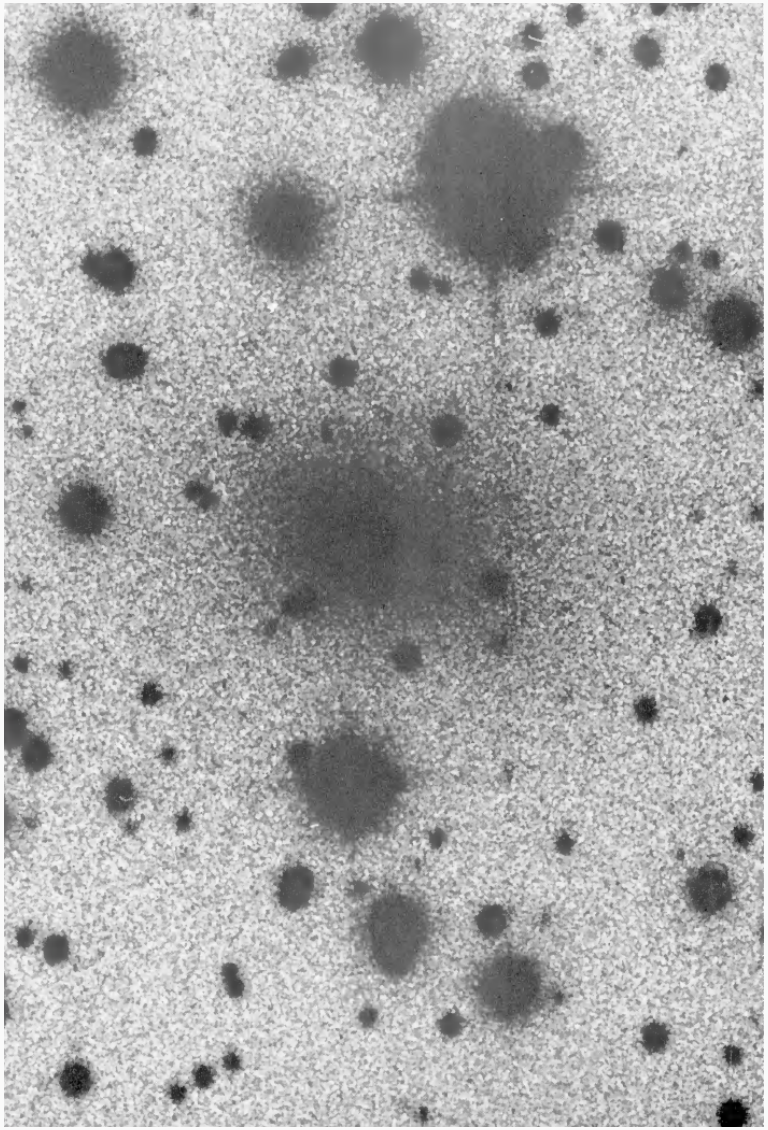
relativistische Betrachtung von Bewegungen

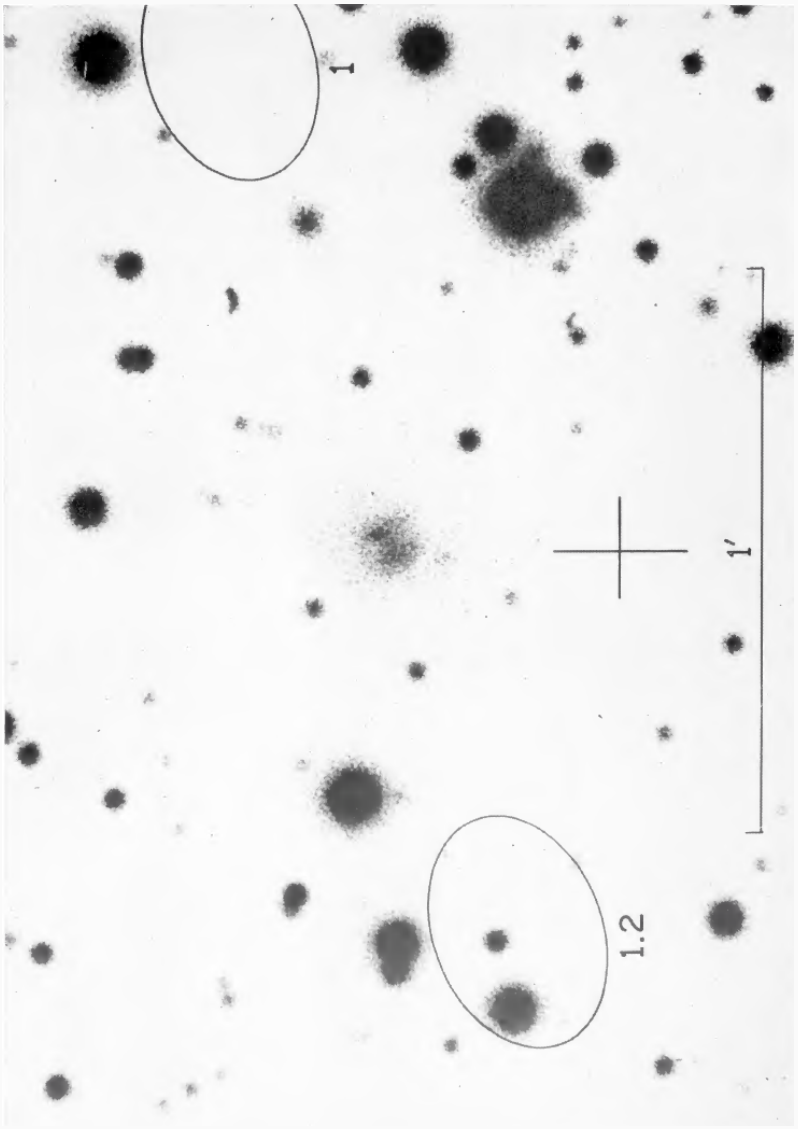
Alexander Helbok

19. Januar 2024

Radiobeobachtungen

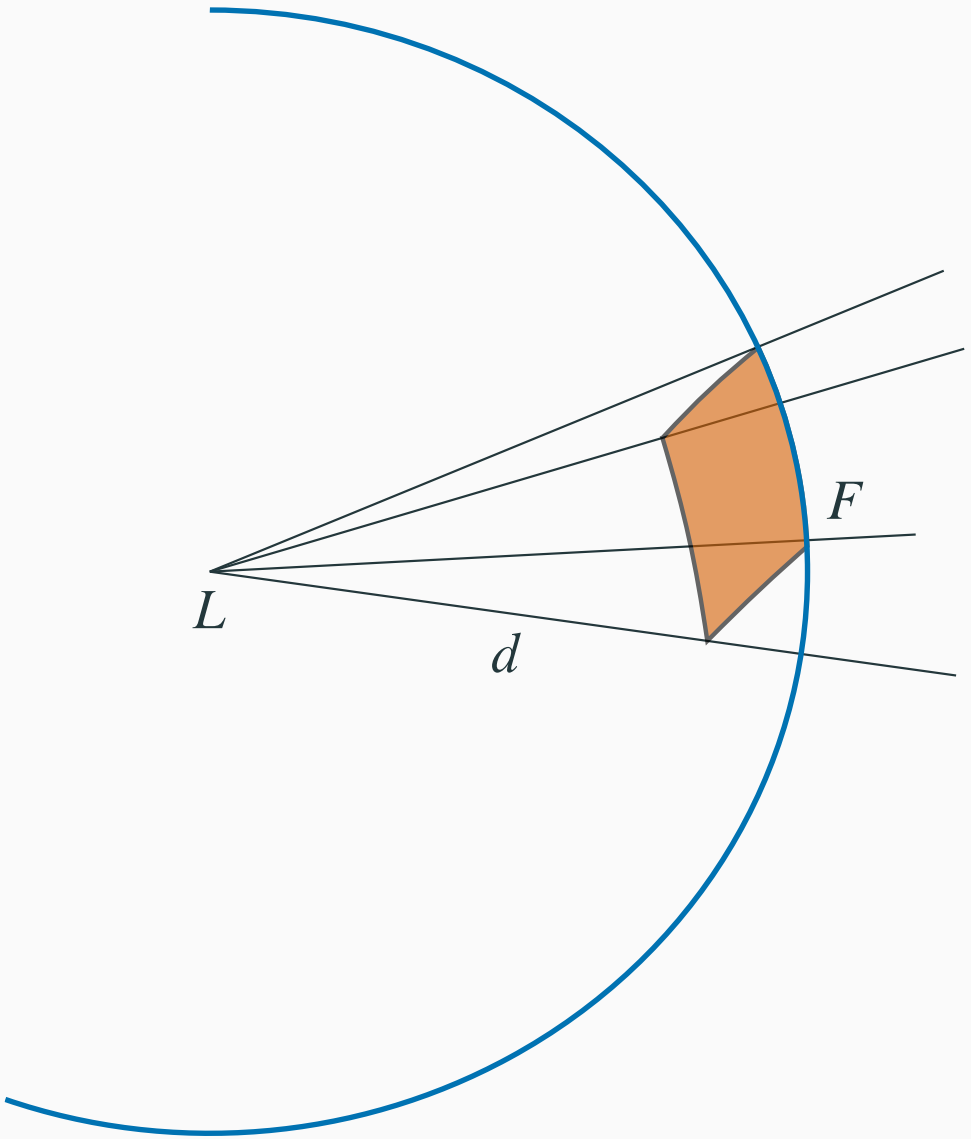


(Matthews, Morgan und Schmidt 1964)



(Matthews, Morgan und Schmidt 1964)

Leuchtkraft von 3C 273



Entfernung über Rotverschiebung

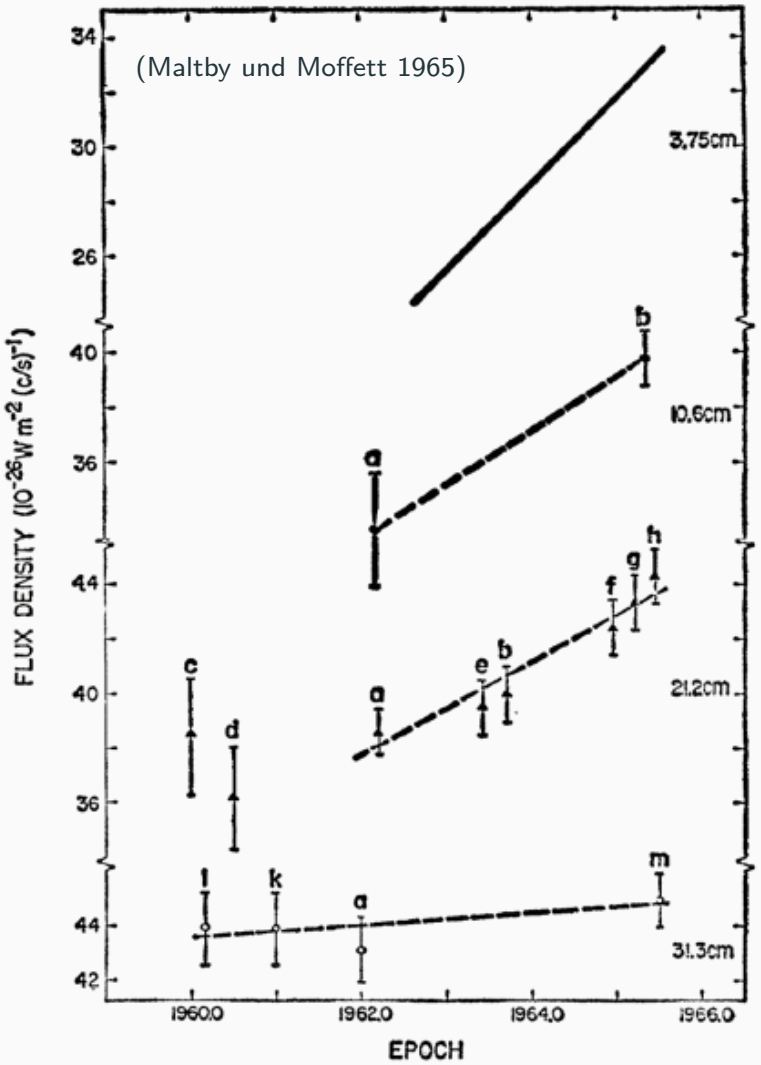
$(z = 0.158)$

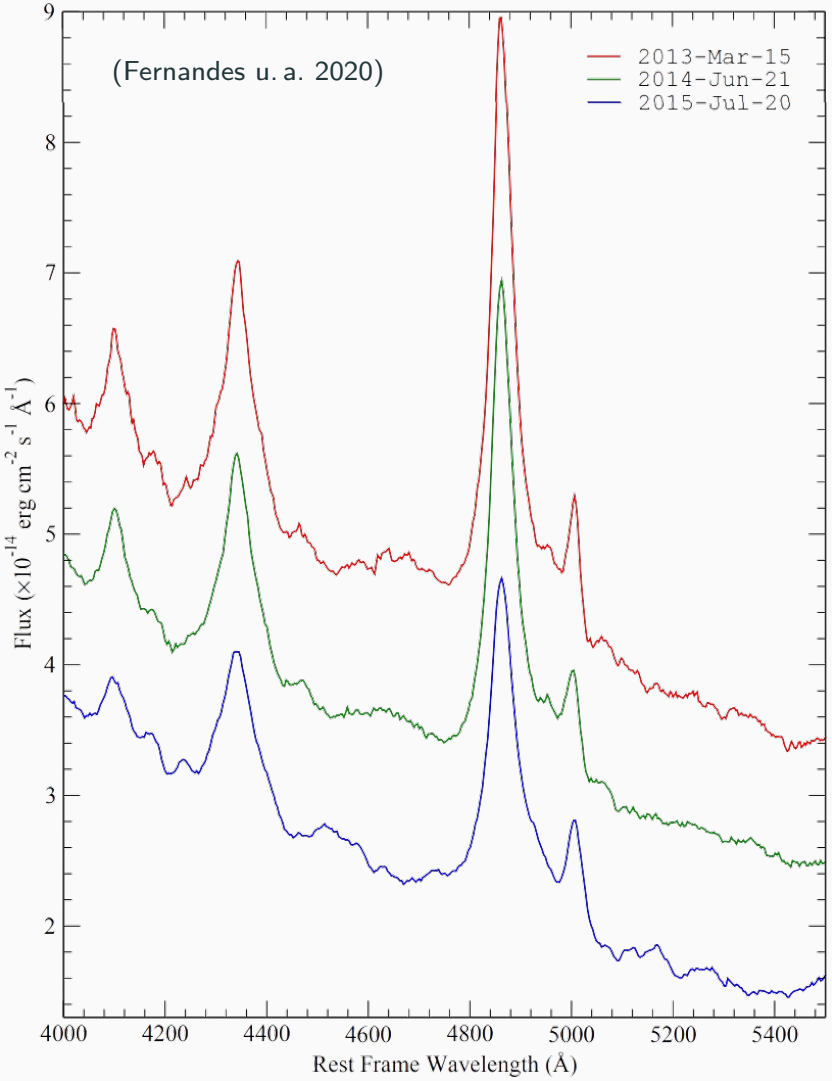
$$L = 4\pi d^2 F$$

Flussmessung im Radiobereich

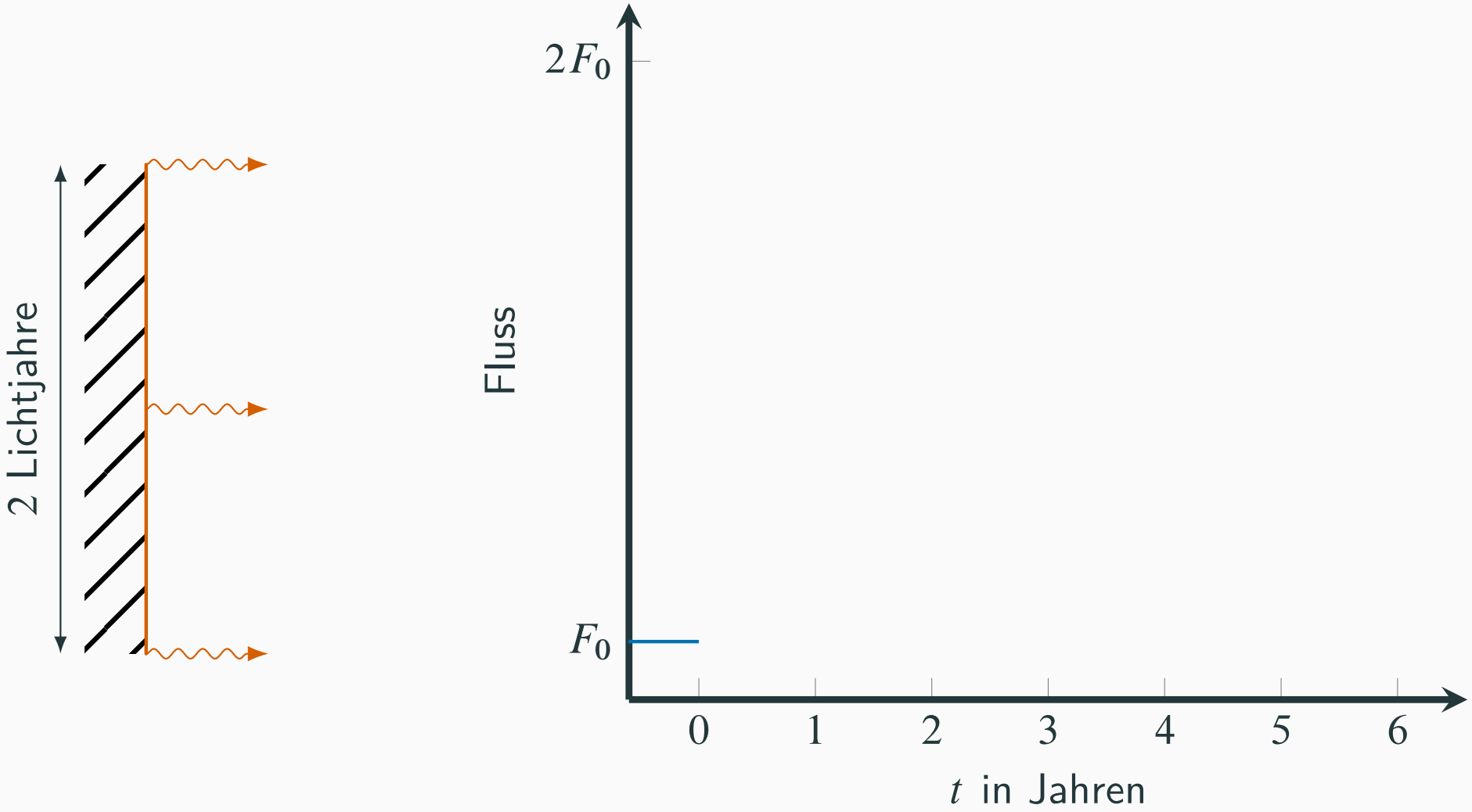
$\Rightarrow$ extrem Hell

Helligkeitsschwankungen in 3C 273

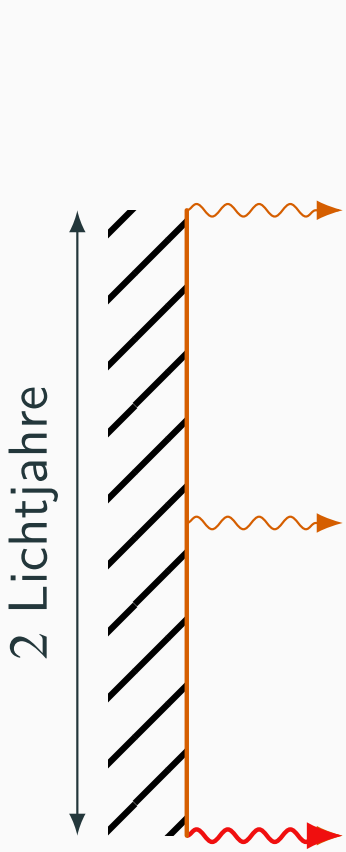


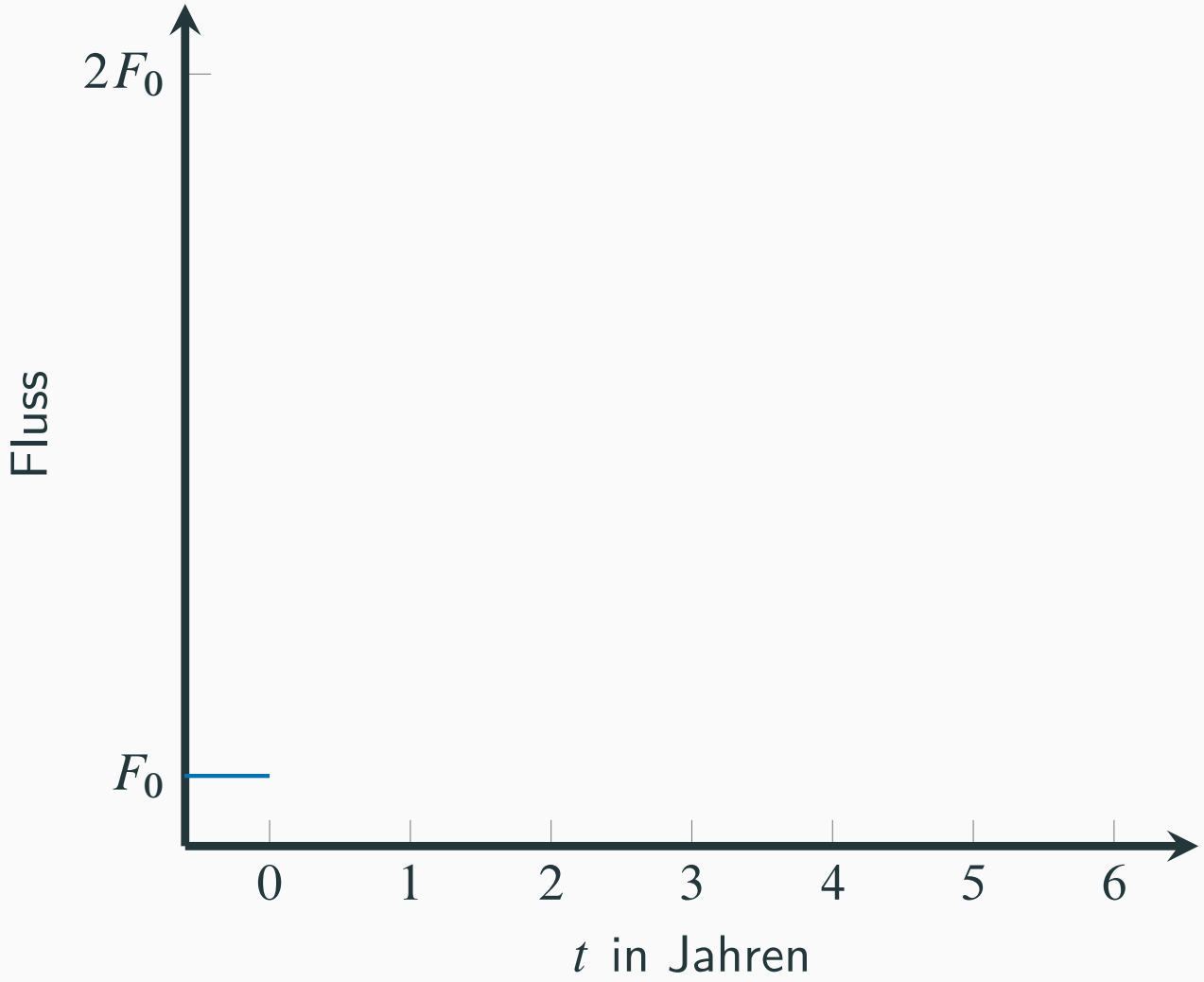


Fluktuationen erklärt



Fluktuationen erklärt





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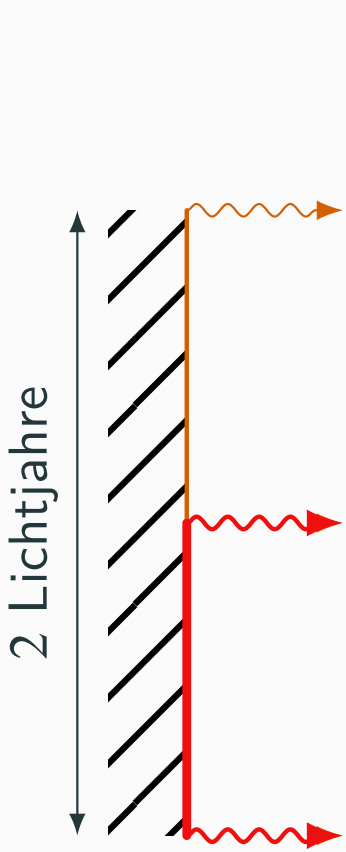

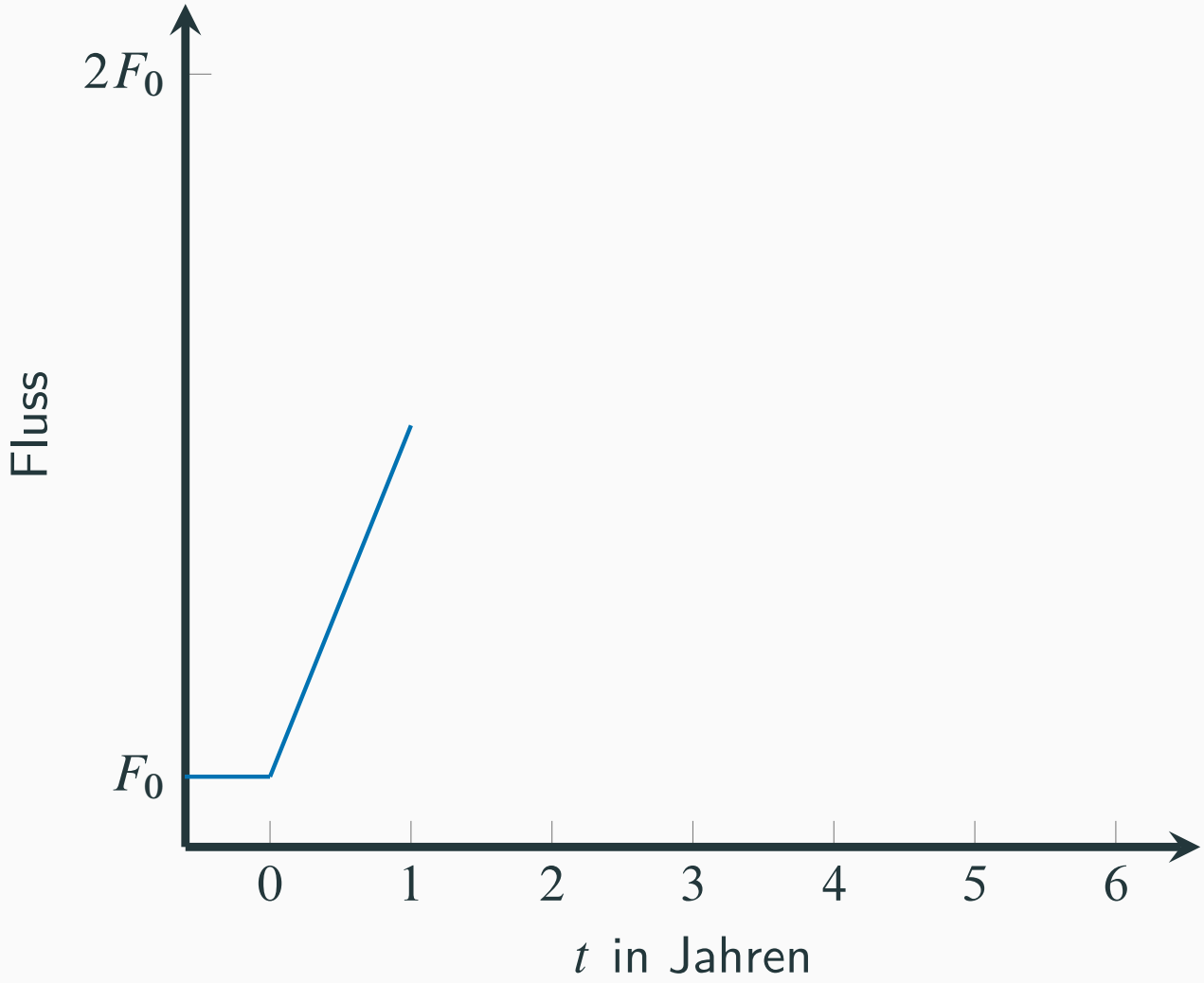

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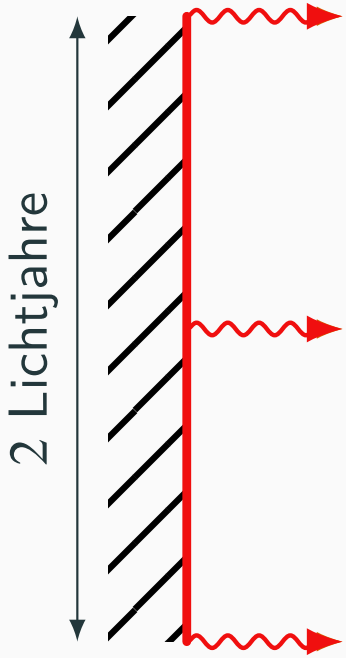

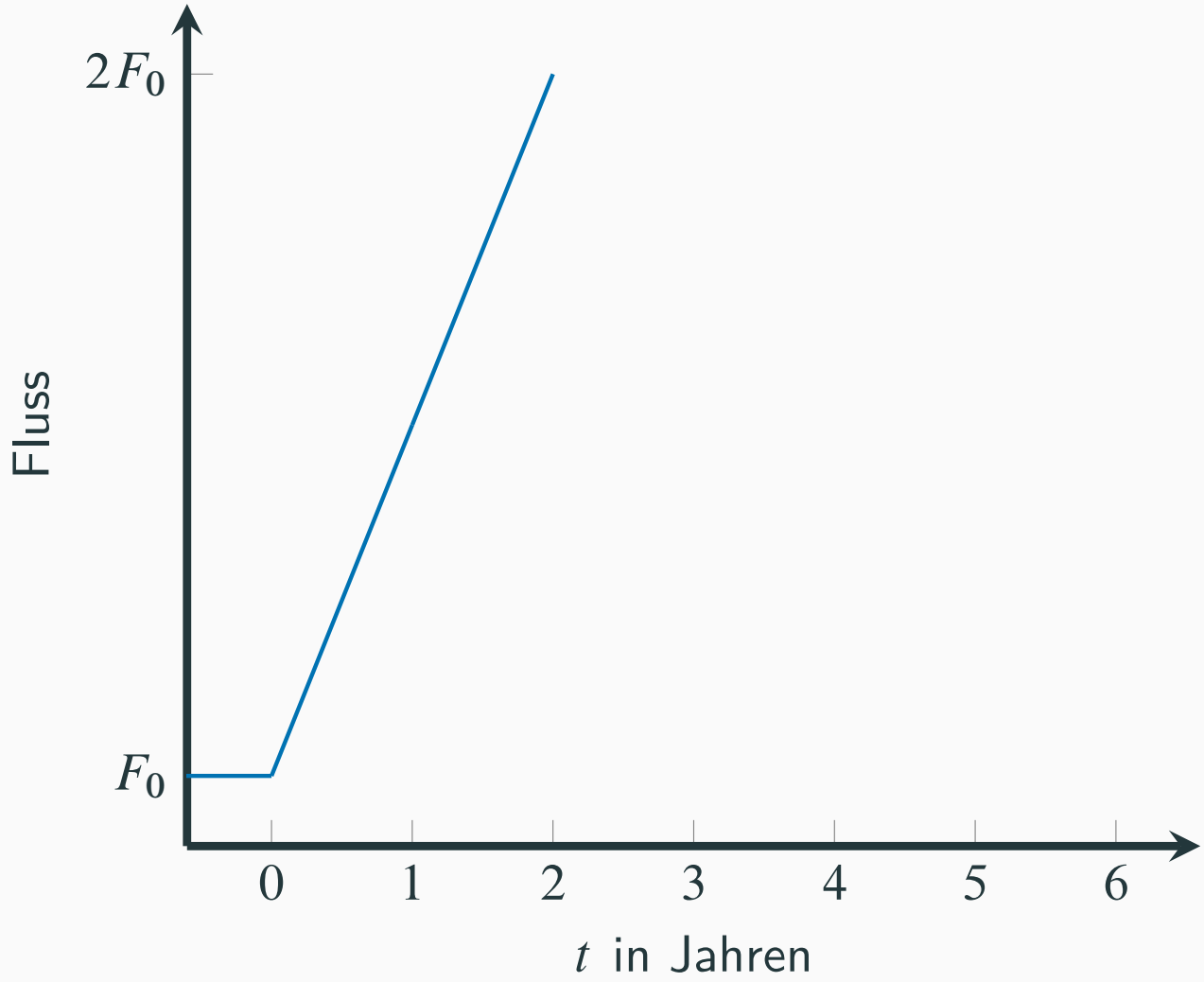

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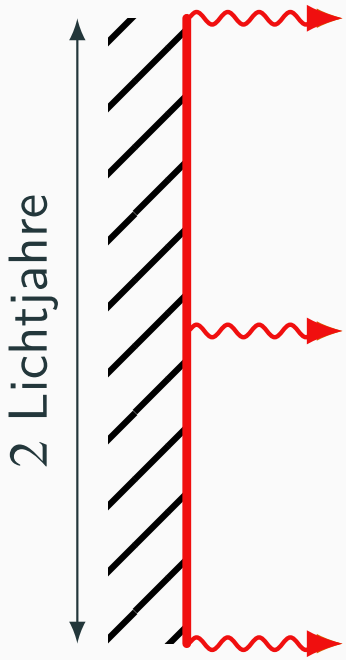
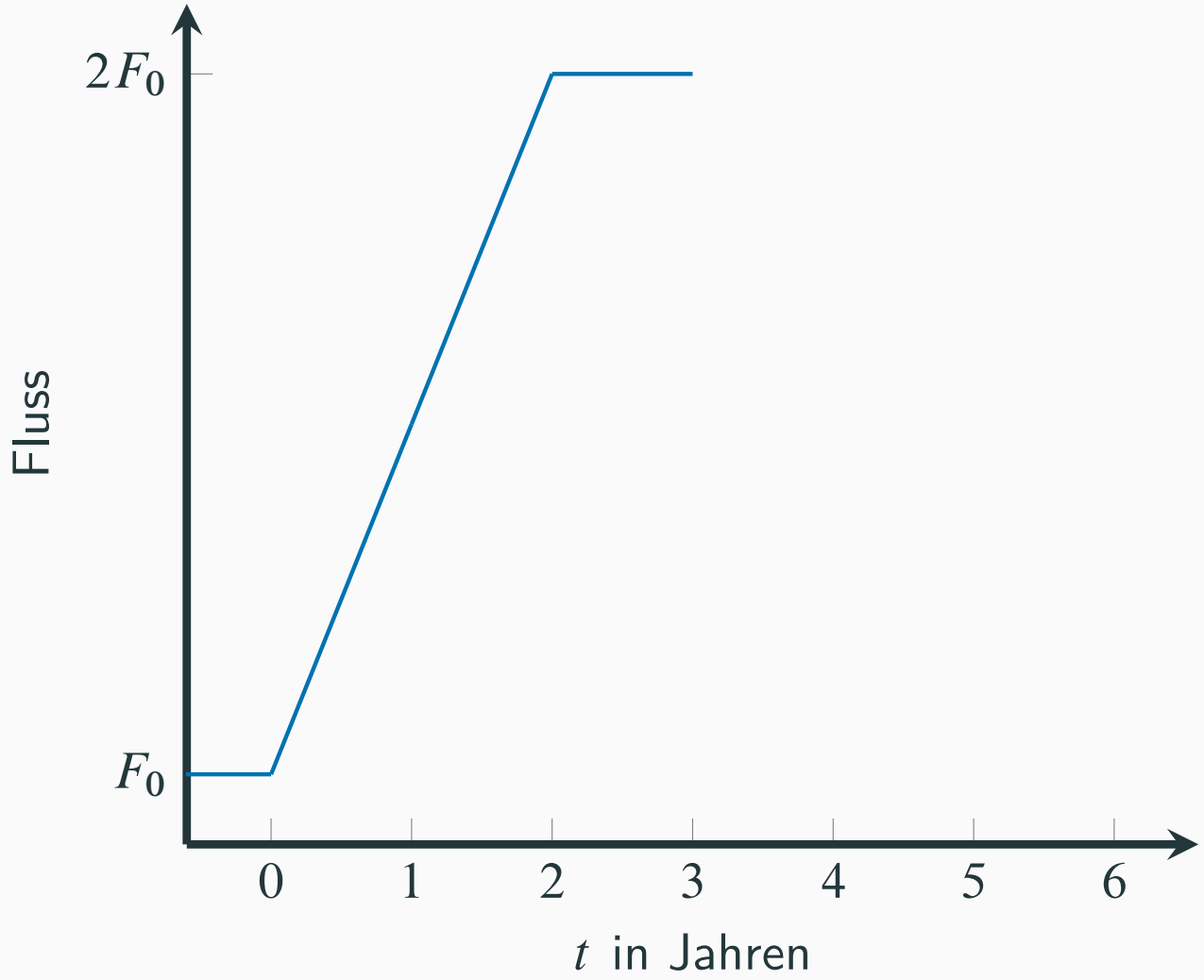
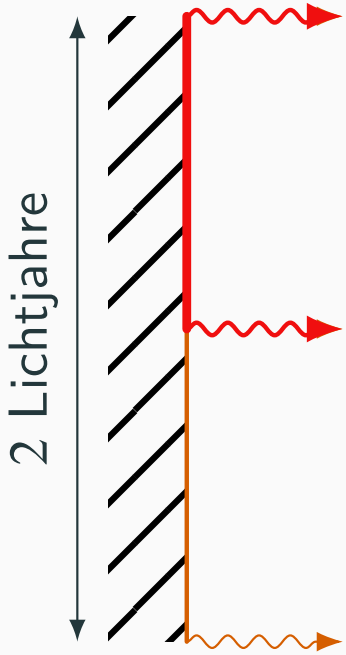
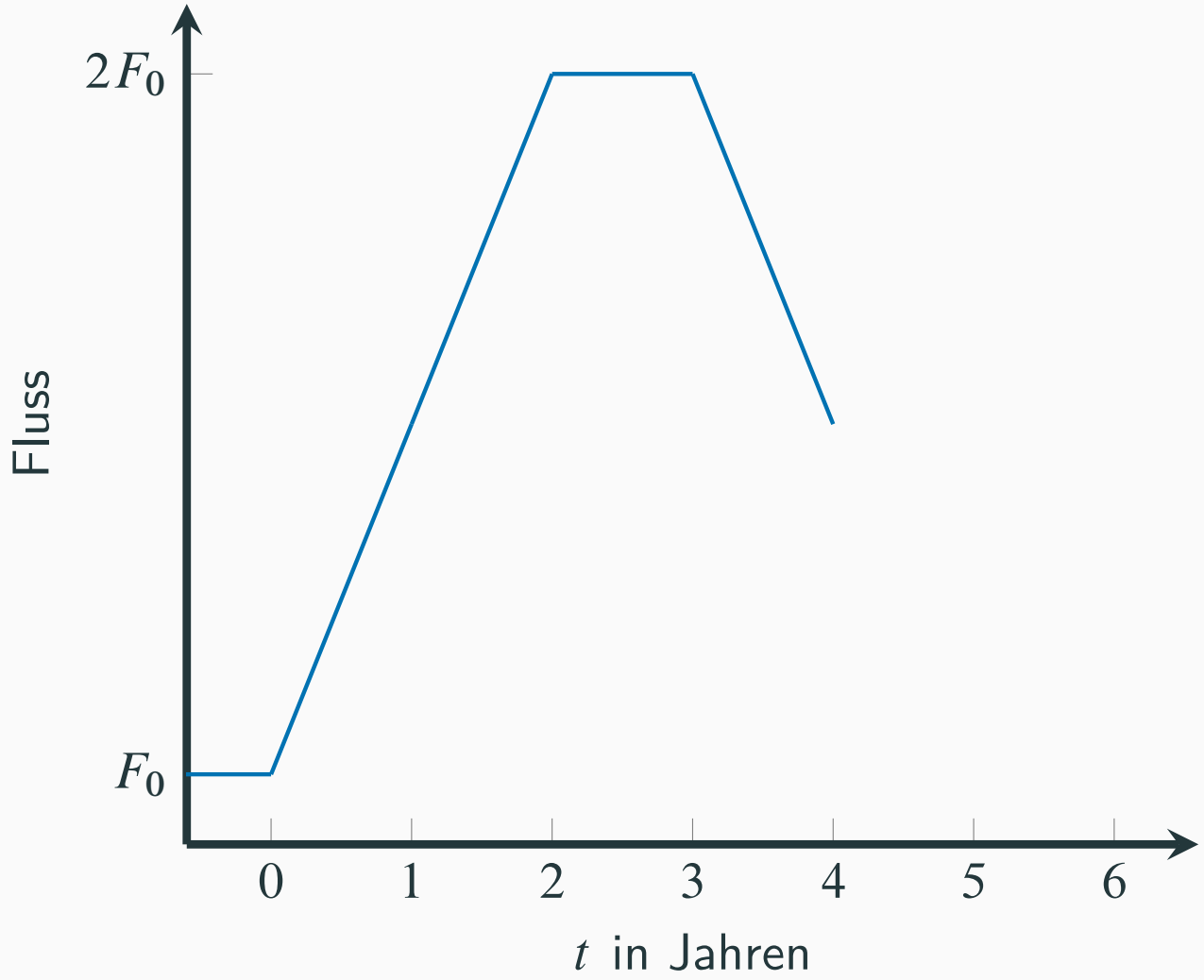


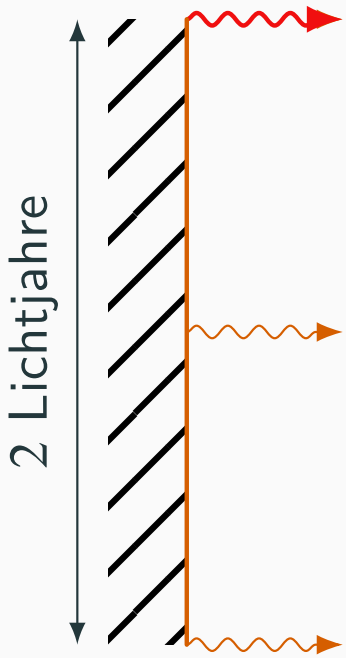


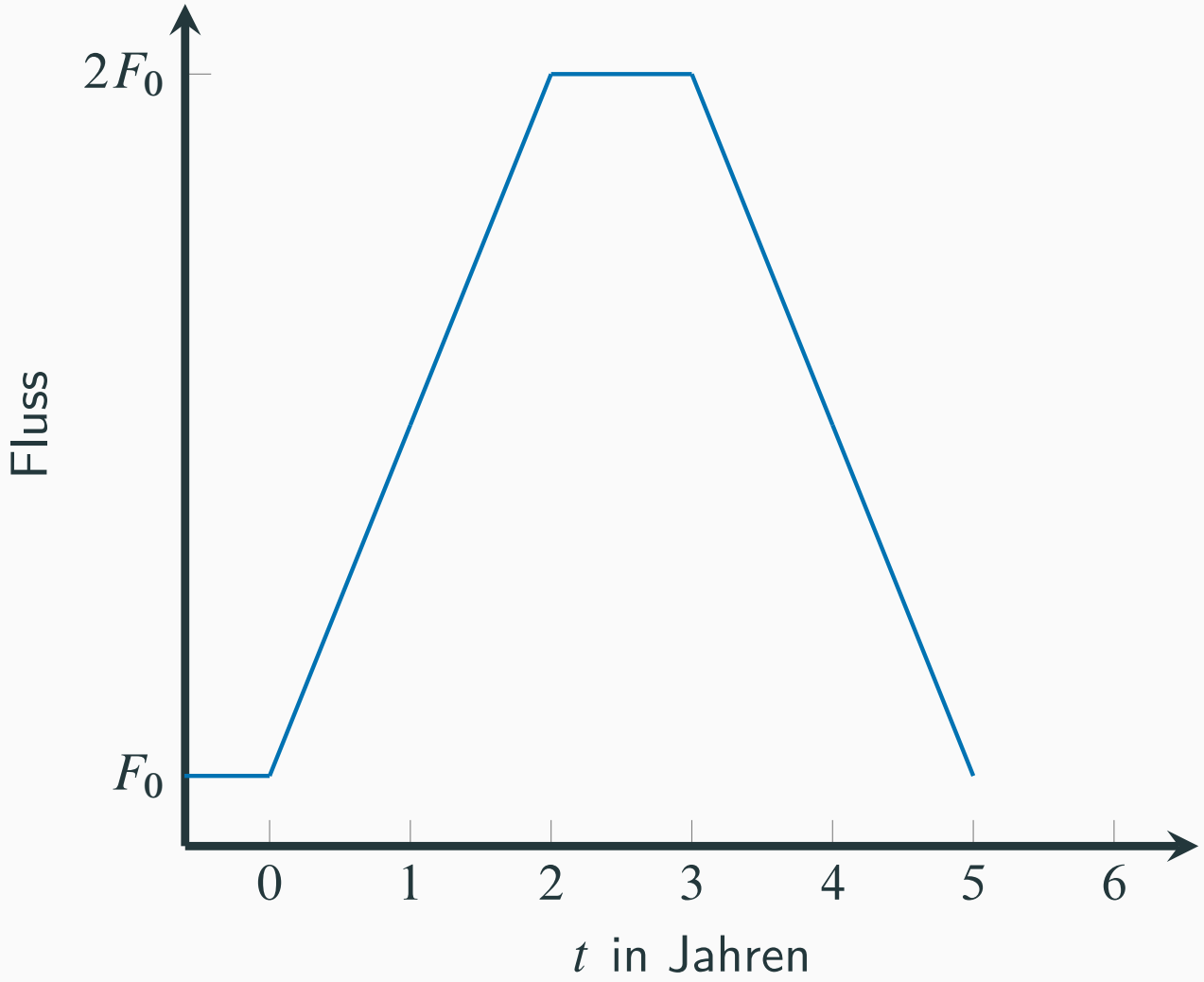
Fluktuationen erklärt



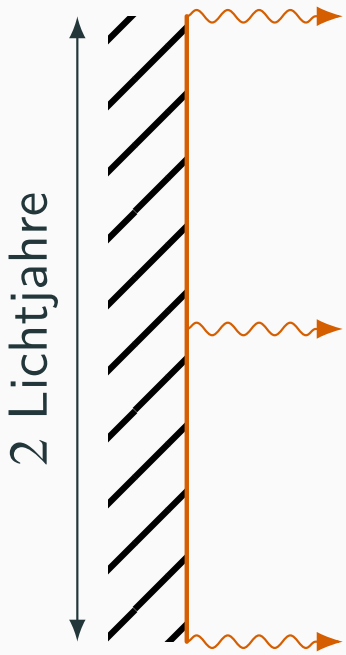


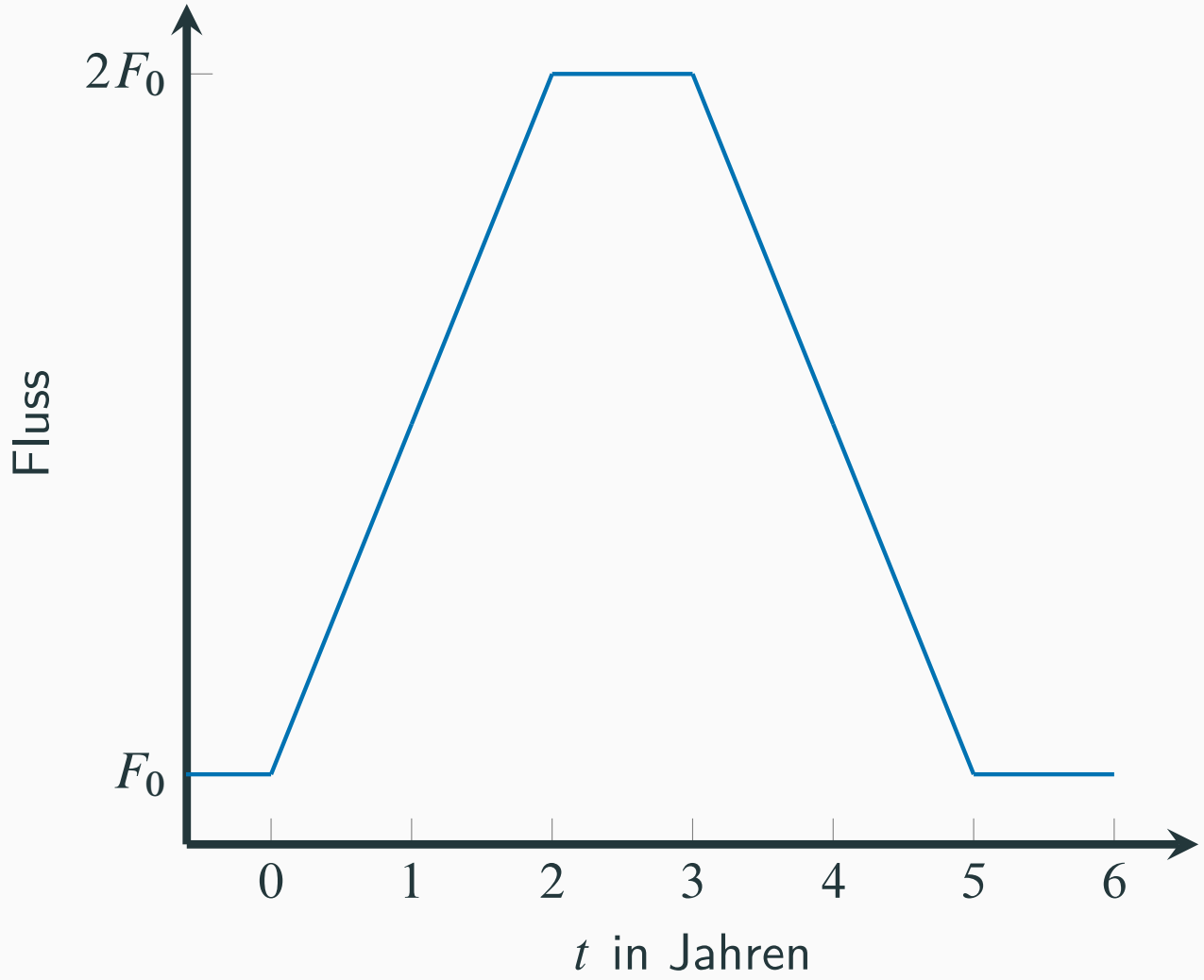
Fluktuationen erklärt



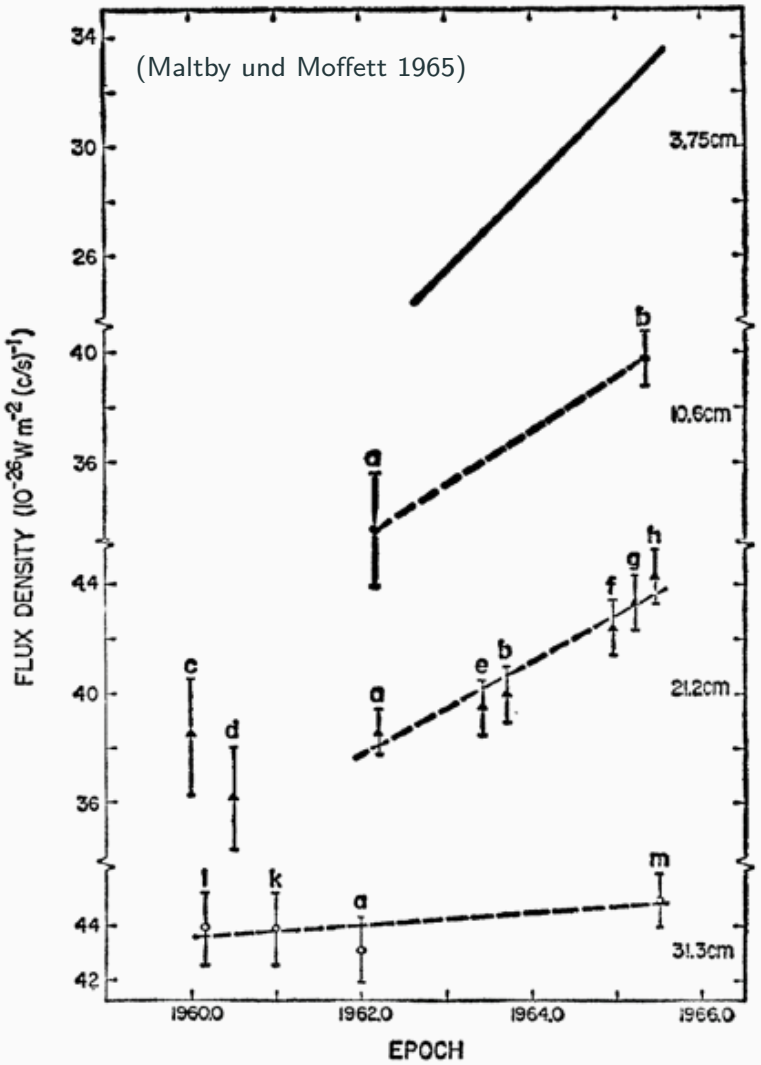


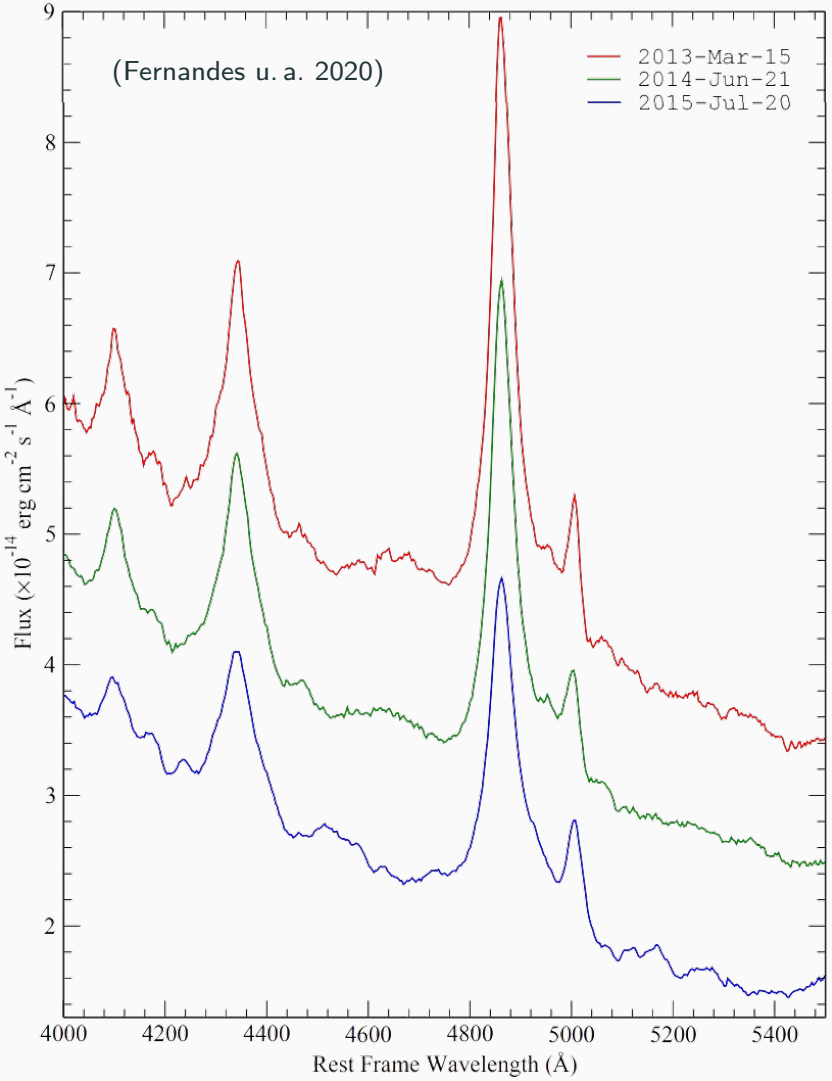
Fluktuationen erklärt





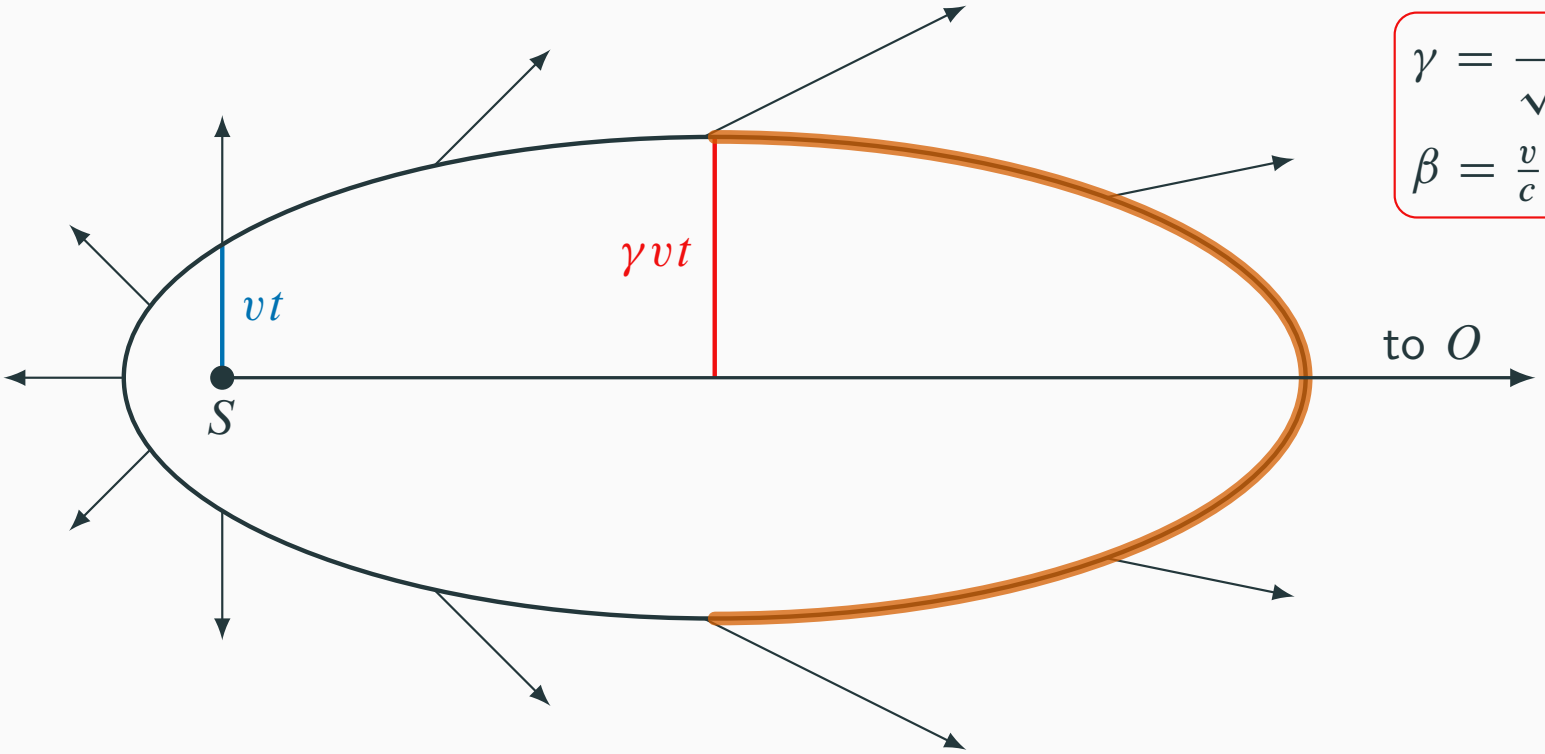
Helligkeitsschwankungen in 3C 273





sphärische Expansion $v \ll c$

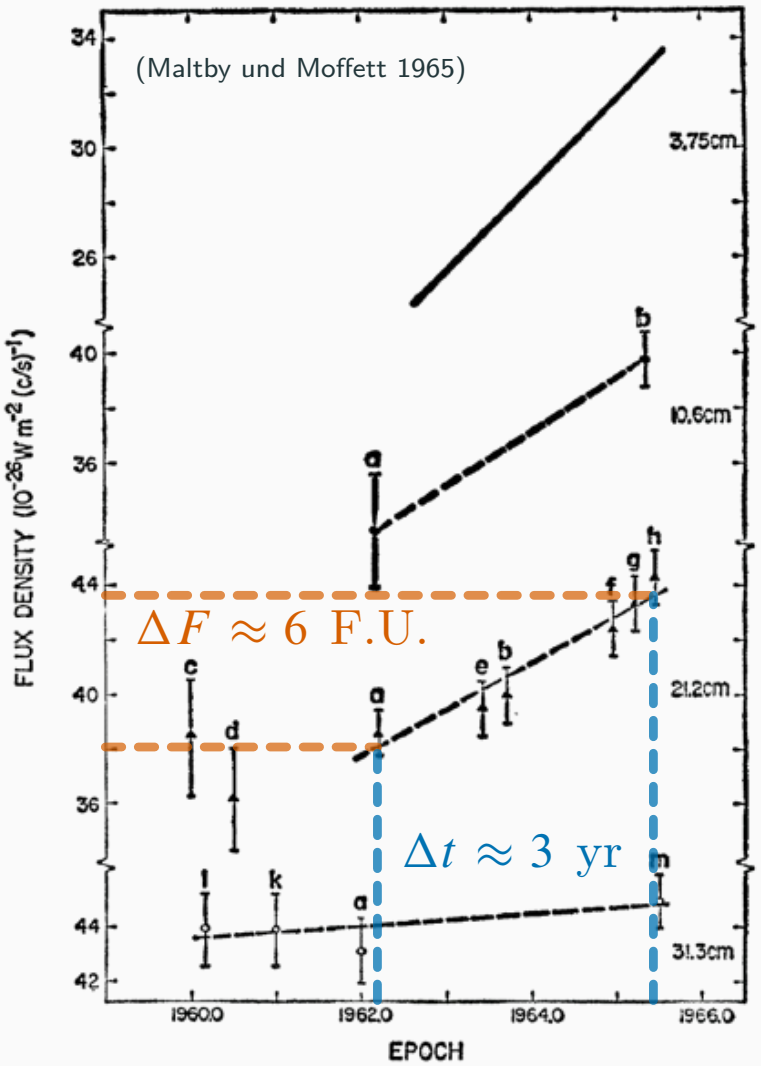
sphärische Expansion $v \sim c$



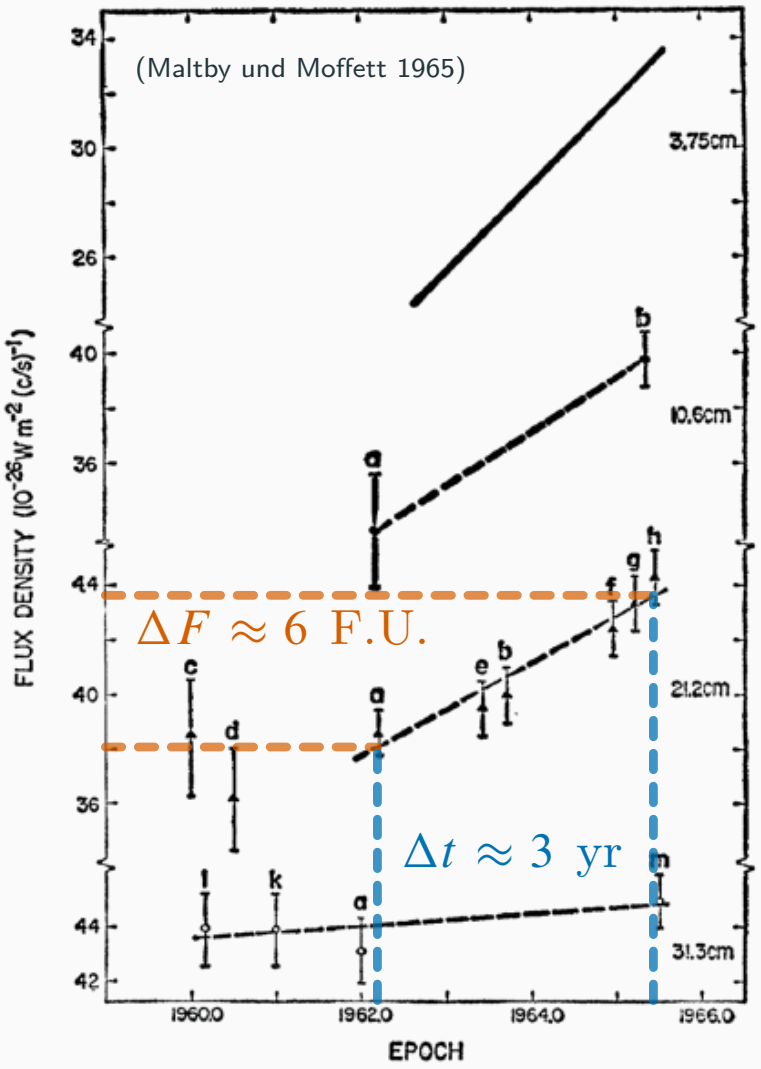
$$\gamma = \frac{1}{\sqrt{1-\beta^2}}$$

$$\beta = \frac{v}{c}$$

Beobachtung



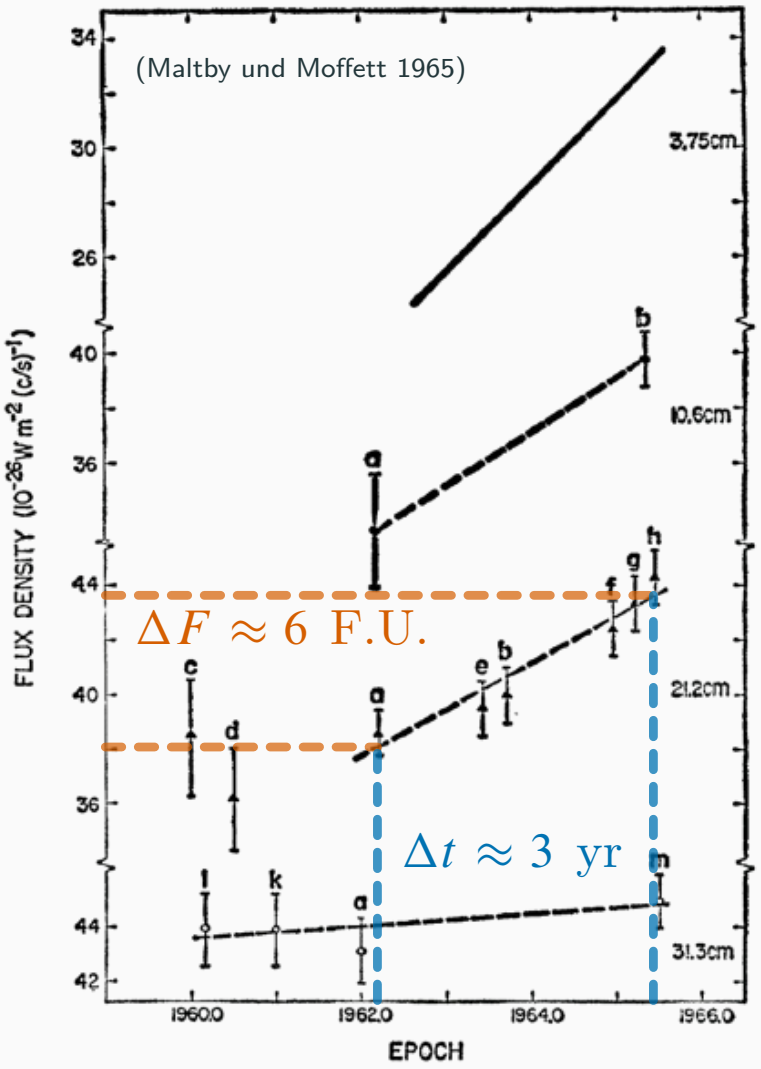
Beobachtung



„Because the observed intensity of a source, for a given surface brightness, is proportional to the apparent size“ [4]

$$F = B \sphericalangle \propto 2\frac{\gamma v t}{R}$$

Beobachtung

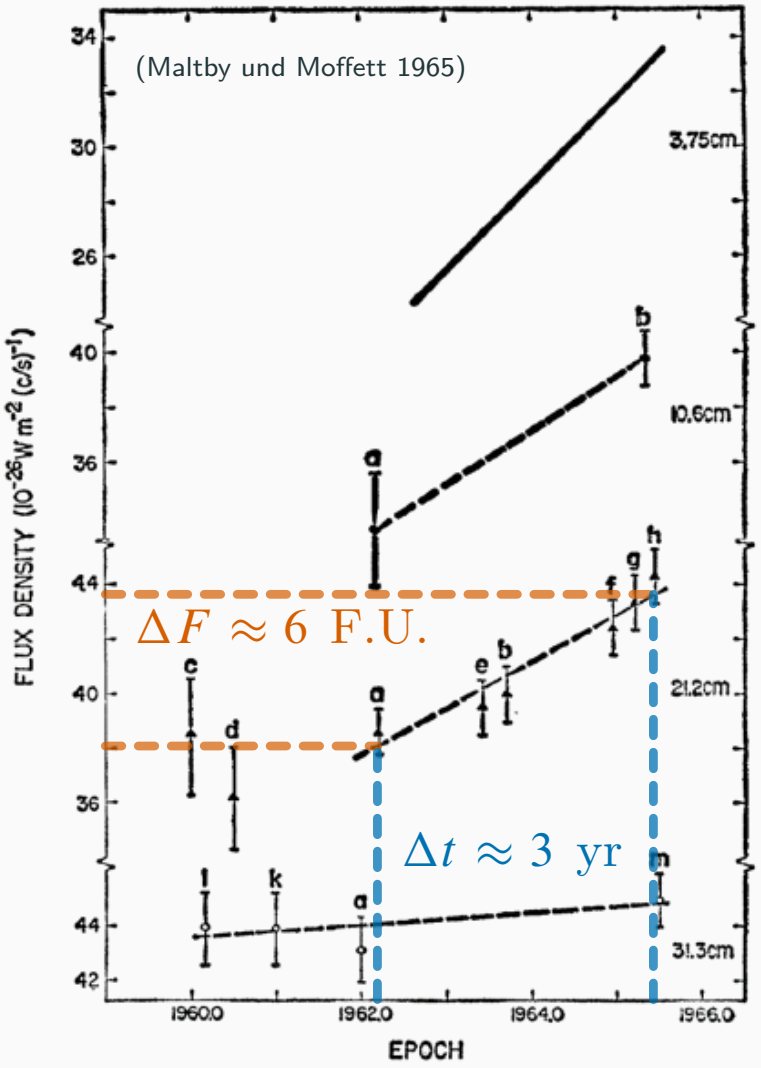


„Because the observed intensity of a source, for a given surface brightness, is proportional to the apparent size“ [4]

$$F = B\sphericalangle \propto 2\frac{\gamma v t}{R} \qquad \frac{\mathrm{d}F}{\mathrm{d}t} = 2\frac{\gamma v}{R} \propto \gamma$$

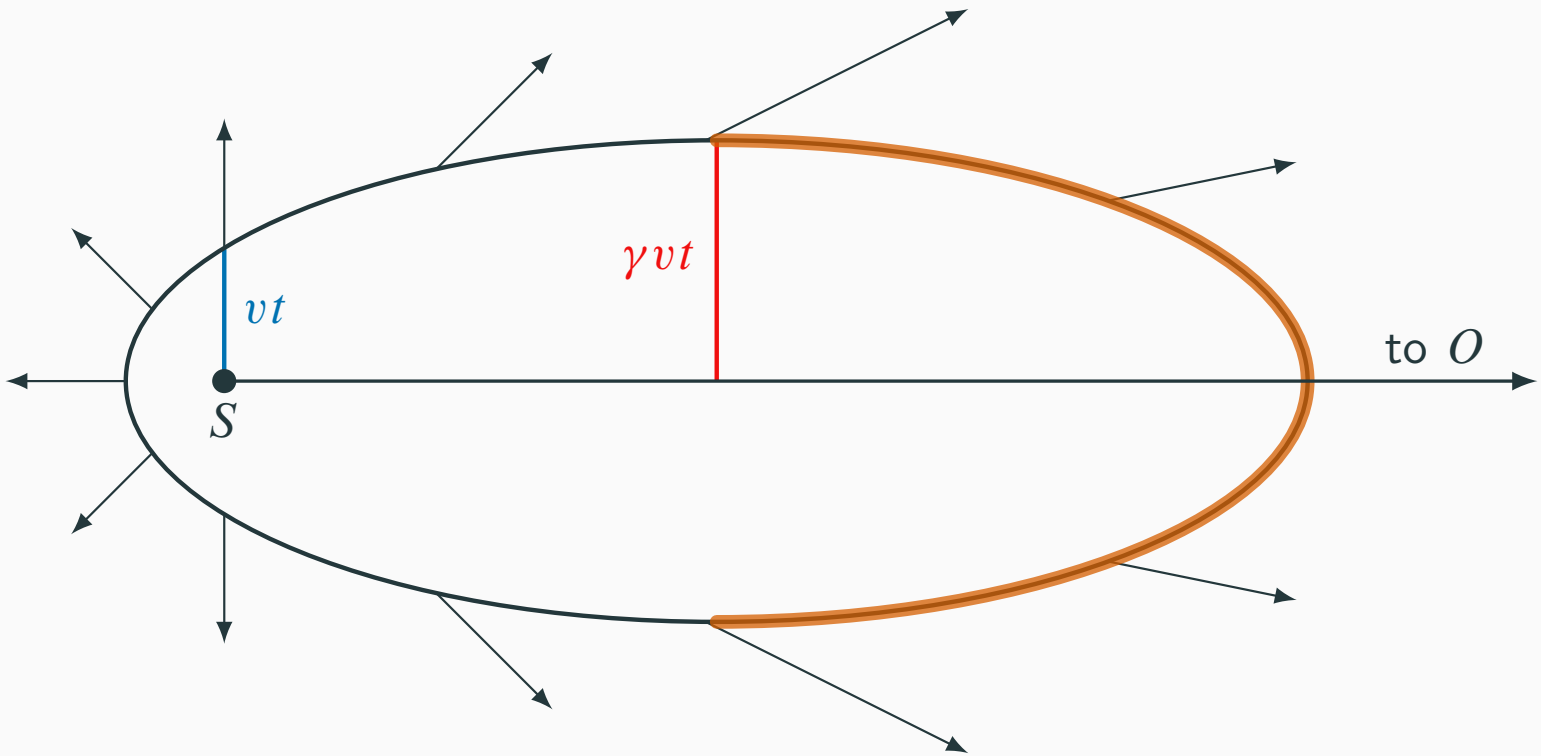
„it is already clear that an expanding source could exhibit a rate of increase of flux density high enough to explain the observations.“ [4]

Beobachtung



„If, however, a source at the distance of 3C 273 were to start to explode with a velocity corresponding to $\gamma = 5$, and if H (measured in a frame sharing the mean particle motion) $\sim 10^{-2}$ gauss, the flux density would have risen to ~ 15 F.U. in 3 years“ [4]

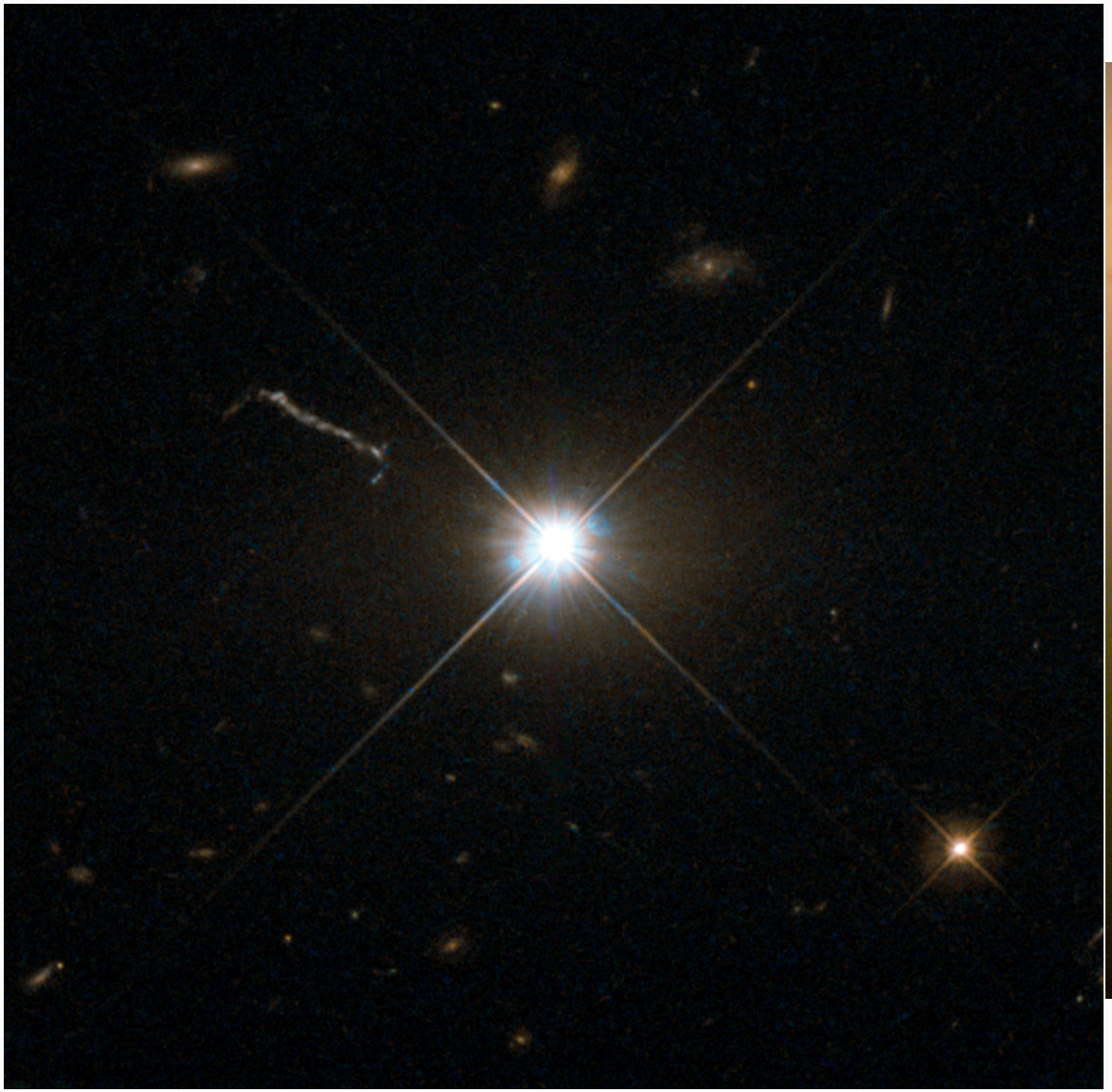
Konsequenz



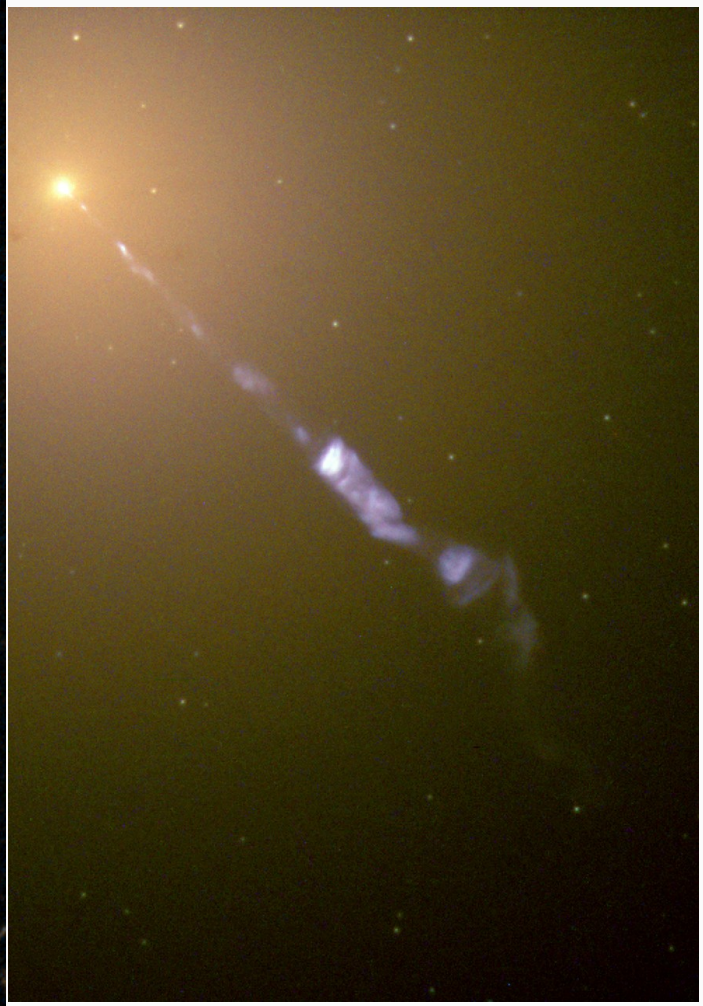
$\beta = \frac{v}{c} \in [0; 1]$

$\gamma = \frac{1}{\sqrt{1-\beta^2}} \in [1, \infty) \quad \Rightarrow \quad \gamma v > c$ möglich!

Kosmische Jets

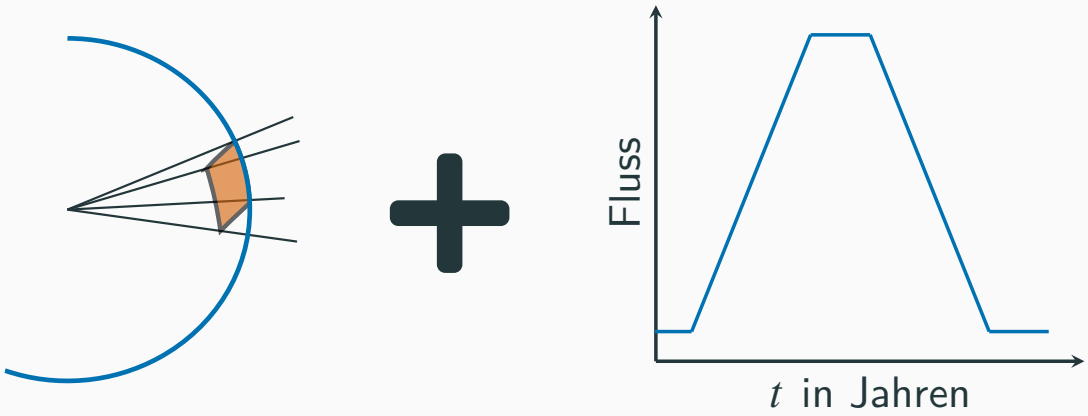


3C 273 © ESA/HUBBLE & NASA

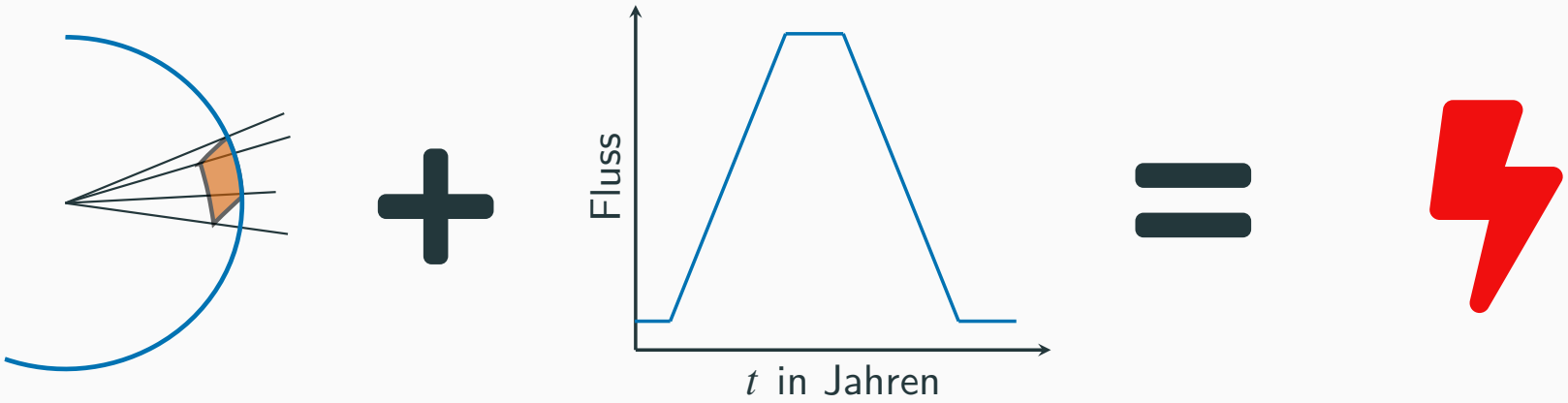


M87 © ESA/HUBBLE & NASA

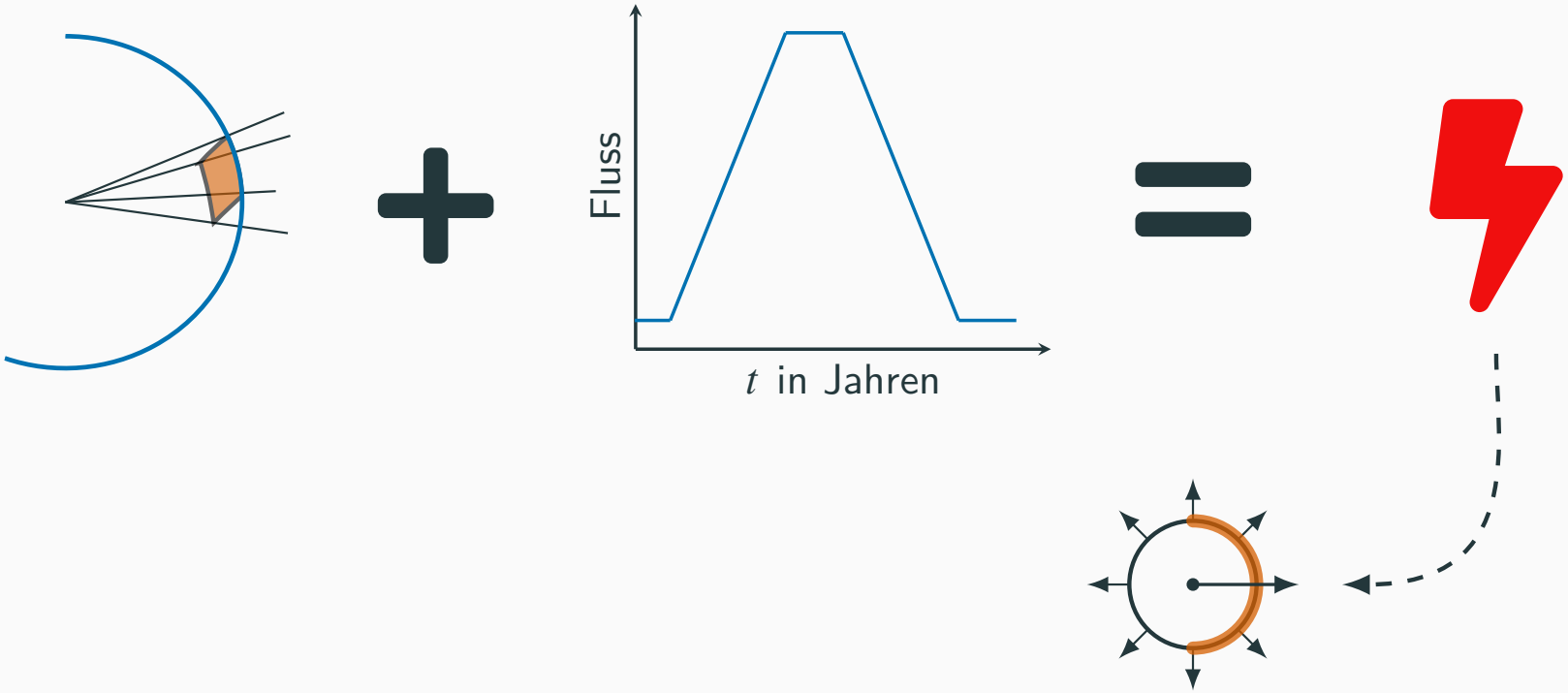
Recap



Recap



Recap



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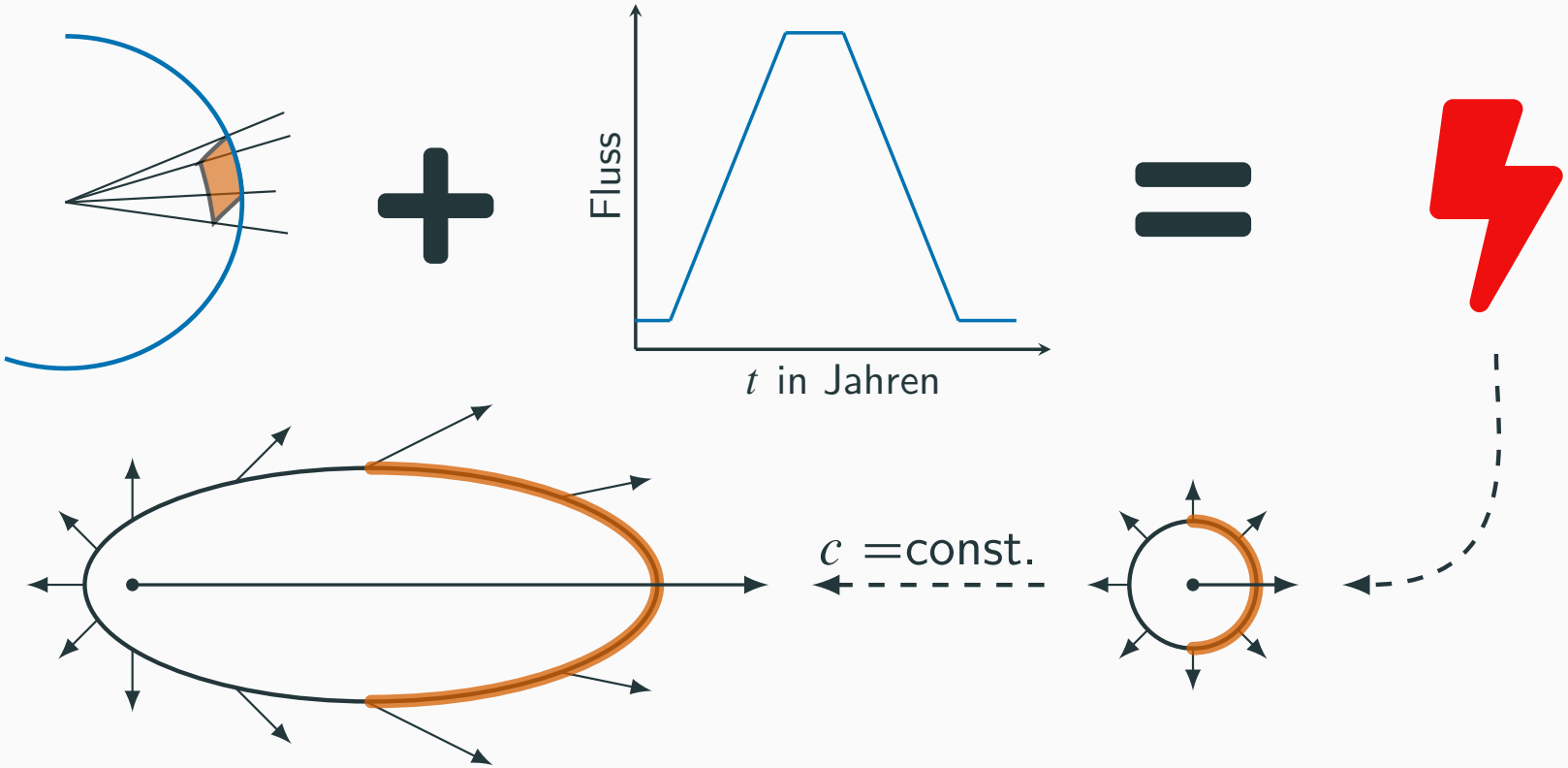

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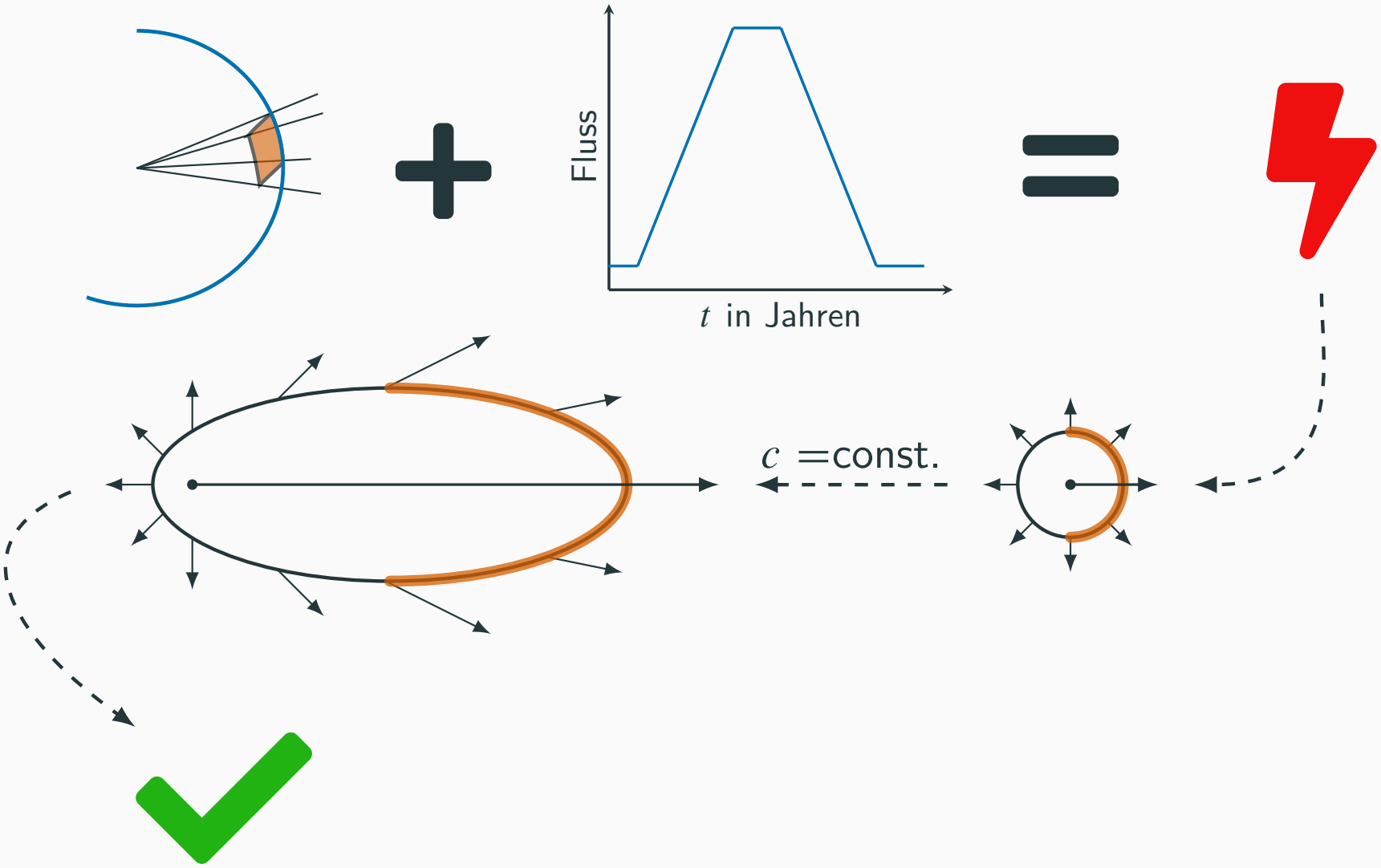
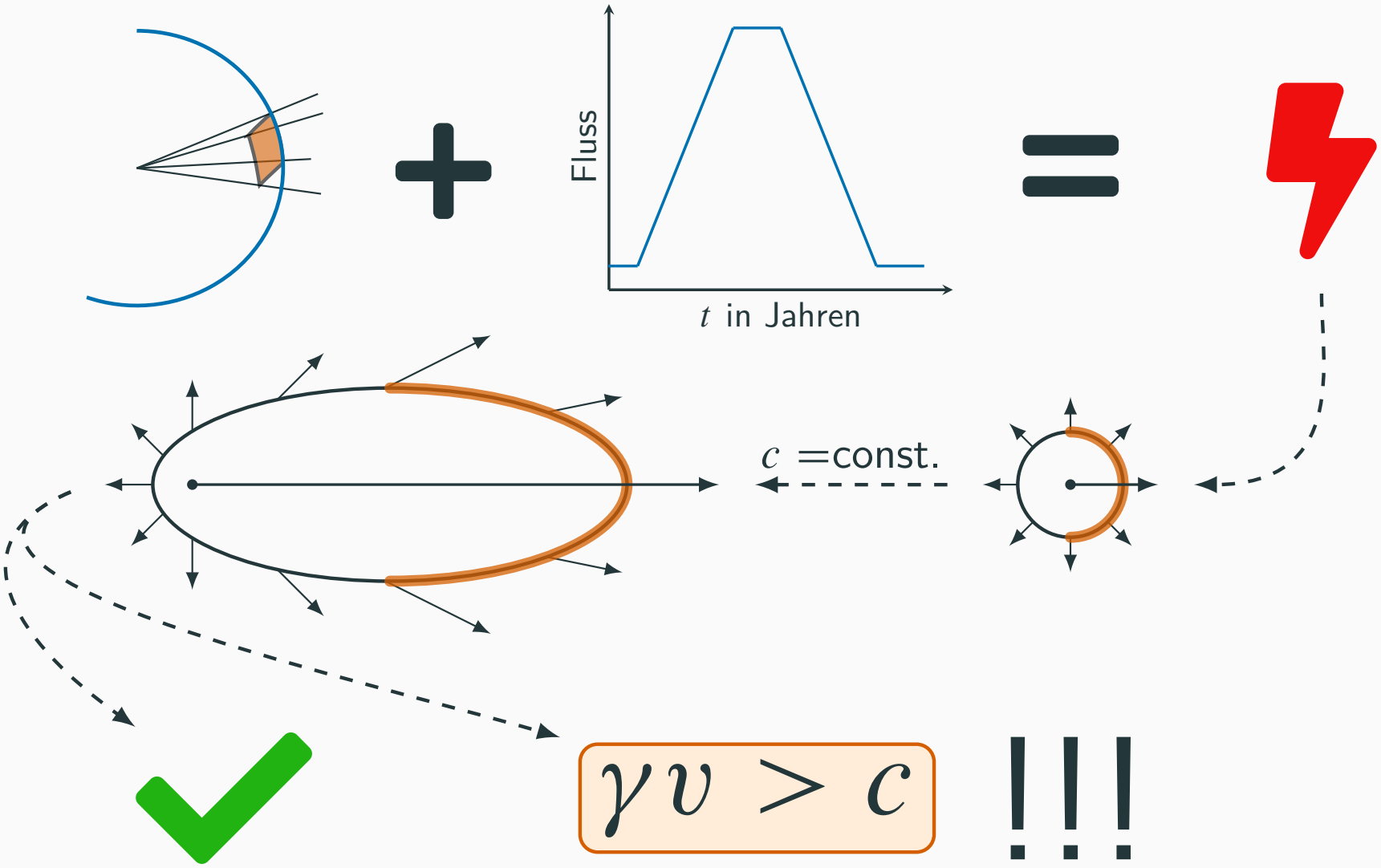


Recap

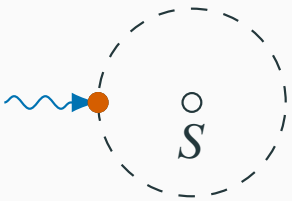


Fragen?

Relativistische Expansion

$\beta = 0.835, \ \gamma = 1.82$

$t = 0$

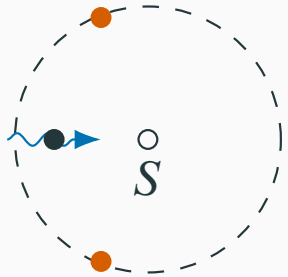


to O

Relativistische Expansion

$\beta = 0.835,\ \gamma = 1.82$

$t = 0.25$

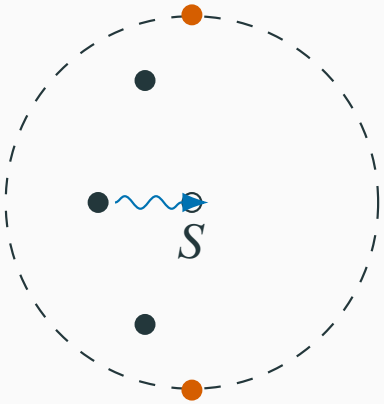


to O

Relativistische Expansion

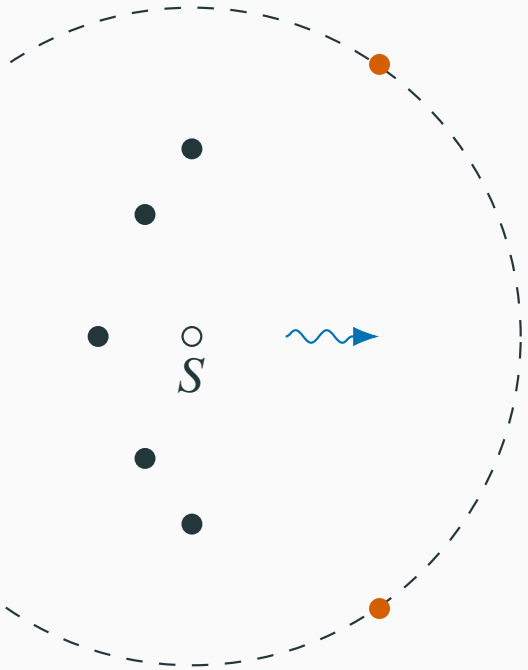
$\beta = 0.835, \ \gamma = 1.82$

$t = 0.59$



to O

Relativistische Expansion

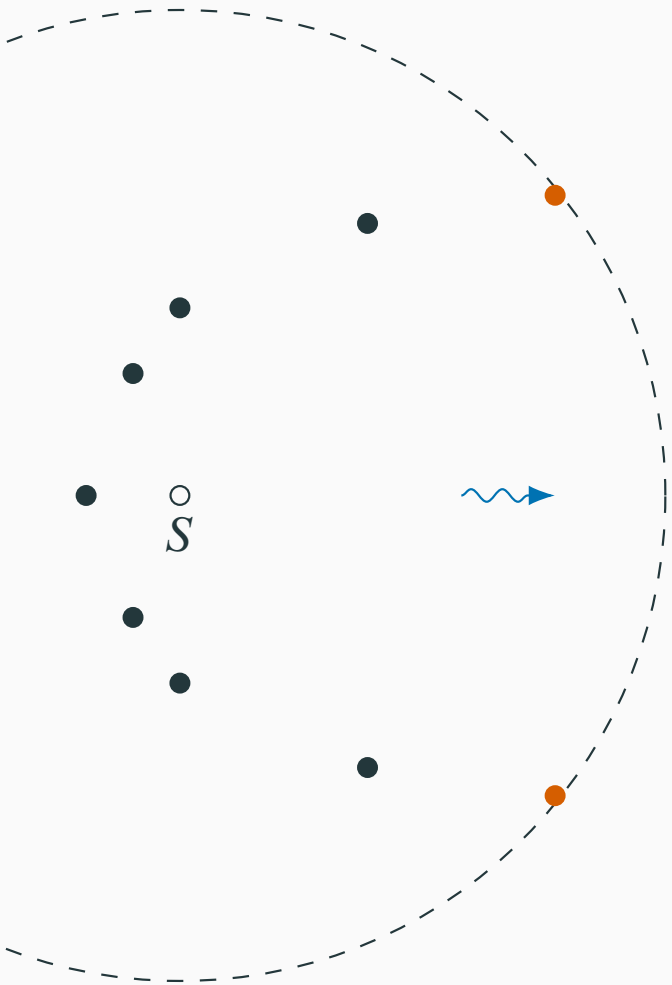


$\beta = 0.835, \ \gamma = 1.82$

$t = 1.5$

to O

Relativistische Expansion

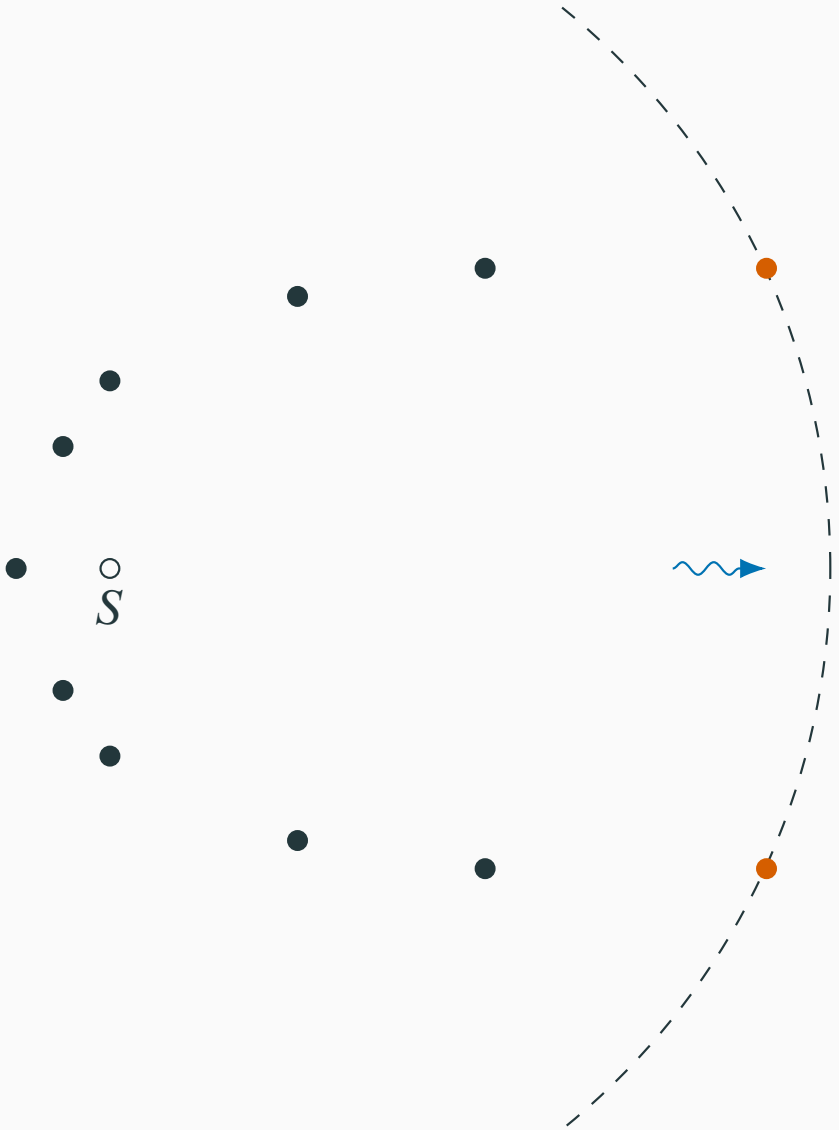


$\beta = 0.835, \ \gamma = 1.82$

$t = 2.5$

to O

Relativistische Expansion

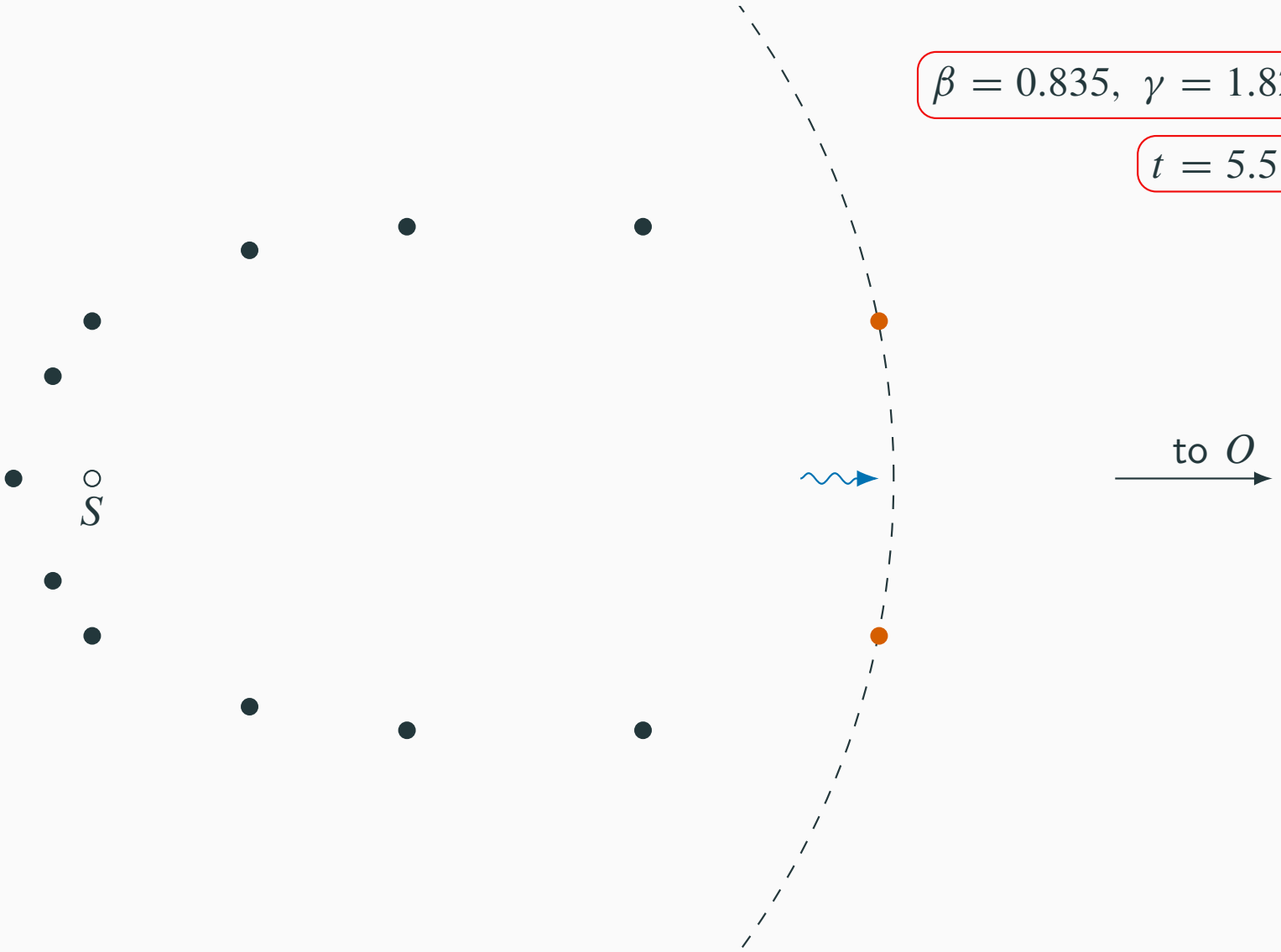


$\beta = 0.835,\ \gamma = 1.82$

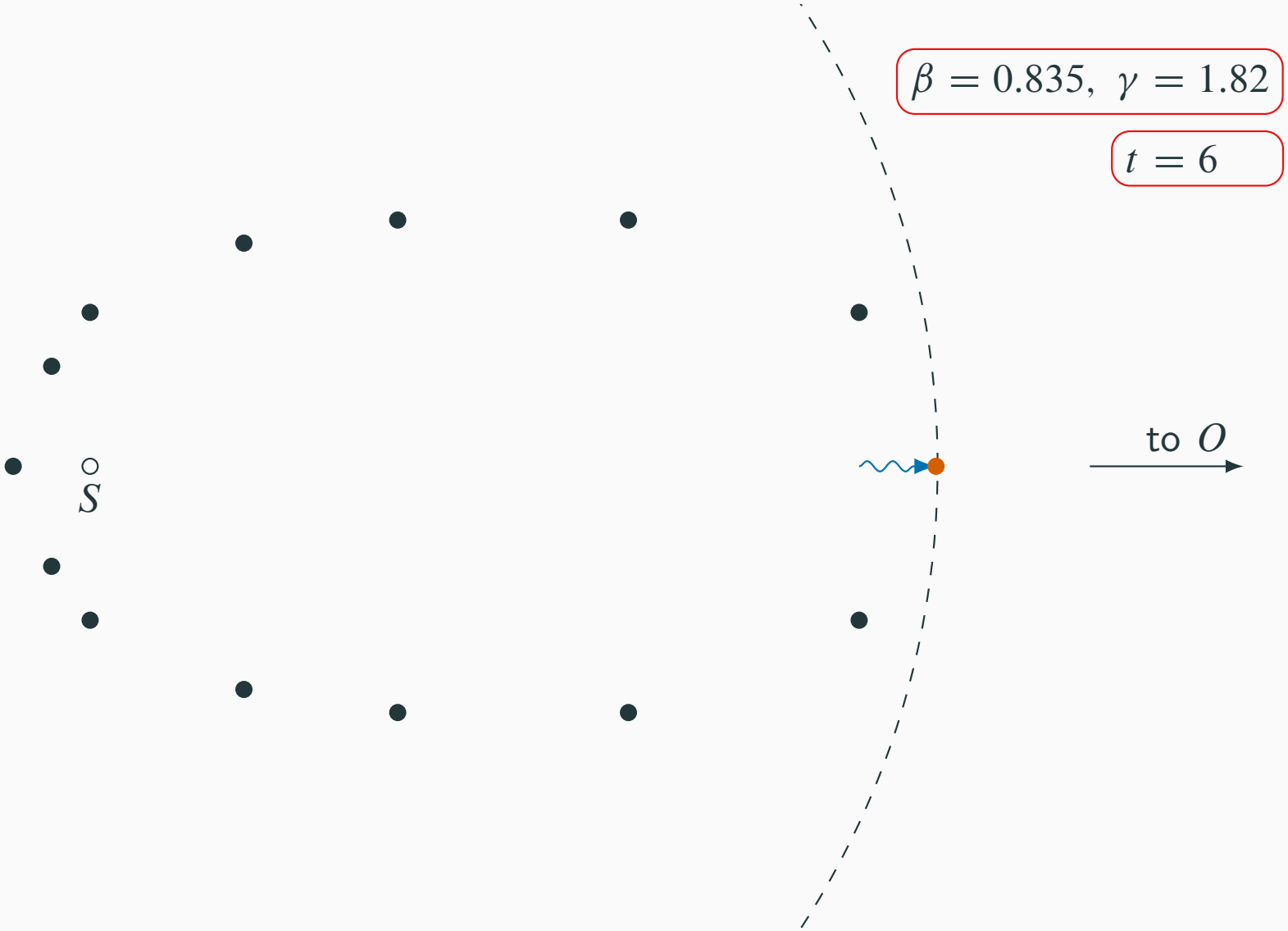
$t = 4$

to O

Relativistische Expansion



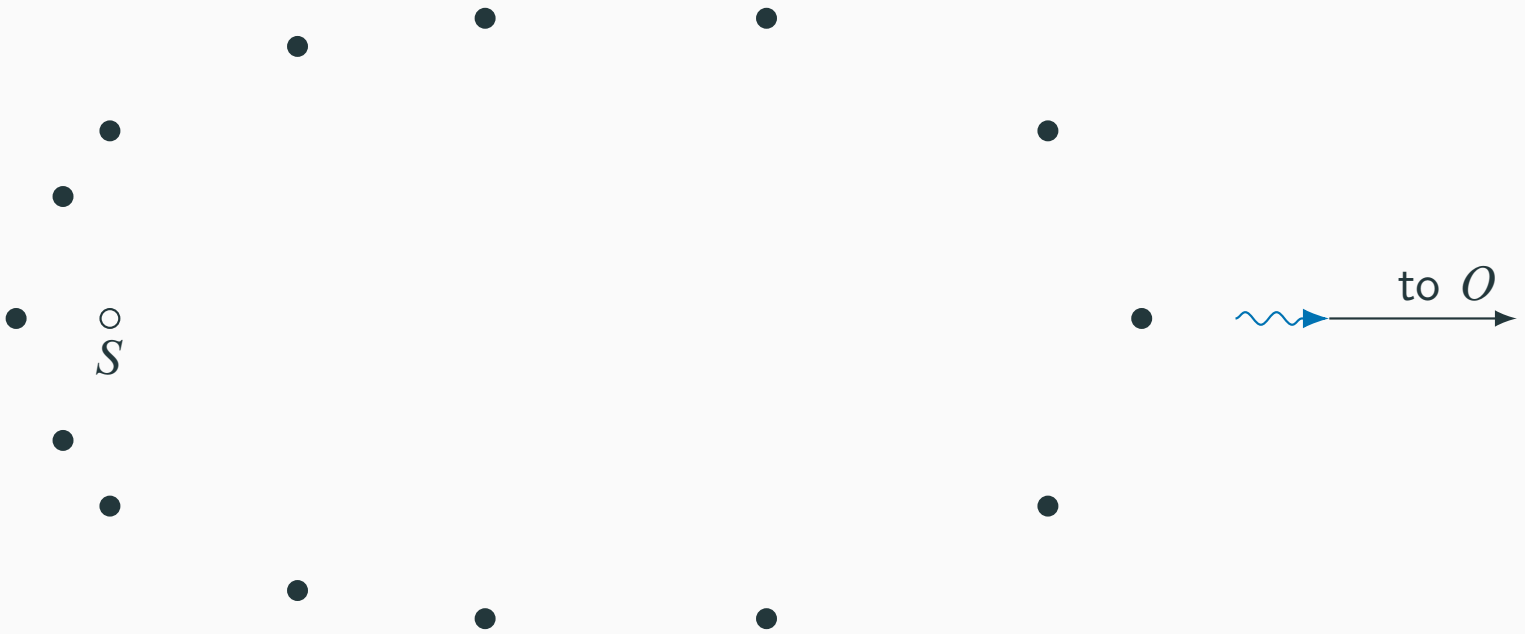
Relativistische Expansion



Relativistische Expansion

$\beta = 0.835,\ \gamma = 1.82$

$t > 6$



Literatur

[1] T. A. Matthews, W. W. Morgan und M. Schmidt. **„A Discussion of Galaxies Indentified with Radio Sources.“.** In: *Astrophysical Journal, vol. 140, p. 35* 140 (1964), S. 35.

[2] P. Maltby und A. T. Moffett. **„Spectrum of the Intensity Variations in 3C 273B“.** In: *Science* 150.3692 (1965), S. 63–64. ISSN: 00368075, 10959203. URL: http://www.jstor.org/stable/1717963 (besucht am 28. 12. 2023).

Sources ii

[3] S. Fernandes u. a. **„Multiwavelength analysis of the variability of the blazar 3C 273“.** In: *Monthly Notices of the Royal Astronomical Society* 497.2 (Juli 2020), S. 2066–2077. ISSN: 1365-2966. URL: http://dx.doi.org/10.1093/mnras/staa2013.

[4] M. Rees. **„Appearance of relativistically expanding radio sources“.** In: *Nature* 211.5048 (1966), S. 468–470.