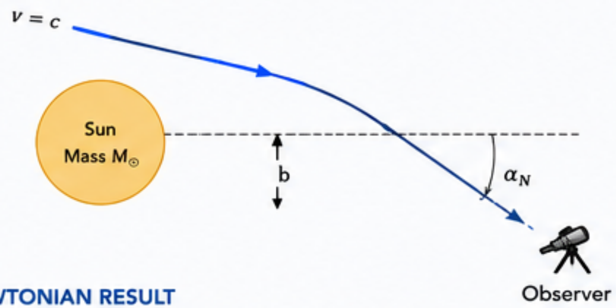
CALULATIONS OF LIGHT DEFLECTION BY THE SUN

Three theoretical results for the total deflection angle α of a light ray grazing the Sun ($b = R_\odot$)

1. NEWTONIAN CALCULATION (CORPUSCULAR LIGHT)

Light is treated as particles of speed c moving in the Newtonian gravitational field of the Sun.

GEOMETRY



NEWTONIAN RESULT

$$\boxed{\alpha_N = \frac{2GM_\odot}{c^2 b}}$$

For grazing incidence, $b = R_\odot$

$\alpha_N \approx 0.87$ arcseconds

DERIVATION SKETCH

Using inverse-square gravitational force and small-angle scattering of a particle passing the Sun with speed c.

$F = \dfrac{GM_\odot m}{r^2}$ → transverse impulse → deflection

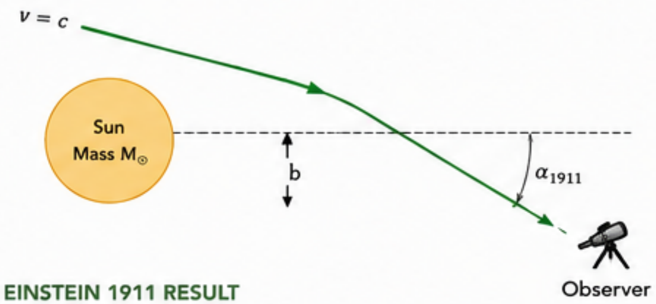
KEY ASSUMPTIONS

- Light is a stream of particles (corpuscles)
- Newtonian gravity: instantaneous action at a distance
- Space is Euclidean; time is absolute

2. EINSTEIN 1911 CALCULATION (EQUIVALENCE PRINCIPLE, *"ENTWURF"*)

Light is treated as an electromagnetic wave. Using the equivalence principle in a static gravitational field.

GEOMETRY



EINSTEIN 1911 RESULT

$$\boxed{\alpha_{1911} = \frac{2GM_\odot}{c^2 b}}$$

For grazing incidence, $b = R_\odot$

$\alpha_{1911} \approx 0.87$ arcseconds

METHOD (EQUIVALENCE PRINCIPLE)

In a uniform gravitational field g, a light ray in a medium of refractive index n experiences an apparent deflection equivalent to being in free fall.

This gives the same result as the Newtonian calculation:

$$\alpha_{1911} = \alpha_N$$

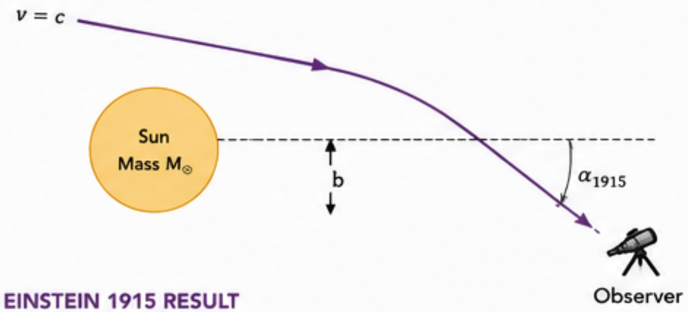
KEY ASSUMPTIONS

- Light is an electromagnetic wave
- Equivalence principle applied in the weak-field limit
- Space is Euclidean; gravitational field is static

3. EINSTEIN 1915 CALCULATION (GENERAL RELATIVITY)

Light follows null geodesics in curved space-time (predicted by General Relativity).

GEOMETRY



EINSTEIN 1915 RESULT

$$\boxed{\alpha_{1915} = \frac{4GM_\odot}{c^2 b}}$$

For grazing incidence, $b = R_\odot$

$\alpha_{1915} \approx 1.75$ arcseconds

METHOD (GENERAL RELATIVITY)

Solve the geodesic equation for light in the Schwarzschild metric (weak-field limit). The deflection comes from two contributions:

Curvature of space (spatial curvature)		Curvature of time (gravitational time dilation)
$\dfrac{2GM_\odot}{c^2 b}$	+	$\dfrac{2GM_\odot}{c^2 b}$

$$\text{Total:}\quad \alpha_{1915} = \frac{4GM_\odot}{c^2 b} = 2\,\alpha_N = 2\,\alpha_{1911}$$

KEY ASSUMPTIONS

- Light follows null geodesics in curved space-time
- Schwarzschild solution (spherically symmetric mass)
- Weak-field approximation (valid for Sun)

NUMERICAL COMPARISON (GRAZING THE SUN)

Theory	Formula for α ($b = R_\odot$)	Deflection
Newton (corpuscular)	$\frac{2GM_\odot}{c^2 R_\odot} \cdot c^2 R_\odot$	0.87 arcsec
Einstein 1911 (equivalence)	$\frac{2GM_\odot}{c^2 R_\odot} \cdot c^2 R_\odot$	0.87 arcsec
Einstein 1915 (GR)	$\frac{4GM_\odot}{c^2 R_\odot} \cdot c^2 R_\odot$	1.75 arcsec

CONSTANTS USED

$G = 6.67430 \times 10^{-11}\ \mathrm{m^3\ kg^{-1}\ s^{-2}}$

$M_\odot = 1.9885 \times 10^{30}$ kg

$R_\odot = 6.957 \times 10^{8}$ m

$c = 2.99792458 \times 10^{8}\ \mathrm{m\ s^{-1}}$

1 arcsec $= 4.84813681 \times 10^{-6}$ rad

HISTORICAL NOTE

The 1919 solar eclipse expeditions measured a deflection of about 1.6–1.98 arcseconds, consistent with the Einstein 1915 prediction (within experimental uncertainty), thereby providing the first observational confirmation of General Relativity.