Brennweite



Gegenstand

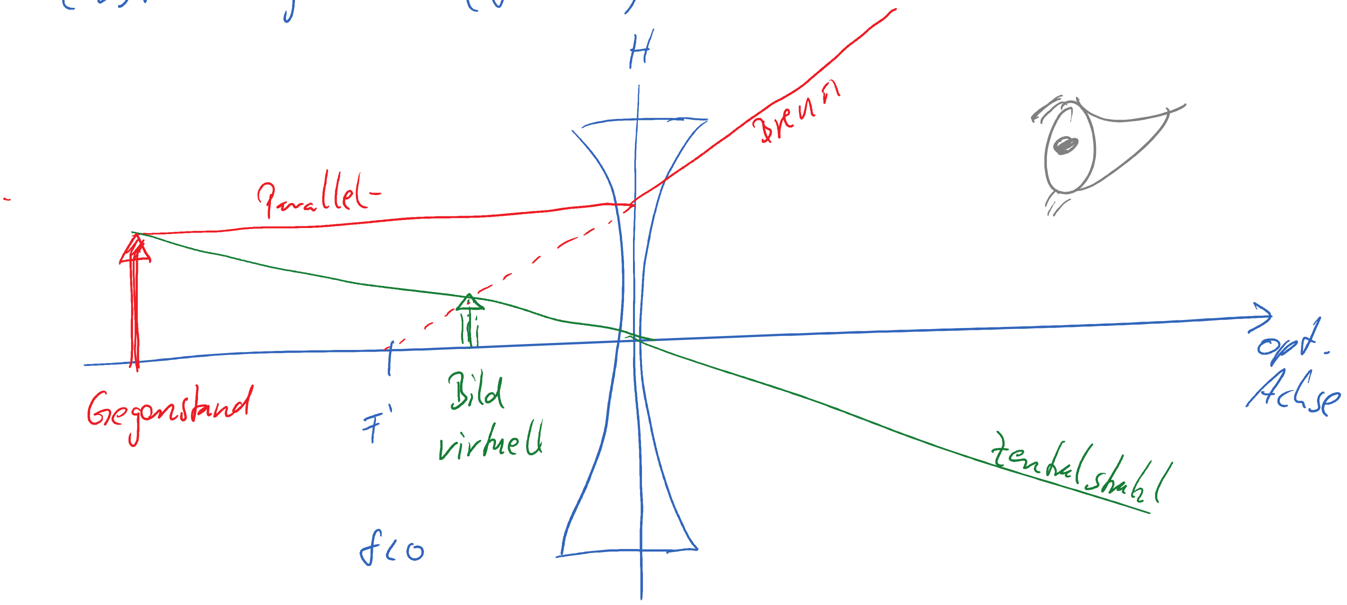
H



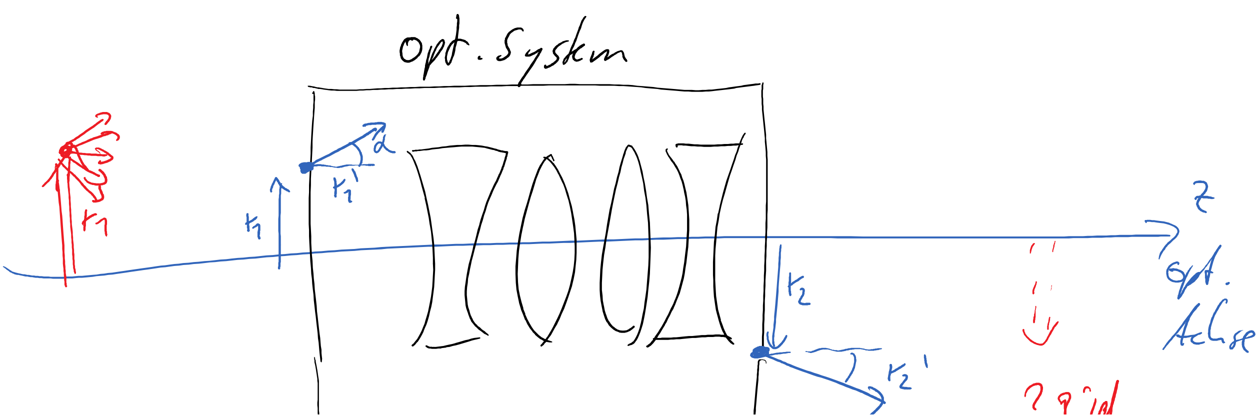
achsparallel $\Leftrightarrow$ Brennstrahl

Zentralstrahl = gerade

Zerstreuungslinse ($f < 0$) & virtuelles Bild



ABCD Matrix-Formalismus



? Bild

Achse

$$\sin\alpha \approx \alpha = r' = \frac{dr}{dz}$$

$$\begin{pmatrix} r_1 \\ r_1' \end{pmatrix} \overset{?}{\longmapsto} \begin{pmatrix} r_2 \\ r_2' \end{pmatrix}$$

ABCD Matrix

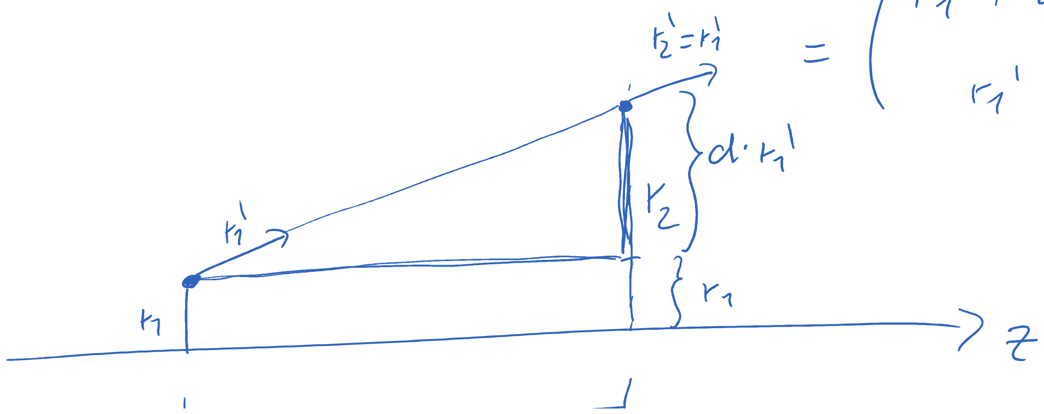
ray transfer matrix $\begin{pmatrix} A & B \\ C & D \end{pmatrix}$ 2x2 Matrix

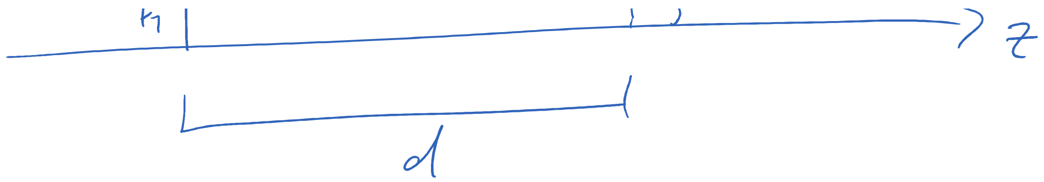
$$\begin{pmatrix} r_2 \\ r_2' \end{pmatrix} = \begin{pmatrix} A & B \\ C & D \end{pmatrix} \cdot \begin{pmatrix} r_1 \\ r_1' \end{pmatrix} = \begin{pmatrix} A\cdot r_1 + B\cdot r_1' \\ C\cdot r_1 + D\cdot r_1' \end{pmatrix}$$

<u>Bsp.</u>

Wegstrecke <u>d</u>: $S = \begin{pmatrix} A & B \\ C & D \end{pmatrix} = \begin{pmatrix} 1 & d \\ 0 & 1 \end{pmatrix}$ Wegstrecke d

$$\begin{pmatrix} r_2 \\ r_2' \end{pmatrix} = \begin{pmatrix} 1 & d \\ 0 & 1 \end{pmatrix} \begin{pmatrix} r_1 \\ r_1' \end{pmatrix} = \begin{pmatrix} 1\cdot r_1 + d\cdot r_1' \\ 0\cdot r_1 + 1\cdot r_1' \end{pmatrix} = \begin{pmatrix} r_1 + d\, r_1' \\ r_1' \end{pmatrix}$$



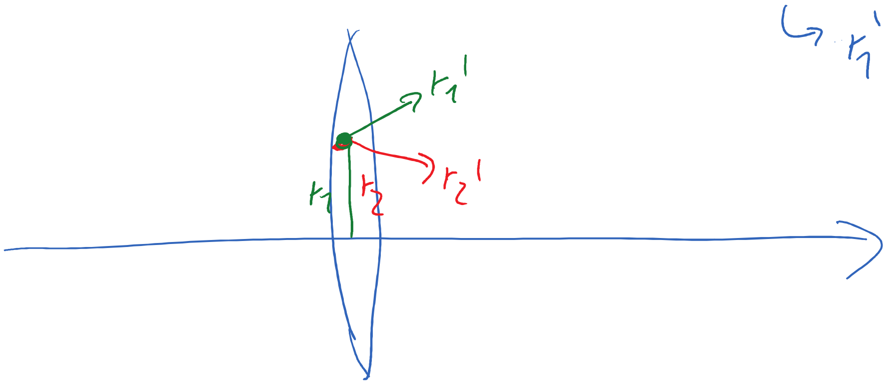


Linse f:

$$L = \begin{pmatrix} A & B \\ C & D \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ -\frac{1}{f} & 1 \end{pmatrix}$$

$$\begin{pmatrix} r_2 \\ r_2' \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ -\frac{1}{f} & 1 \end{pmatrix} \begin{pmatrix} r_1 \\ r_1' \end{pmatrix} = \begin{pmatrix} r_1 \\ -\frac{r_1}{f} + r_1' \end{pmatrix}$$

$\hookrightarrow r_1' - \frac{r_1}{f}$



$$r_2' = r_1' - \frac{r_1}{f}$$

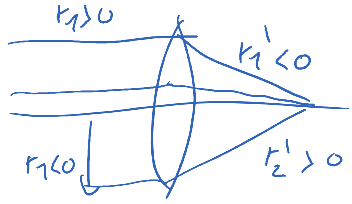
Zentralstrahl: $r_1 = 0$

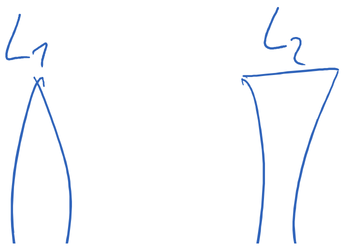
$r_2' = r_1'$

wird nicht gebrochen

Parallelstrahl: $r_1' = 0$

wird prop. zu r_1 gebrochen





$$(M) = (L_2)(d_1)(L_1) = \begin{pmatrix} 1 & 0 \\ -\frac{1}{f_2} & 1 \end{pmatrix} \begin{pmatrix} 1 & d_1 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ -\frac{1}{f_1} & 1 \end{pmatrix}$$

matrix - multiplication

$$\begin{pmatrix} A_{tot} & B_{tot} \\ C_{tot} & D_{tot} \end{pmatrix}$$ des Gesamtsystems