# PHY-765 SS19: Gravitational Lensing. Worksheet Week 5

## 1 Poster presentations

The main task of this week is presenting your prepared posters. Presentations will be ∼4 minutes plus a few questions from the audience.

## 2 The Lens Mass of The First Lens Discovered

The lens shown in Figure 1 was the first lens discovered (Walsh, Carswell & Wemann, 1979). The following exercise offers the opportunity to estimate the mass of the galaxy (system) lensing the background quasar. As shown in Figure 1 the two images of the background quasar ('A' and 'B') are roughly $6\farcs0$ apart. The source quasar is at redshift 1.41 and the lens galaxy, labelled 'G1' in Figure 1, is at redshift 0.36.

### 2.1

From the relative position of the QSO images estimate the Einstein radius for the Twin Quasar.

### 2.2

Use the Einstein radius to obtain an estimate of the mass of the lens galaxy, assuming a point mass lens.

### 2.3

Is this a large or small lensing mass for the single galaxy G1?

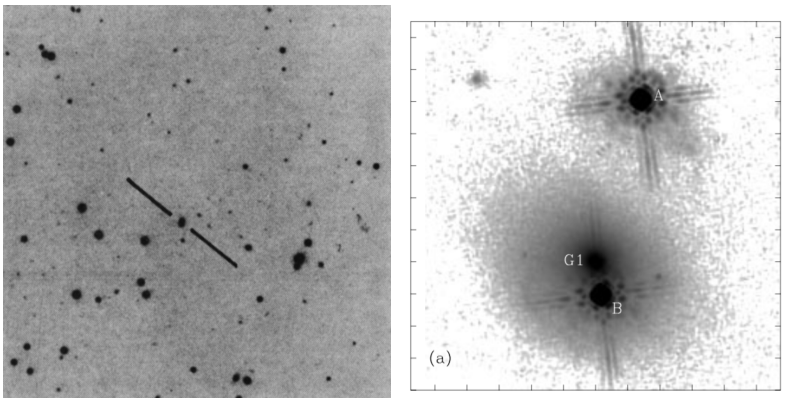


Figure 1: The first gravitational lens discovered: "the Twin Quasar" QSO 0957+561. The left panel shows the original finding chart from Walsh, Carswell & Wemann (1979), whereas the right panel presents a $\sim 12 \times 12$ arcsec zoom-in from Keeton et al. (2000).

# 3 The size of the Einstein radii for IS and CIS lenses

## 3.1

For an Isothermal Sphere (IS) lens assume that the lensed source is much further behind the lens, than the lens is from the observer. What is then the size of the Einstein radius (in arc seconds) if the lens is 1) a galaxy and 2) a galaxy cluster?

## 3.2

What would the Einstein radii be for the galaxy and galaxy cluster lenses if they were modeled as Cored Isothermal Spheres (CIS) with core sizes of 1 and 10 arc seconds, respectively?

## 3.3

What is the size of the Einstein radius for the CIS lenses if the core radii are instead 2 and 20 arc seconds for the galaxy and galaxy cluster lens, respectively?

## 3.4

For a standard cosmological model with $H_0$=70, $\Omega_m = 0.3$ and $\Omega_\Lambda = 0.7$, how large is a core of 1 arc second on the sky in kpc at $z = 0.22$ and $z = 0.54$? Hint: use Ned Wright's cosmological calculator.

# 4 Multiple images of SN Refsdal

Having seen the spectacular lens geometry of SN Refsdal in this week's slides, how does the results from exercise 2.5 on the worksheet from Week 3 compare to this?