

# Astrophysical Thinking SS 2018

hand in April 19

## Question 7: Strong gravitational lensing and the Hubble constant

- No need to look up any text books! No need to type your answers!

The quasar 0957+561 at  $z = 1.4$  is strongly lensed by a foreground galaxy at  $z = 0.4$  resulting in two images (A and B). Image A is offset from the foreground galaxy by  $\sim 5$  arcseconds, while image B is offset by  $\sim 1$  arcseconds. **Which of the two images is the one that is more strongly deflected?**

Flux variations seen in image A are replicated 420 days later in image B indicating a significant time delay. **Use this information to estimate the Hubble constant!** What is the mass of the foreground galaxy?

Hint: Start from the Schwarzschild metric

$$ds^2 = \left( c^2 - \frac{2MG}{r} \right) dt^2 - \left( 1 - \frac{2MG}{rc^2} \right)^{-1} dr^2 - r^2 d\Omega^2$$

and estimate both the time delay and the spatial deflection of light in this metric (approximation is okay).