

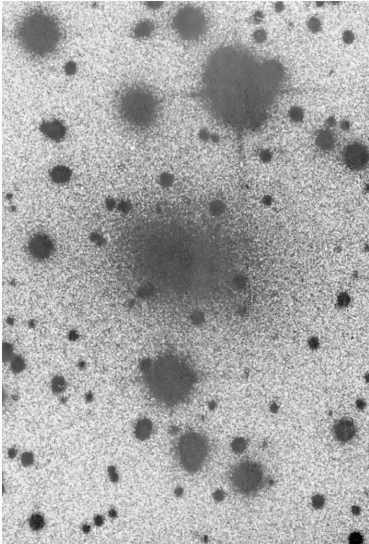
# relativistische Betrachtung von Bewegungen

---

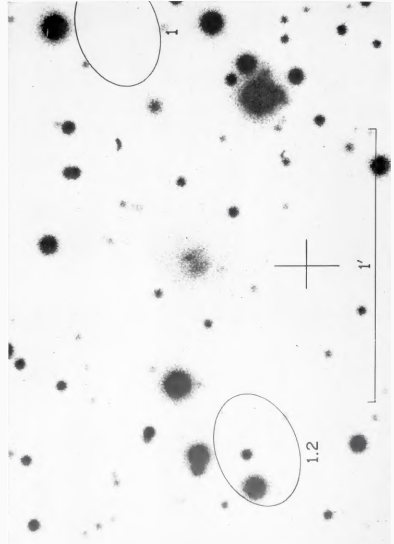
Alexander Helbok

19. Januar 2024

# Radiobeobachtungen

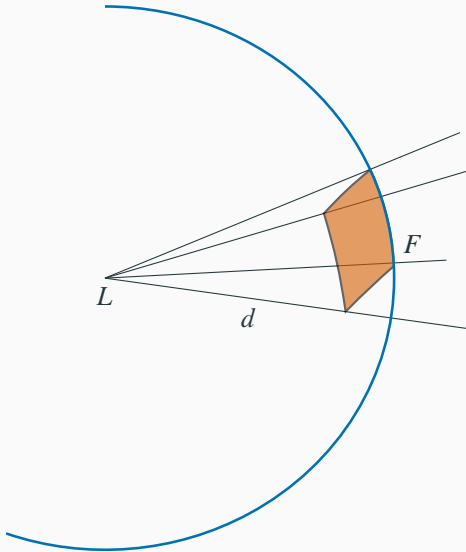


(Matthews, Morgan und Schmidt 1964)



(Matthews, Morgan und Schmidt 1964)

# Leuchtkraft von 3C 273



Entfernung über Rotverschiebung

$$(z = 0.158)$$



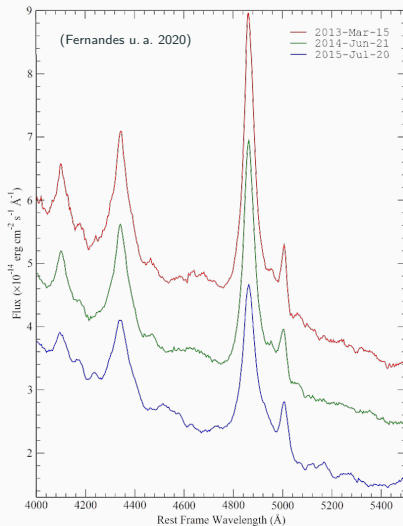
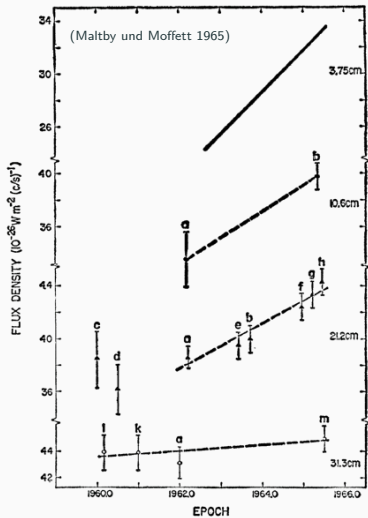
$$L = 4\pi d^2 F$$



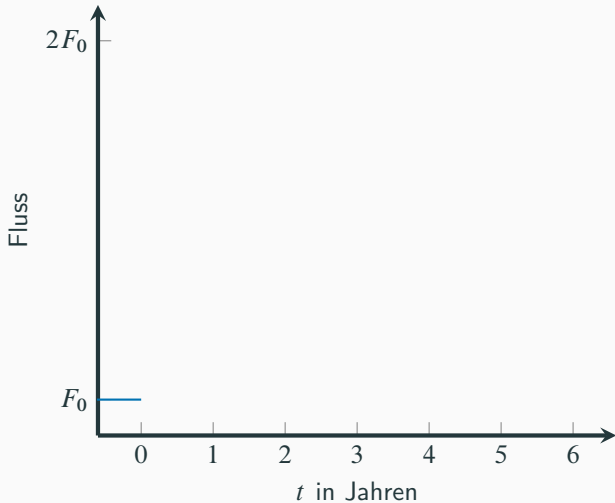
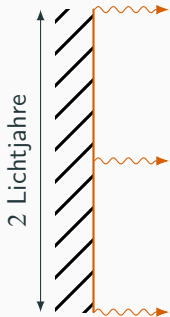
Flussmessung im Radiobereich

$\Rightarrow$  extrem Hell

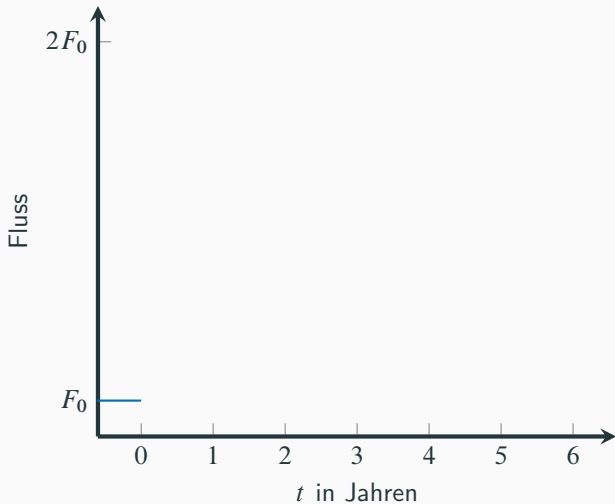
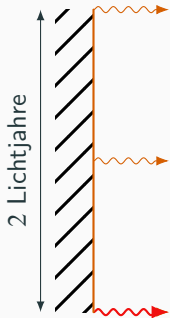
# Helligkeitsschwankungen in 3C 273



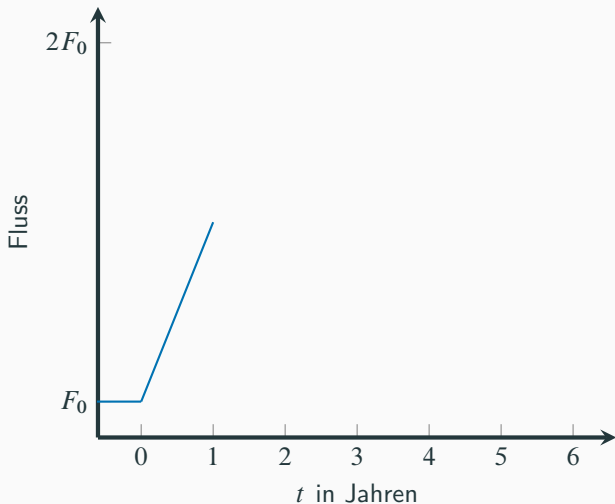
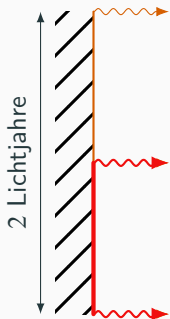
# Fluktuationen erklärt



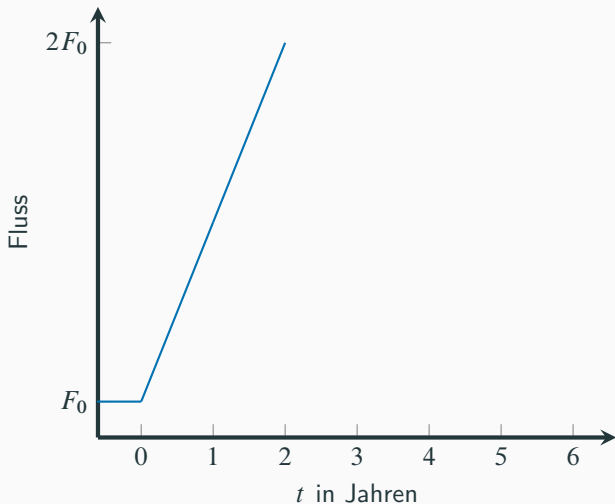
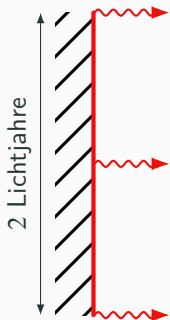
# Fluktuationen erklärt



# Fluktuationen erklärt

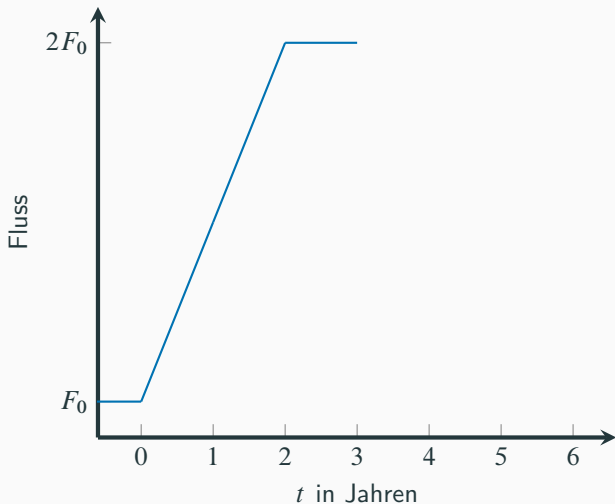
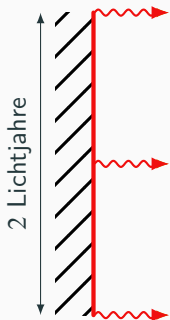


# Fluktuationen erklärt

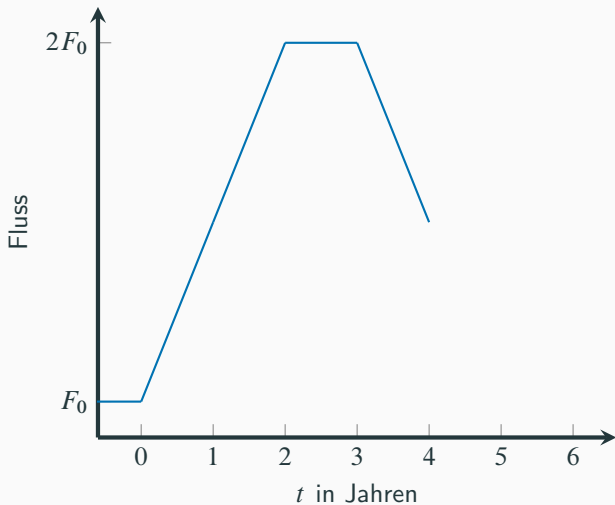
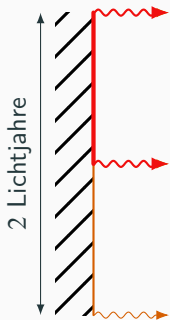




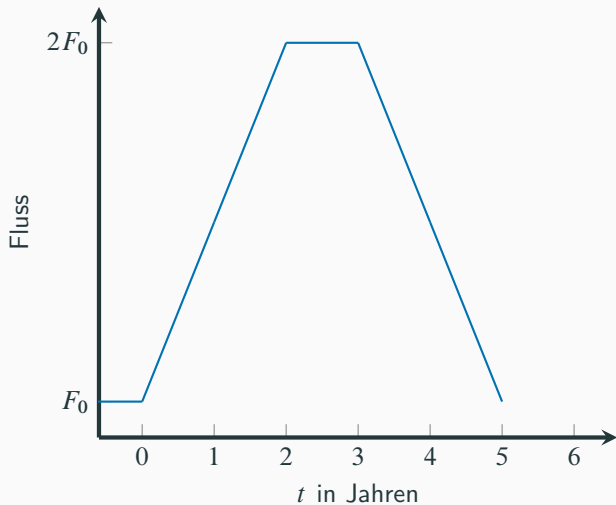
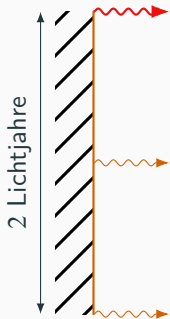
# Fluktuationen erklärt



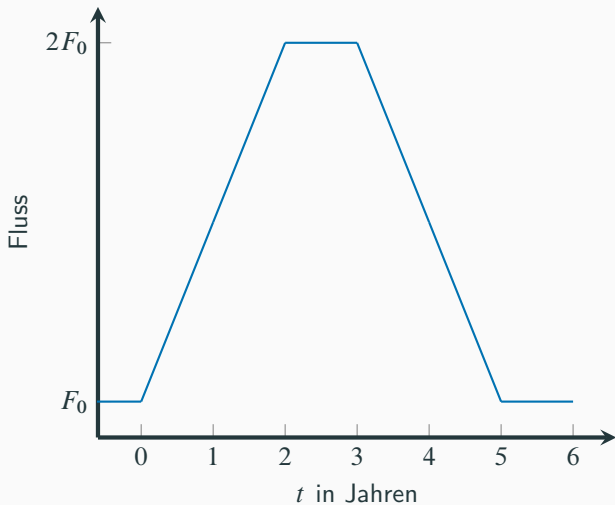
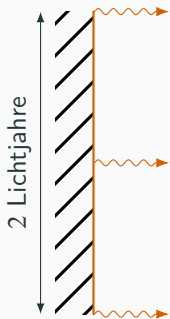
# Fluktuationen erklärt



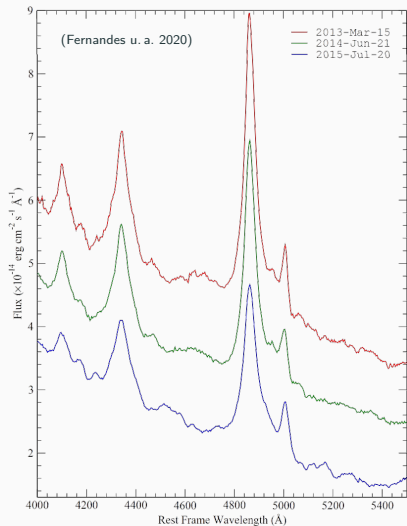
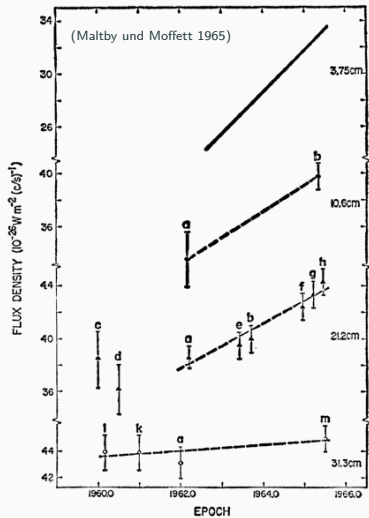
# Fluktuationen erklärt



# Fluktuationen erklärt



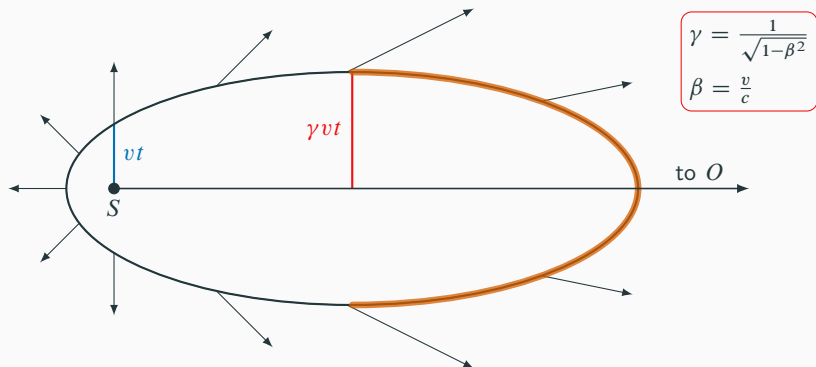
# Helligkeitsschwankungen in 3C 273



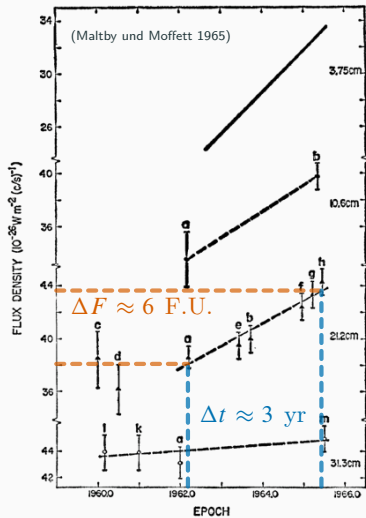
# sphärische Expansion $v \ll c$



# sphärische Expansion $v \sim c$

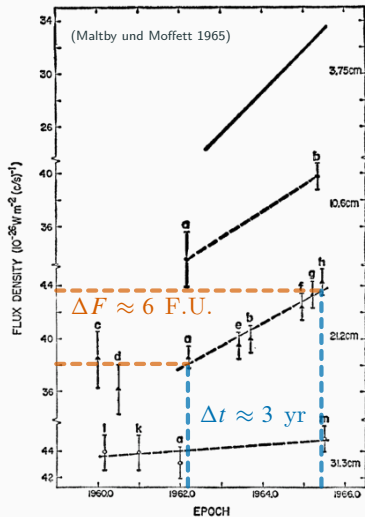


# Beobachtung





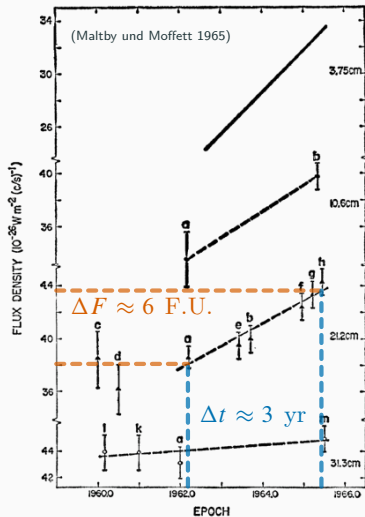
# Beobachtung



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

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

# Beobachtung

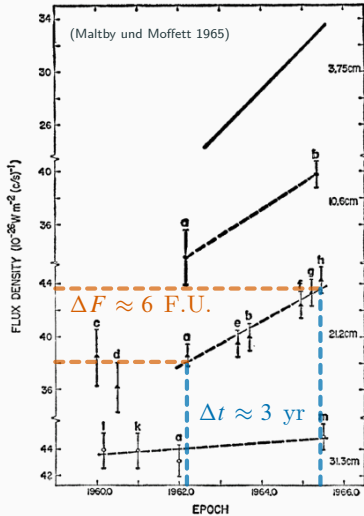


„Because the **observed intensity** of a source, for a given **surface brightness**, is proportional to the **apparent size**“ [4]

$$F = B \triangleleft \propto 2 \frac{\gamma v t}{R} \quad \frac{dF}{dt} = 2 \frac{\gamma v}{R} \propto \gamma$$

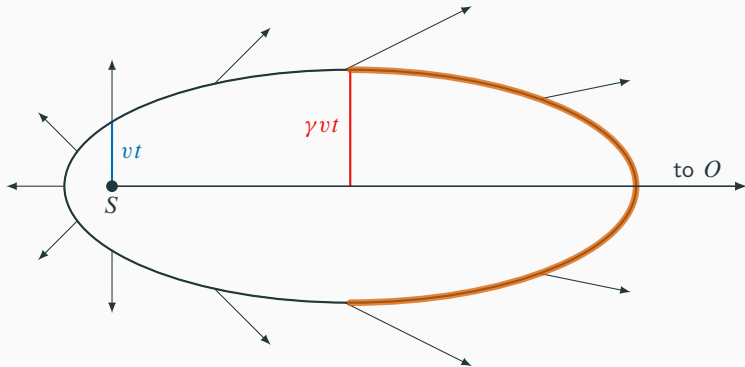
„it is already clear that an expanding source could exhibit a rate of increase of flux density high enough to explain the observations.“ [4]

# 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  $\sim 15 \text{ F.U.}$  in 3 years“ [4]

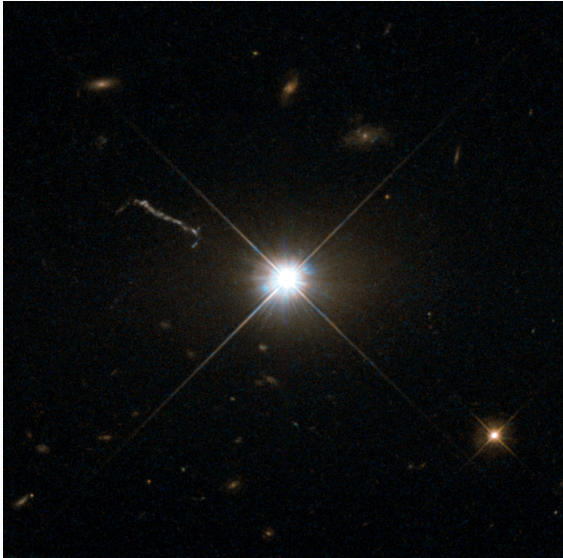
# Konsequenz



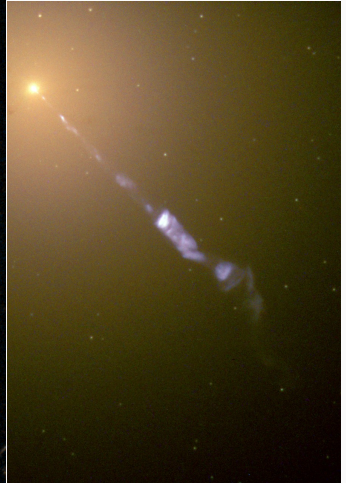
$$\beta = \frac{v}{c} \in [0; 1]$$

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

# Kosmische Jets

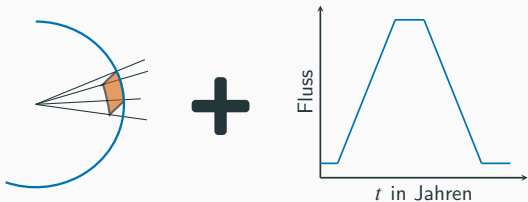


3C 273 © ESA/HUBBLE & NASA

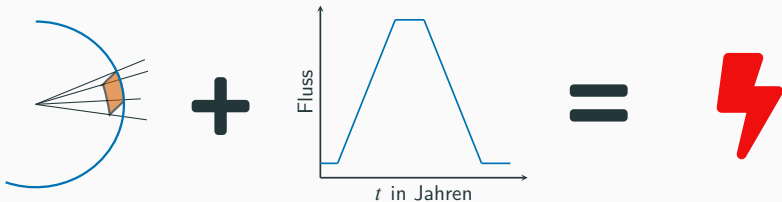


M87 © ESA/HUBBLE & NASA

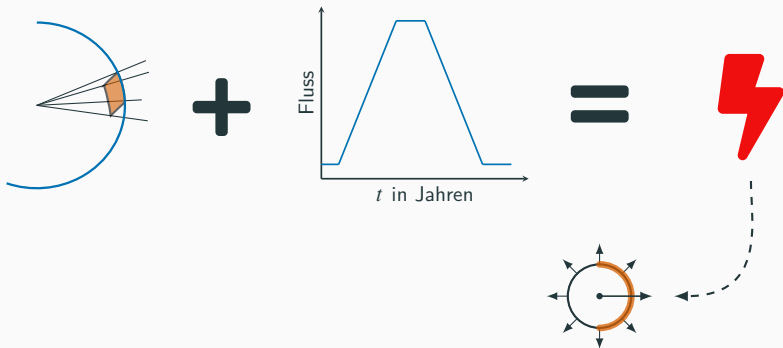
# Recap



# Recap

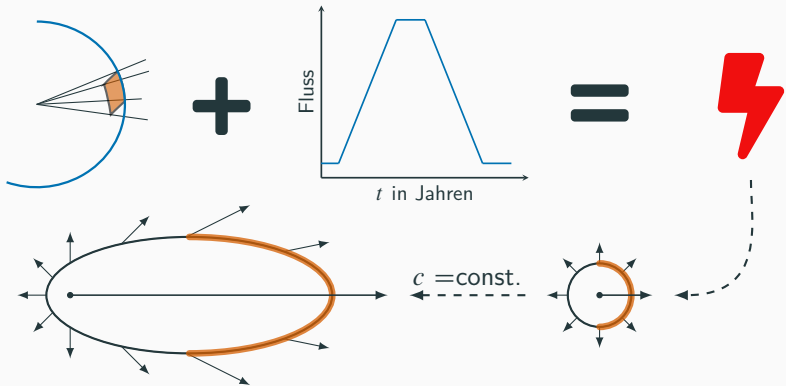


# Recap

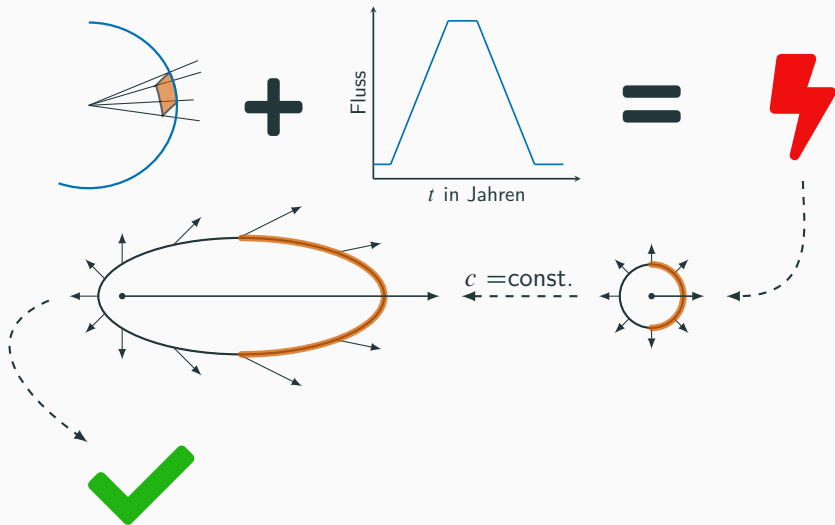




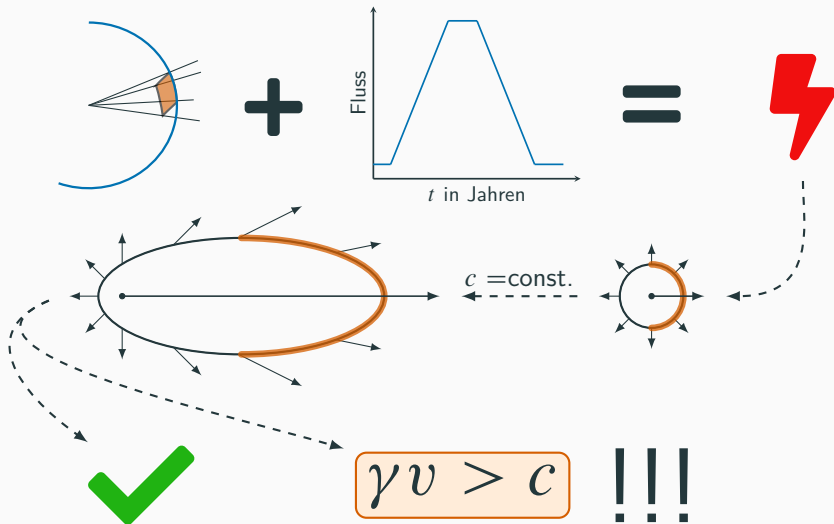
# Recap



# Recap



# Recap



**Fragen?**

# Relativistische Expansion

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

$$t = 0$$



to  $O$

A horizontal arrow pointing to the right, indicating the direction of observation or expansion.

# Relativistische Expansion

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

$$t = 0.25$$

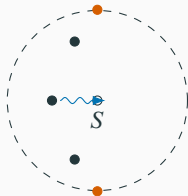


to  $O$


# Relativistische Expansion

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

$$t = 0.59$$



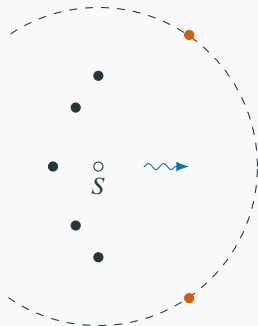
to  $O$



# Relativistische Expansion

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

$$t = 1.5$$



to  $O$



# Relativistische Expansion

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

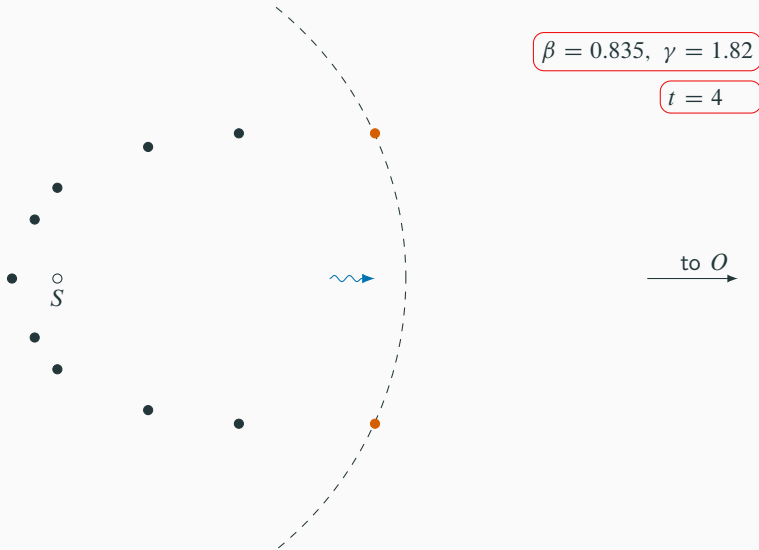
$$t = 2.5$$

to  $O$

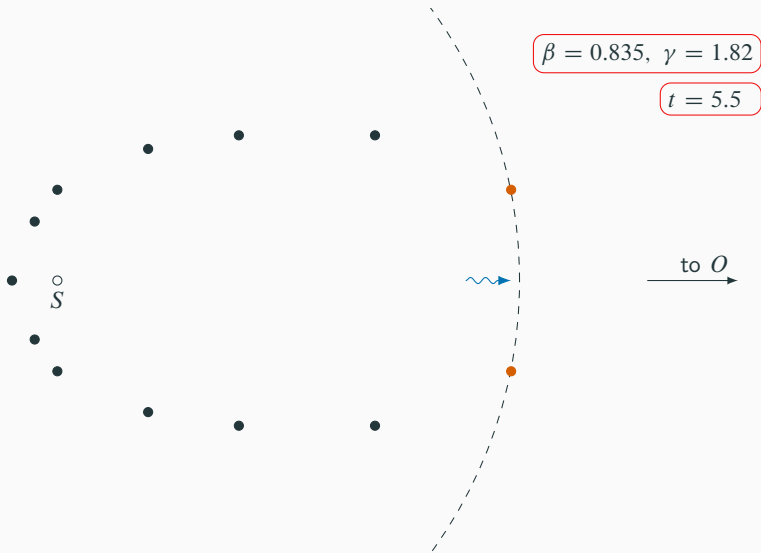


The diagram illustrates a relativistic expansion. A dashed circle represents the boundary of a region. Inside this circle, there are several black dots representing particles. A central point is labeled 'S' with a small circle above it. A blue wavy arrow points from the center towards the right edge of the circle. Two orange dots are located on the right side of the dashed circle, one near the top and one near the bottom. To the right of the circle, there is a horizontal arrow pointing to the right, labeled 'to O'.

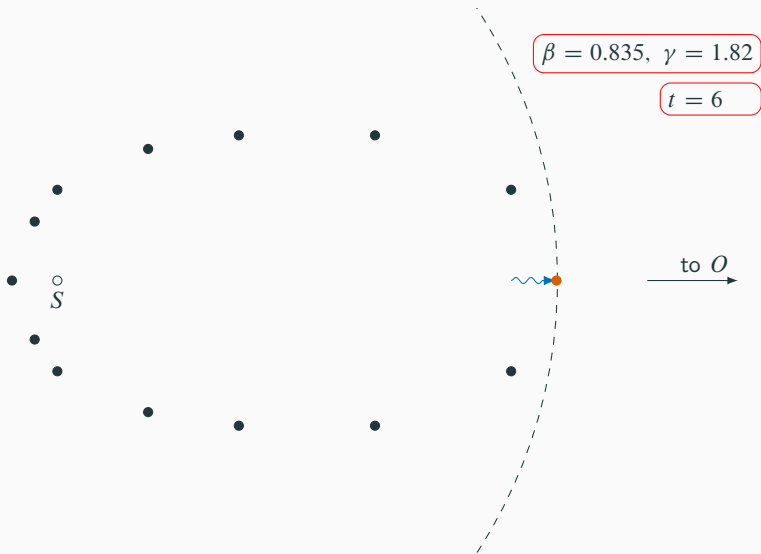
# Relativistische Expansion



# 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 Identified 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).

- [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.