PHY-765 SS19: Gravitational Lensing. Worksheet Week 12

1 Give presentation on topic selected week 10 (second half of presentations)

In week 10's exercise 1 you prepared a scientific presentation on a topic of your choosing. As the first exercise of this week, the second half of the class will present their 8+2 minutes prepared talks to the rest of the group.

2 Weak lensing and ellipticity.

In this week's slides it was shown that for the simplified case where $\kappa = \gamma_2 = 0$ and γ_1 is different from 0 but small the components of the Jacobian matrix added in quadrature is the functional form of an ellipse, describing the shearing of a circular image.

2.1

For the case where $\kappa = \gamma_1 = 0$ and γ_2 is different from 0 (but small) show that a similar expression is obtained, namely

$$1 = \frac{(\theta_1 - \gamma_2\theta_2)^2}{\beta_0^2} + \frac{(\theta_2 - \gamma_2\theta_1)^2}{\beta_0^2} \tag{1}$$

3 The ellipticity expressed from the Jacobian matrix

In this week's slides the Jacobian matrix was used to relate the ellipticity of galaxies to the gravitational potential through the convergence (κ) and the shear (γ)

3.1

From the definition of the Jacobian matrix

$$\mathcal{A}(\boldsymbol{\theta}) = (\delta_{ij} - \boldsymbol{\Psi}_{ij}) \quad \text{where} \quad \boldsymbol{\Psi}_{ij} \equiv \begin{pmatrix} \kappa + \gamma_1 & \gamma_2 \\ \gamma_2 & \kappa - \gamma_1 \end{pmatrix} \tag{2}$$

and δ_{ij} is the identity matrix, determine $\mathcal{A}^{-1}$.

3.2

Use the definition of $\mathcal{A}^{-1}$ to express the ellipticities defined in this week's slides in terms of κ and γ, showing that

$$\epsilon_i = \frac{2\gamma_i}{1-\kappa}\left[1 - \frac{\gamma^2}{(1-\kappa)^2}\right]^{-1} \tag{3}$$

for the distortion of a spherical object.

4 The characteristic sizes of lensed sheared galaxies

A key point of weak lensing studies, is to beat down the noise and uncertainties on the shape measurements by considering large samples of galaxies. To obtain these large samples (at high redshift) deep observations in large fields of view are desirable. Pushing to higher depths and to the limits of the observations (to detect as many galaxies as possible) requires detection of shapes on small noisy galaxies.

4.1

Estimate the angular size of a galaxy with half-light radius $\sim$10 kpc, if that galaxy was observed to be at redshift 0.05, 0.35, 1.5 and 8.0.

4.2

How do these angular sizes compare to the size of the seeing disk and/or the full width at half max (FWHM) of the point spread function for standard ground and space-based observations?