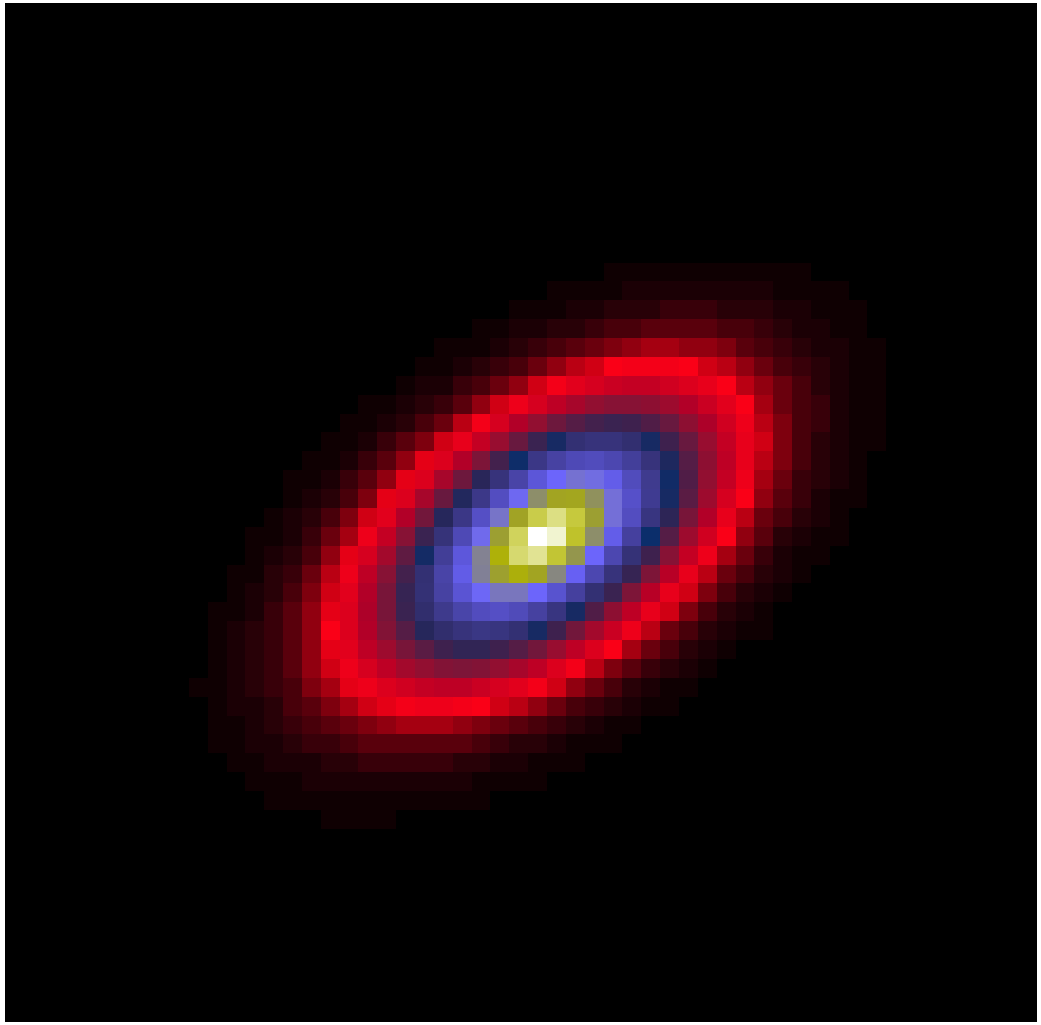
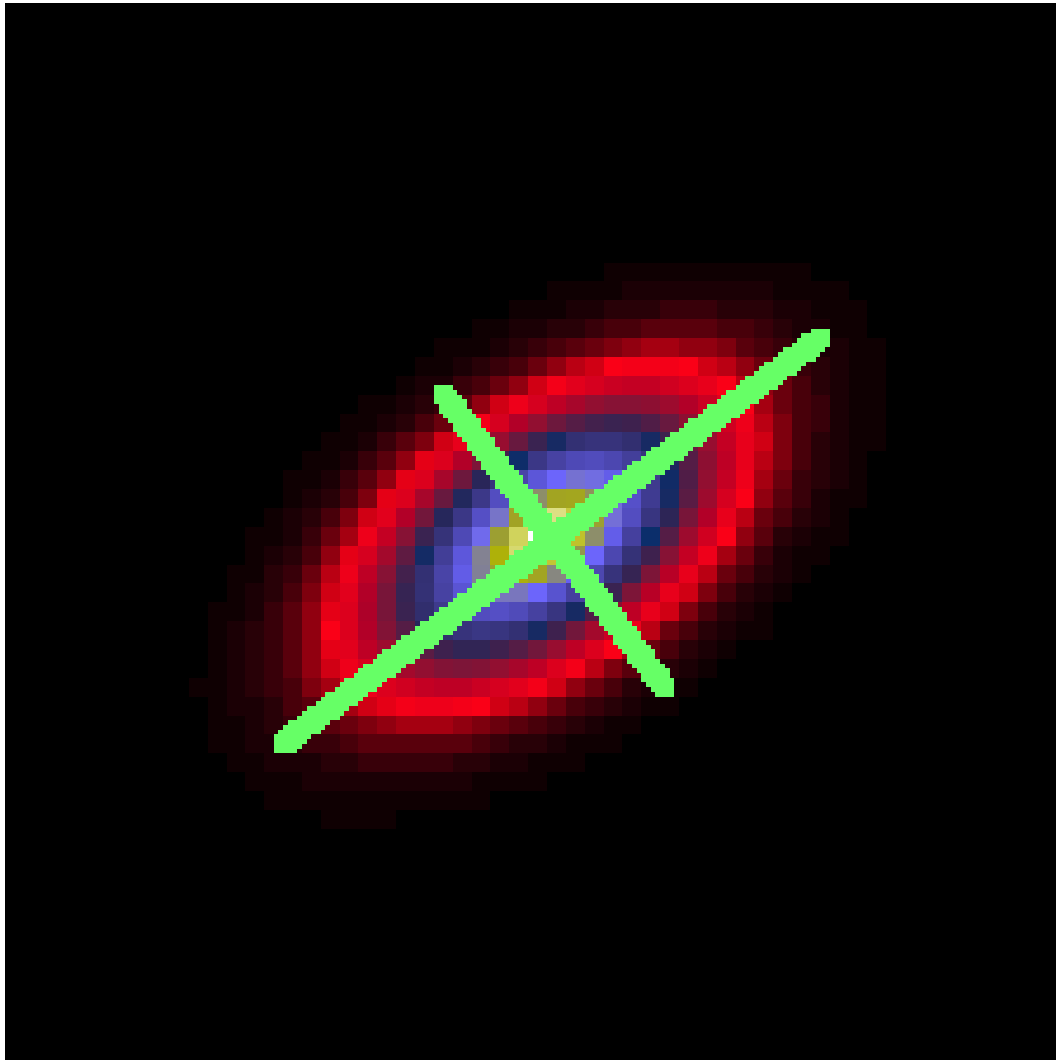
Measuring galaxy shapes
Elliptical isophotes



Measuring galaxy shapes
Elliptical isophotes



Measuring galaxy shapes
Galaxies

Figure: Courtesy: R Mandelbaum, Cosmo21, 2018

Measuring galaxy shapes
Moment-based methods

A common way of defining a (complex) ellipticity of a galaxy image uses the quadrupole moments

$$Q_{ij} = \frac{\int \mathrm{d}^2x\,(x_i - X_{0,i})\,(x_j - X_{0,j})\,I(\boldsymbol{x})}{\int \mathrm{d}^2x\,I(\boldsymbol{x})} \tag{1}$$

of $I(\boldsymbol{x})$ relative to a centroid position

$$\boldsymbol{X}_0 = \frac{\int \mathrm{d}^2x\,\boldsymbol{x}\,I(\boldsymbol{x})}{\int \mathrm{d}^2x\,I(\boldsymbol{x})} \tag{2}$$

$$e := \frac{Q_{22} - Q_{11} + iQ_{12}}{Q_{22} + Q_{11}}$$

is then an unbiased estimator of “ellipticity” (Schneidez & Seitz 1994)

Measuring galaxy shapes in real life
Moment-based methods & noise

- Think $Q_{11} := \sum_p I_p x_p^2$, $Q_{12} := \sum_p I_p x_p y_p$ etc.
- Very non-convergent in presence of noise! Need to apply a window function:

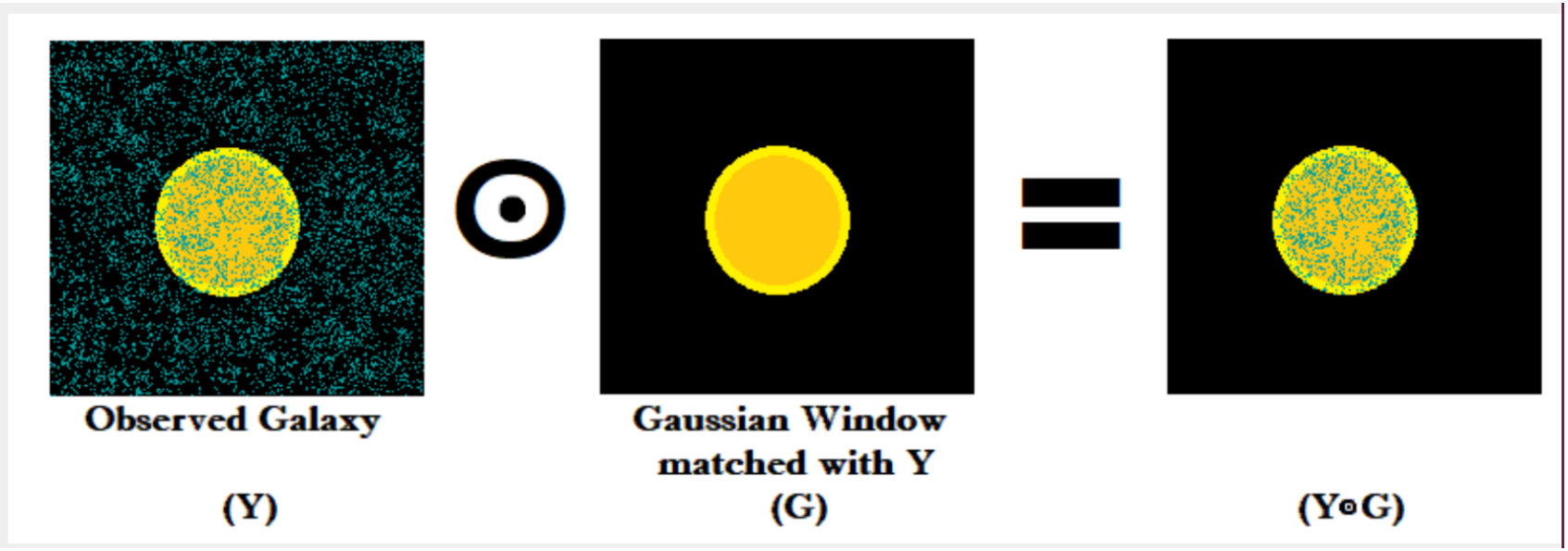


Figure: Courtesy: F Nammour

Measuring galaxy shapes in real life
Moment-based methods, noise & PSF

- “HSM” (or adaptive moments, Hirata & Seljak 2003, Mandelbaum et al 2004): match the gaussian window to the object
- Handling the PSF: Kaiser, Squires & Broadhurst 1995 (KSB!), etc.

Measuring galaxy shapes in real life
Model-fitting

Alternatives to moment-based methods:

- Model-fitting: assume (an) analytical profile(s) for your galaxies $\tilde{I}(r, \theta)$, convolve it with the PSF, find the best θ (which includes ellipticity)
- Honorable mention: G Bernstein's bayesian, unbiased estimator of shear (not ellipticity)

Today's paper!

Simon & Schneider, 2017

- 2.1: “GLAM": generalized adaptive moments
- 2.2: Why GLAM - recovers true ellipticity with elliptical isophotes
- 2.3: Why GLAM - unbiased estimator of reduced shear
- 2.4: Real life: pixellation and PSF -> model bias (aka “underfitting bias”)
- 3.1: The need for a Bayesian analysis
- (3.2: Real life: noise and model bias)
- 3.3: Prior bias
- 4: Empirical experiments:
  - 4.1-4.3: set up
  - 4.4 Ellipticity posterior sampling (MC)
  - 4.5 From ellipticity to shear posterior

Today's paper!
Who's who again?

- $I := I_{\text{post}} + \delta I = L I_{\text{pre}} + \delta I$
- $R_{\text{pre}} = I_{\text{pre}} - A f_{\rho}$