Rough Estimate of Photon Mass from Light Deflection

(Note 151(1))

The gravitational metric is accepted for the sake of argument. Any other valid metric may be used. Thus:

$$\Delta\phi = \int_{R_0}^{\infty} \frac{1}{r^2}\left(\frac{1}{b^2} - \left(1 - \frac{r_0}{r}\right)\left(\frac{1}{a^2} + \frac{1}{r^2}\right)\right)^{-1/2} dr \quad -(1)$$

where $a = \frac{L}{mc}$, $b = \frac{cL}{E}$, $\quad -(2)$

$$L = mr^2 \frac{d\phi}{d\tau} = \text{constant}. \quad -(3)$$

Assume that the energy E for one photon is:

$$E = \hbar\omega \quad -(4)$$

so

$$a = \left(\frac{E}{mc^2}\right) b = \left(\frac{\hbar\omega}{mc^2}\right) b \quad -(5)$$

In the first approximation:

$$L = mr^2 \frac{d\phi}{dt} = mr^2\omega \quad -(6)$$

and

$$\omega = \frac{v}{r} \quad -(7)$$

If the photon is travelling close to c, then:

$$\omega = \frac{c}{r} \quad -(8)$$

is a rough first approximation.

2) So: $L \sim mrc$ — (9)

and $a = r$ — (10)

Assume $r = R_\odot = 6.955 \times 10^{8}$ metres — (11)

$= $ radius of sun

so $\boxed{a = 6.955 \times 10^{8} \text{ metres.}}$ — (12)

Therefore $b = \left(\frac{c^2 R_\odot}{\hbar \omega} \right) m$ — (13)

Assume that light of visible frequency has:

$\omega \sim 10^{16}$ radians s^{-1} — (14)

so $\boxed{b \sim 5.93 \times 10^{43}\, m}$ — (15)

The photon mass m may be found from the observed deflection $\Delta \phi$ using eqns (1), (12) and (15).