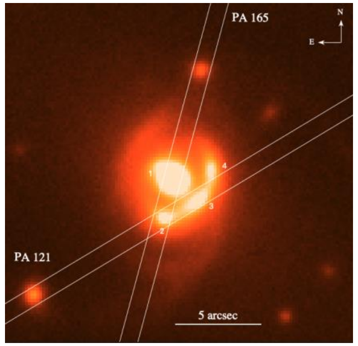
SuGOHI! Dissecting a strong lensing interacting galaxy system



COSMO-22

João Paulo Correia de França

Advisor: Martin Makler

Brazilian Center for Research in Physics (CBPF)

Contributors: Ingrid Beloto, Eduardo Cypriano, Thiago Gonçalves, Damián Mast, Renan Oliveira, Fernanda Araujo, Grasiele Bezerra, Juan Caso, Clécio De Bom, Cristina Furlanetto, Elizabeth Gonzalez, Carlos Melo, Karín Menéndez-Delmestre, Gabriel Oio, Davi Rodrigues, Luidhy Silva, Eduardo Valadão & Anibal Varela

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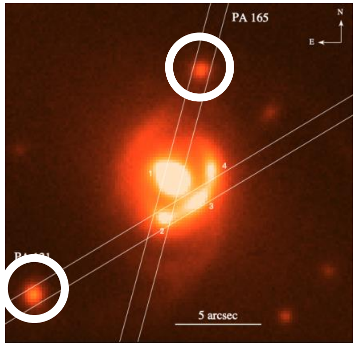

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/sugoi/

すごい ≅ Amazing!

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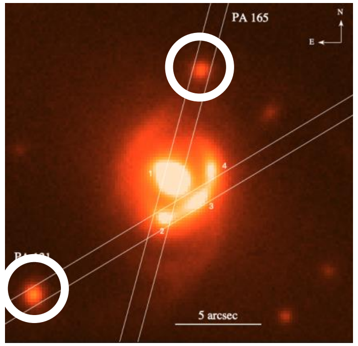

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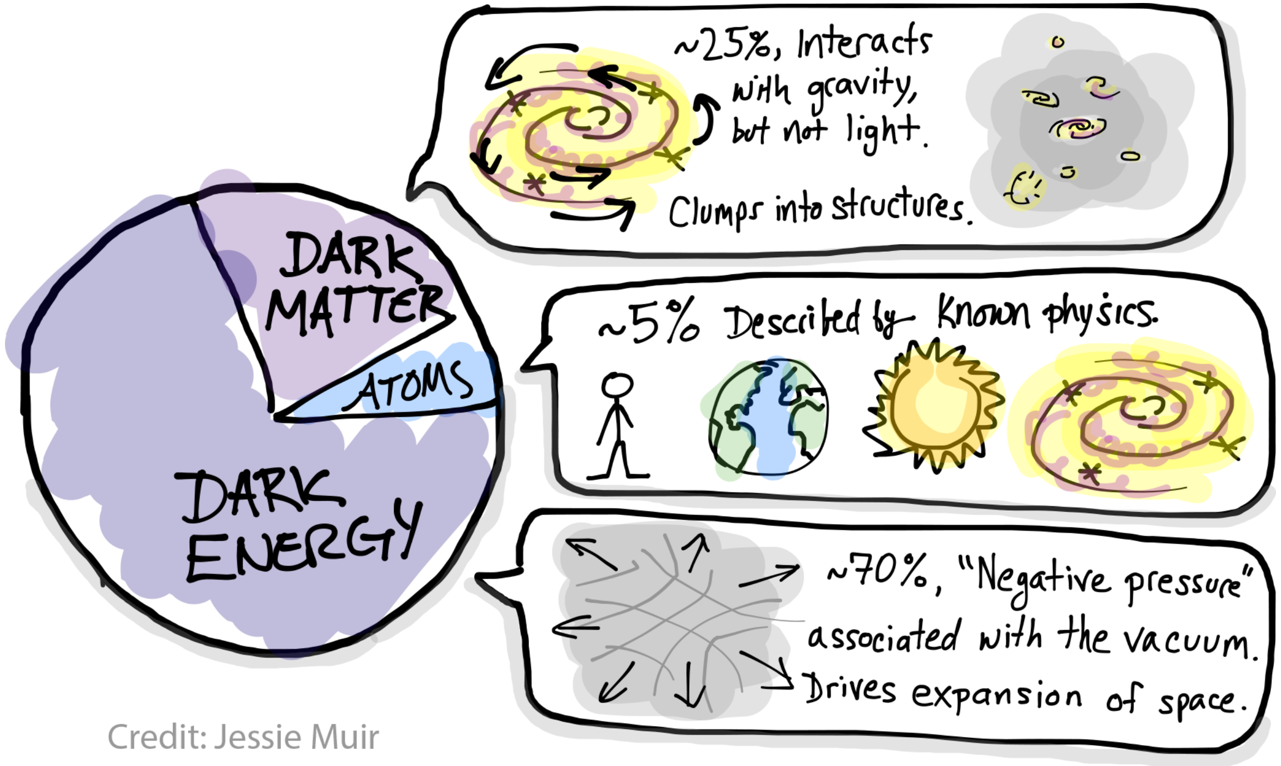
Outline

- ➢Our current understanding of the universe
- ➢Follow-up proposals
- ➢Preliminary results
- ➢Summary and future work

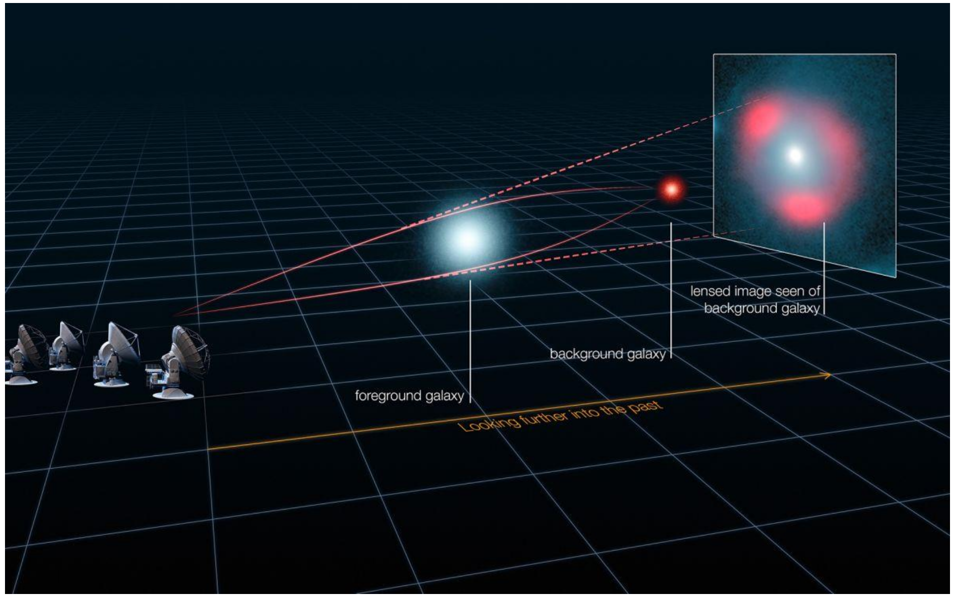
Our current understanding of the universe

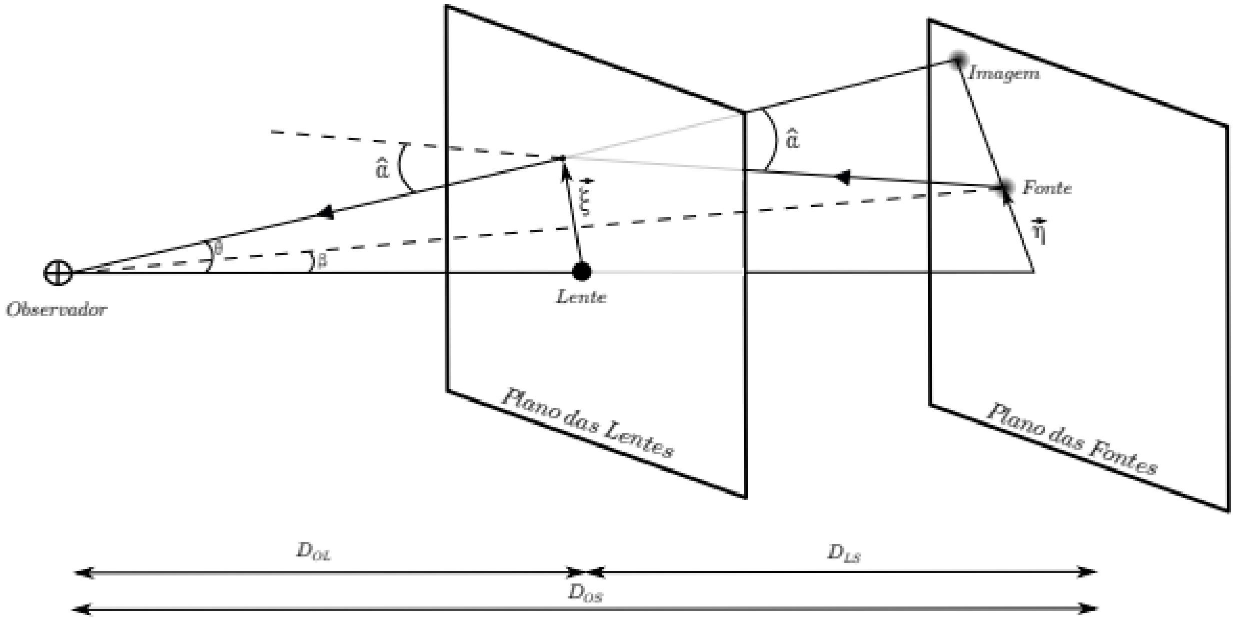


Credit: Jessie Muir

jessiemuir.com

Gravitational Lensing as a tool





Eduardo V. (2022)

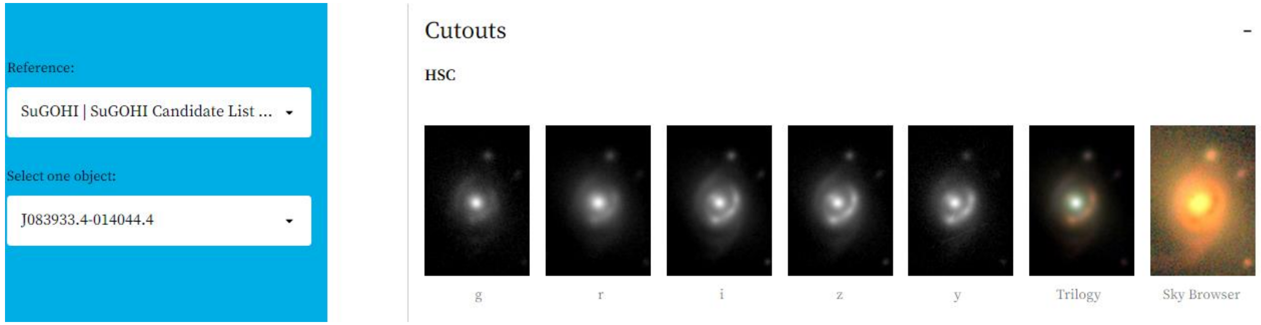
$$\boldsymbol{\beta} = \boldsymbol{\theta} - \frac{D_{LS}}{D_{OS}}\hat{\boldsymbol{\alpha}}$$

J083933.4-014044.4

- KiDS, Legacy and HSC Imaging-Surveys
- **Photometric** redshifts:
  - $z_l^{(s)} = 0.27$ (GAMA)
  - $z_s^{(p)} = 0.61$ (SuGOHI-V)

The last stand before the LLST: a compilation of strong lensing systems in wide-field surveys

In prep

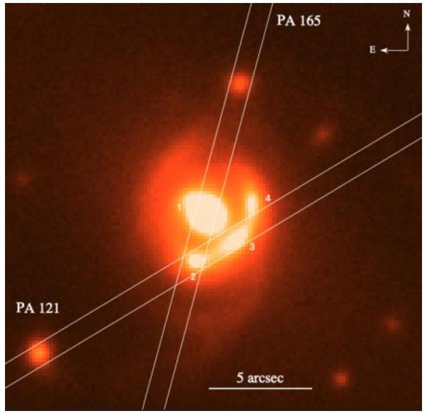


Renan Oliveira

Follow-up proposals

Gemini Fast-Turnaround, 2021B

- I-Lens magnitude: $m_{lens}{\sim}17.6$
- I-Arcs magnitude: $m_{arcs}{\sim}18$
- PA (165º) 2x600 sec
- PA (121º) 3x600 sec

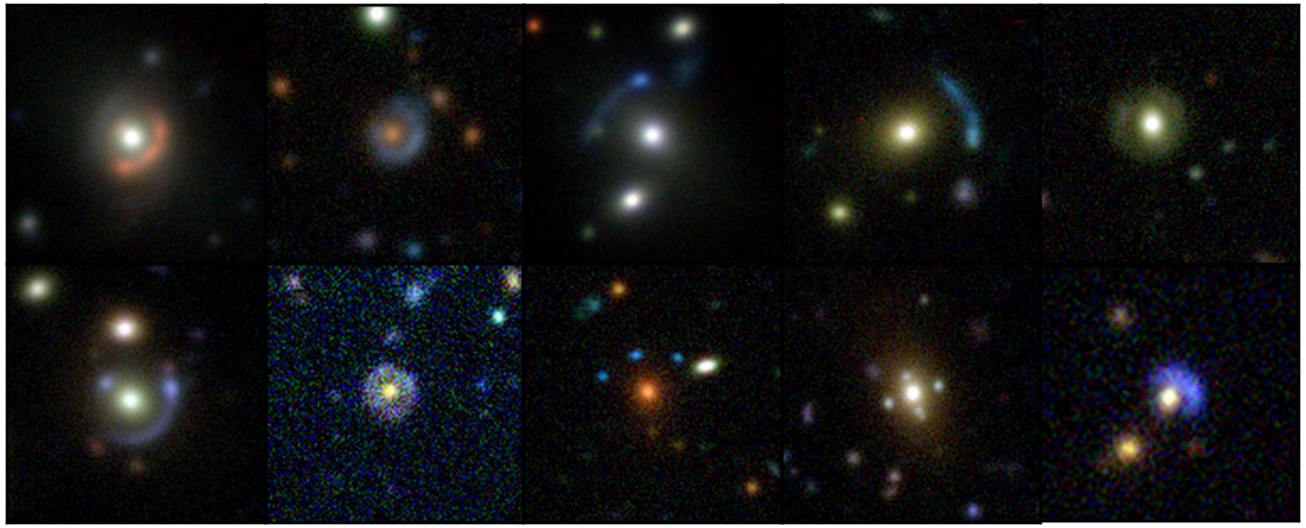


Slit position angles (PA)

Gemini Observatory

Follow-up proposals

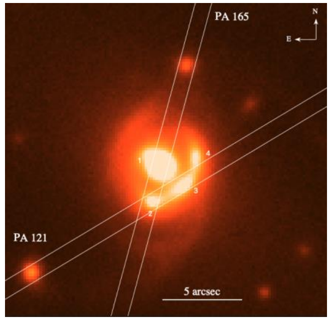
SOAR, 2022A

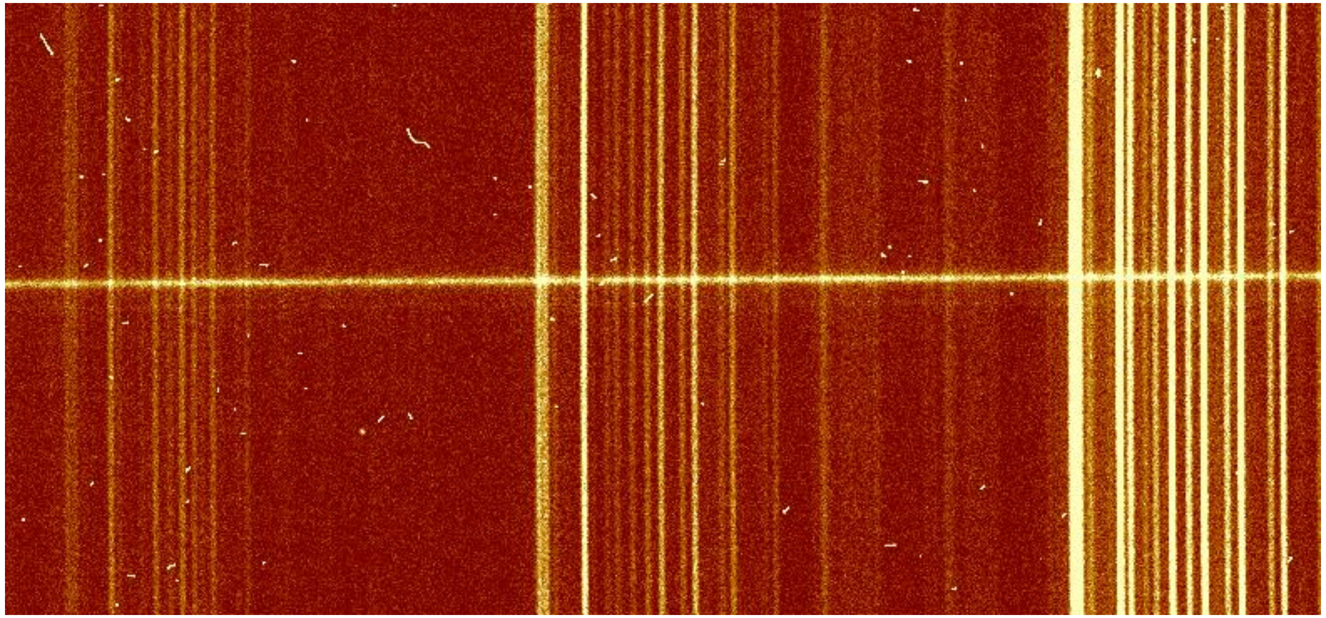


Mosaic of 10 Strong Lensing systems

SOAR

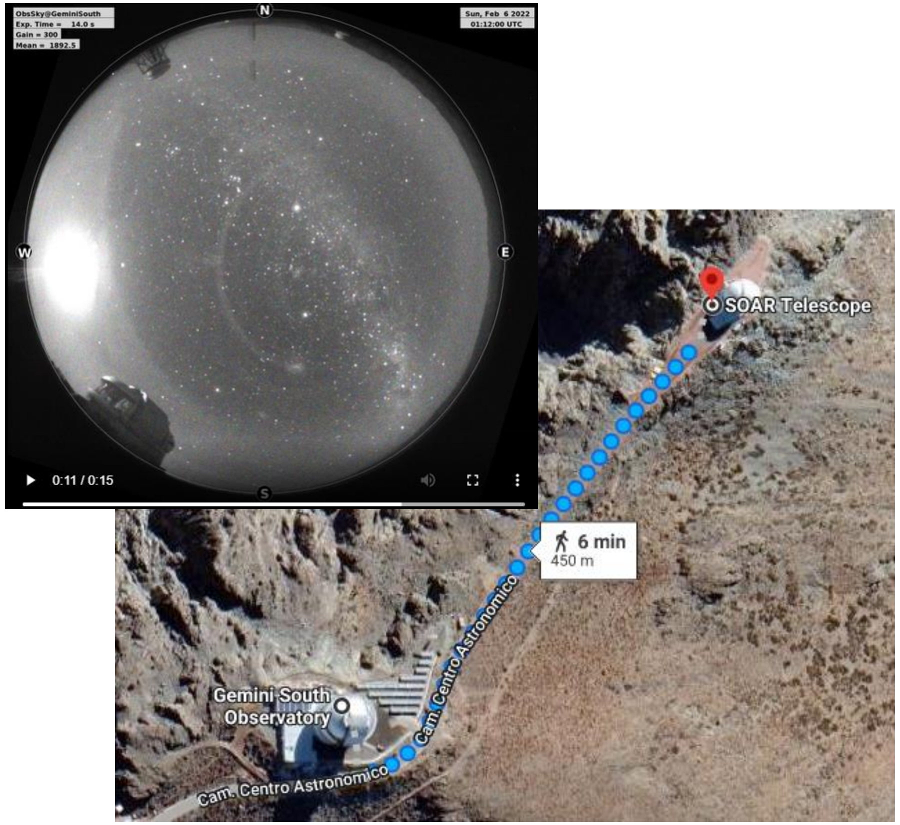
Preliminary results

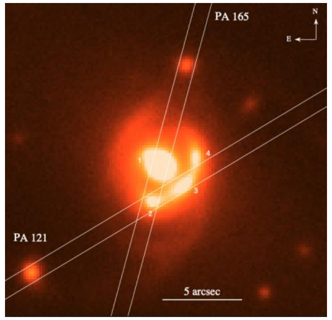


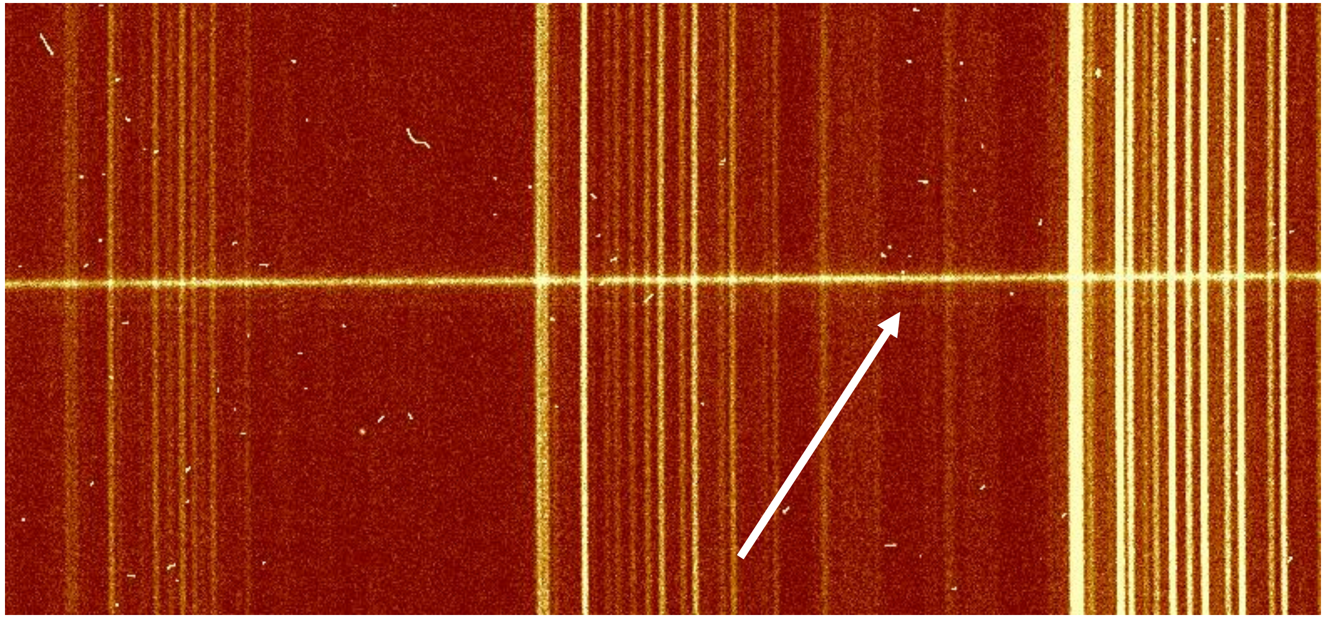


Saturday, 02/05/2022

Preliminary results



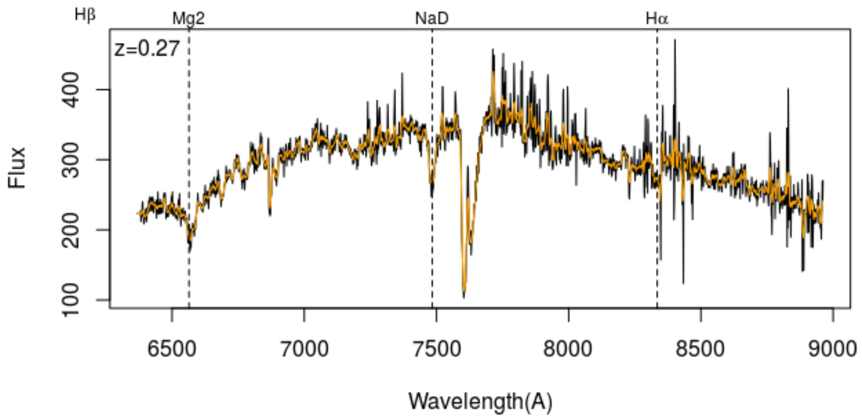




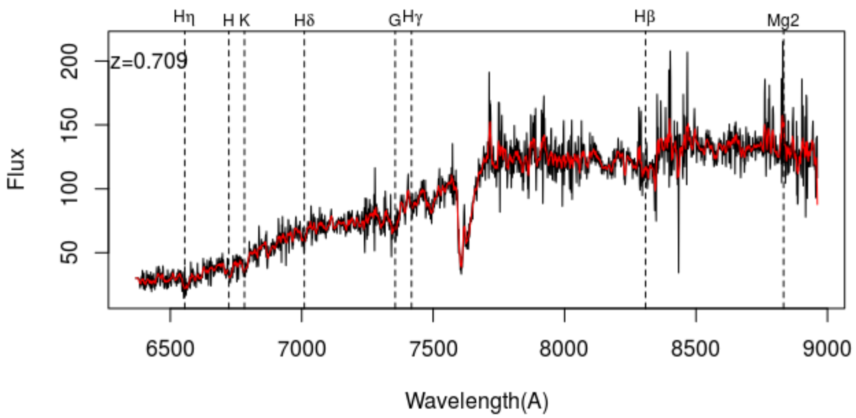
Saturday, 02/05/2022

Preliminary results

Lens spectra



Source spectra



- Lens stellar mass: $M = 9 \cdot 10^{11}\, M_{\odot}$
- $z_l^{(s)} = 0.27$
- $z_s^{(s)} = 0.71$
- $\sigma_v = 288 \pm 15\ \mathrm{km/s}$

(Very) preliminary results

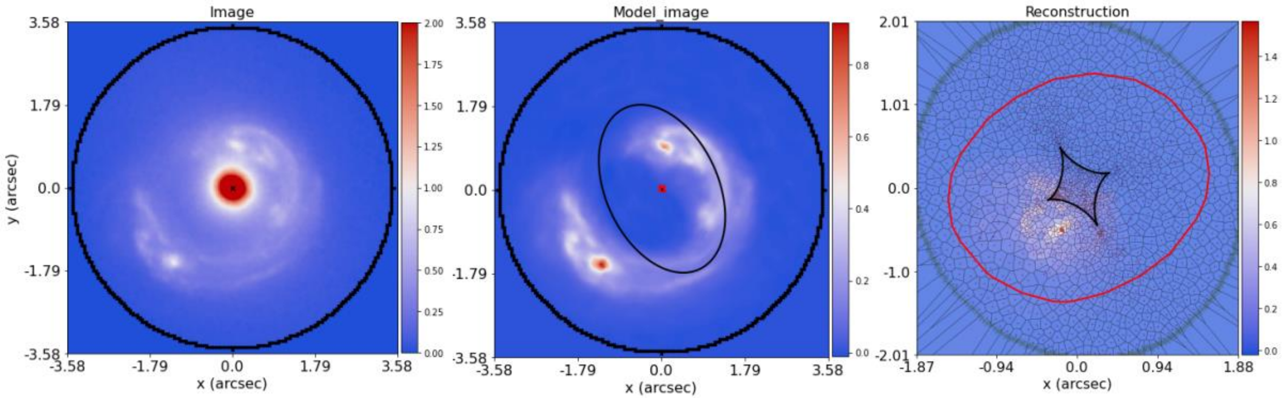
INSTITUTO DE ASTRONOMIA, GEOFÍSICA E CIÊNCIAS ATMOSFÉRICAS

Eduardo Cypriano

Ingrid Beloto

(Inverse) modelling approach

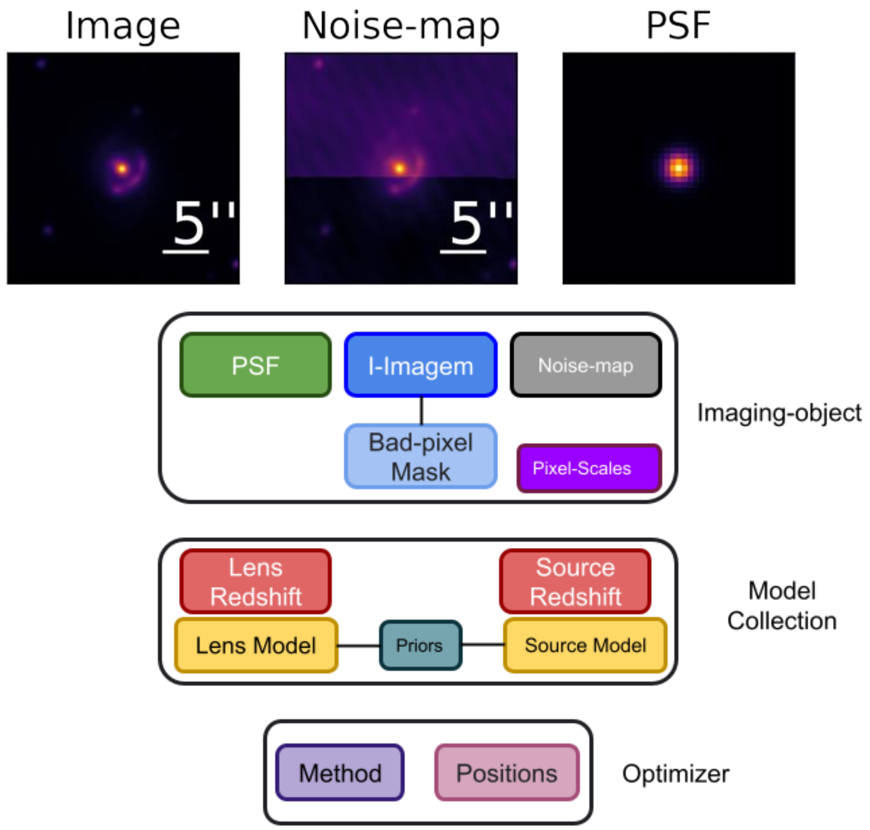
- PyAutoLens: Automated modeling of a strong lens' light, mass, and source
  - Nightingale & Dye (2015)
  - Nightingale, Dye and Massey (2018)
  - pyautolens.readthedocs.io



SLACS1430+4105

(Inverse) modelling approach

- Input parameters
  - $z_l^{(s)} = 0.27$
  - $z_s^{(s)} = 0.71$
  - I-bandpass image (HSC)
  - Noise-map
  - Point spread function (PSF)



(Inverse) modelling approach

Pipeline	Phase	Component	Model	Prior-Info	Varied
Lens-Light Subtraction	**LLS1**	Lens Light	Sérsic	-	✓
	LLS2	Lens Light	Sérsic	-	✓
Source Parametric	**SP1**	Lens Mass	SIE + Shear	-	✓
		Source Light	Sérsic	-	✓
Source Inversion	**SI1**	Lens Mass	SIE + Shear	SP1	
		Source Light	MPR	-	✓
	SI2	lens Mass	SIE + Shear	SP1	✓
		Source Light	MPR	SI1	
	SI3	Lens Mass	SIE + Shear	SI2	
		Source Light	BPR	-	✓
	SI4	Lens Mass	SIE + Shear	SI2	✓
		Source Light	BPR	SI3	
Stochastic Fit	**SF1**	Lens Mass	SIE + Shear	SI4	✓
		Source Light	BPR	SI3	✓

Nightingale & Dye (2015)
Etherington, *et al* (2022)

(Inverse) modelling approach

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		Source Light	MPR	SI1	
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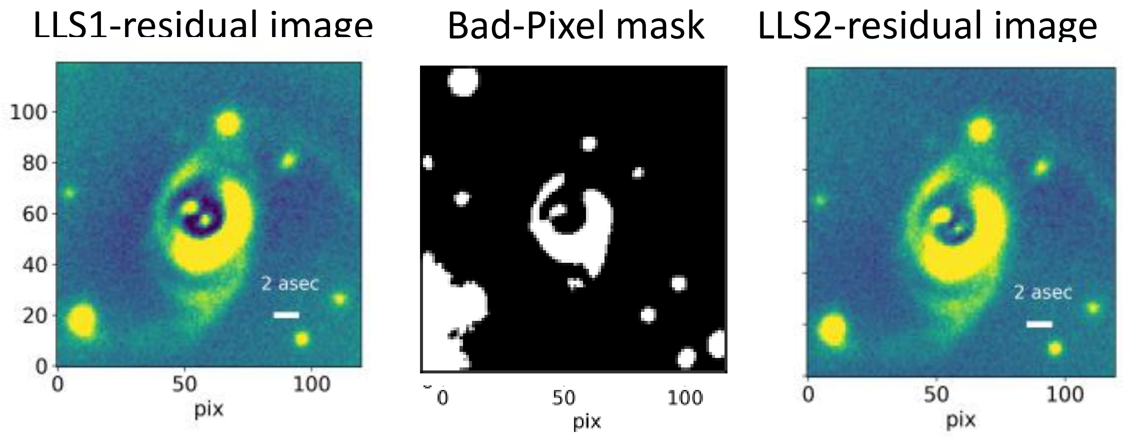
		Source Light	BPR	-	✓
	SI4	Lens Mass	SIE + Shear	SI2	✓
		Source Light	BPR	SI3	
Stochastic Fit	**SF1**	Lens Mass	SIE + Shear	SI4	✓
		Source Light	BPR	SI3	✓



Sérsic profile distribution

$$I(R) = I_0 \exp\left\{ -b_n \left(\frac{R}{R_e} \right)^{1/n} \right\}$$

(Inverse) modelling approach

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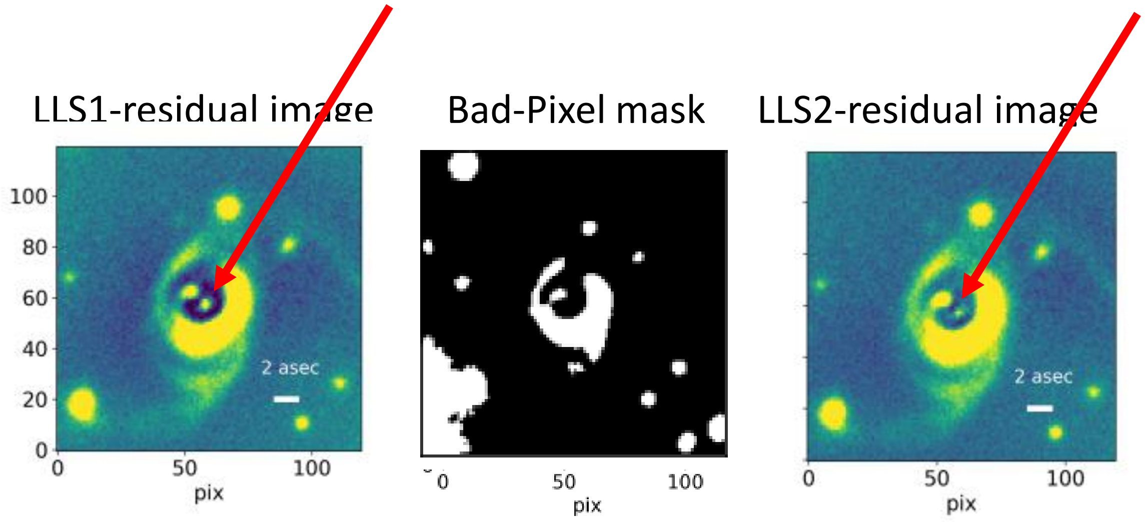
		Source Light	MPR	-	✓
	SI2	lens Mass	SIE + Shear	SP1	✓
		Source Light	MPR	SI1	
	SI3	Lens Mass	SIE + Shear	SI2	
		Source Light	BPR	-	✓
	SI4	Lens Mass	SIE + Shear	SI2	✓
		Source Light	BPR	SI3	
Stochastic Fit	SF1	Lens Mass	SIE + Shear	SI4	✓
		Source Light	BPR	SI3	✓



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		Source Light	BPR	-	✓
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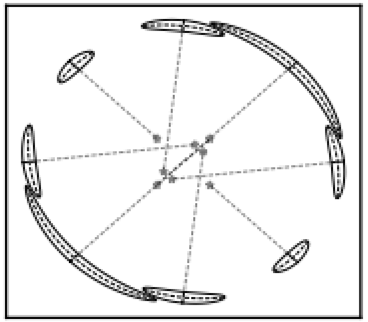
		Source Light	BPR	SI3	
Stochastic Fit	**SF1**	Lens Mass	SIE + Shear	SI4	✓
		Source Light	BPR	SI3	✓

Singular Isothermal Ellipsoid (SIE)

$$\rho(\xi_1, \xi_2, z) = \frac{\sigma_v^2}{2\pi G} \frac{\sqrt{f}}{(\xi_1^2 + f^2\xi_2^2 + z^2)}$$

Shear



Birrer, 2021

Sérsic profile distribution

$$I(R) = I_0 \exp\left\{-b_n\left(\frac{R}{R_e}\right)^{1/n}\right\}$$

(Inverse) modelling approach

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		Source Light	MPR	SI1	
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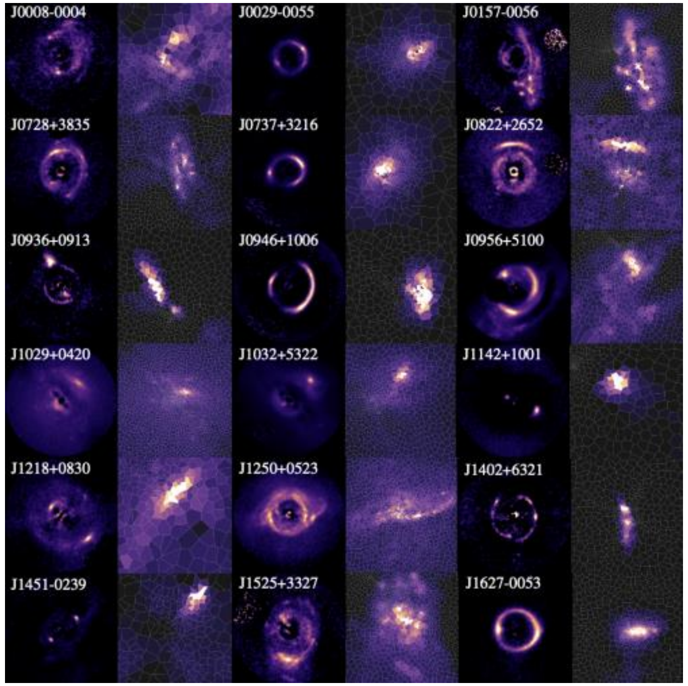
		Source Light	BPR	-	✓
	SI4	Lens Mass	SIE + Shear	SI2	✓
		Source Light	BPR	SI3	
Stochastic Fit	**SF1**	Lens Mass	SIE + Shear	SI4	✓
		Source Light	BPR	SI3	✓

$$-2\ln\mathcal{L} = \chi^2 + \ln\left[\det(\mathbf{F}+\lambda\mathbf{H})\right] - \ln[\det(\lambda\mathbf{H})] + \lambda\mathbf{S}^T\mathbf{H}\mathbf{S} + \sum_{k=1}^{K}\sum_{j=1}^{J_k}\ln\left[2\pi(\sigma_j^k)^2\right]$$



Automated galaxy-galaxy strong lens modelling: no lens left behind
Etherington, *et al* (2022)

(Inverse) modelling approach

Pipeline	Phase	Component	Model	Prior-Info	Varied
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		Source Light	BPR	-	✓
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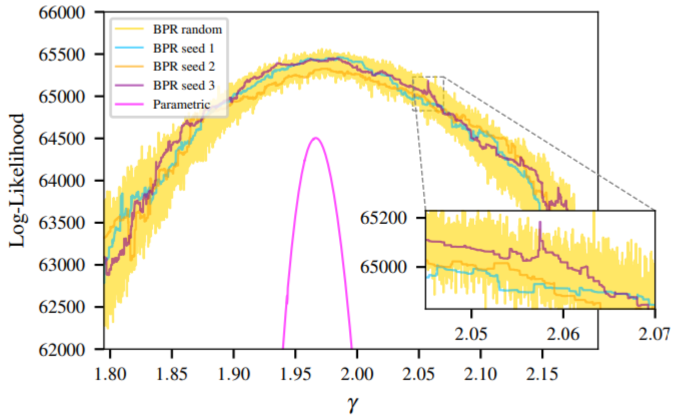
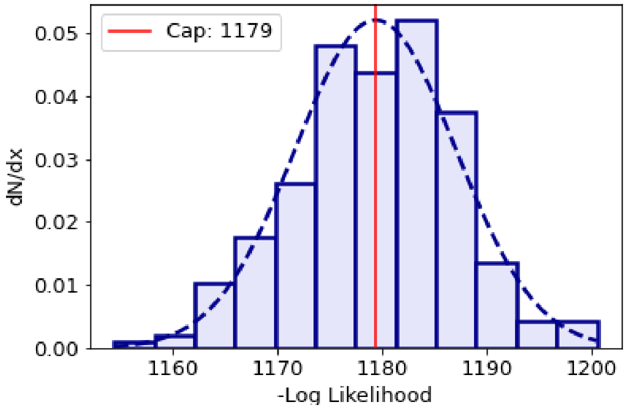
		Source Light	BPR	SI3	
Stochastic Fit	SF1	Lens Mass	SIE + Shear	SI4	✓
		Source Light	BPR	SI3	✓

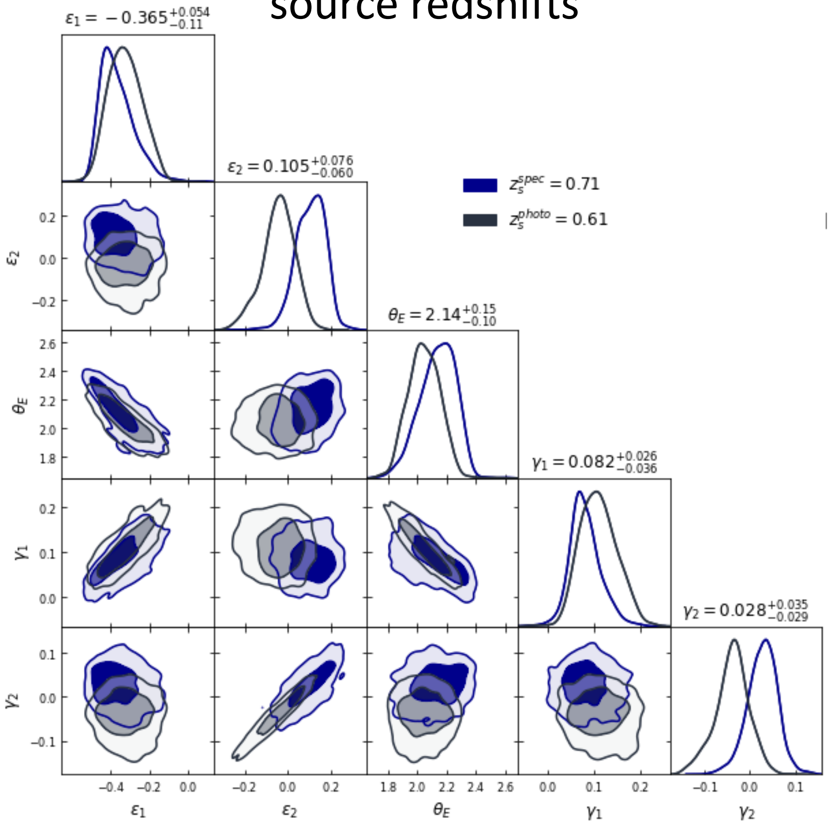




Automated galaxy-galaxy strong lens modelling: no lens left behind
Etherington, *et al* (2022)

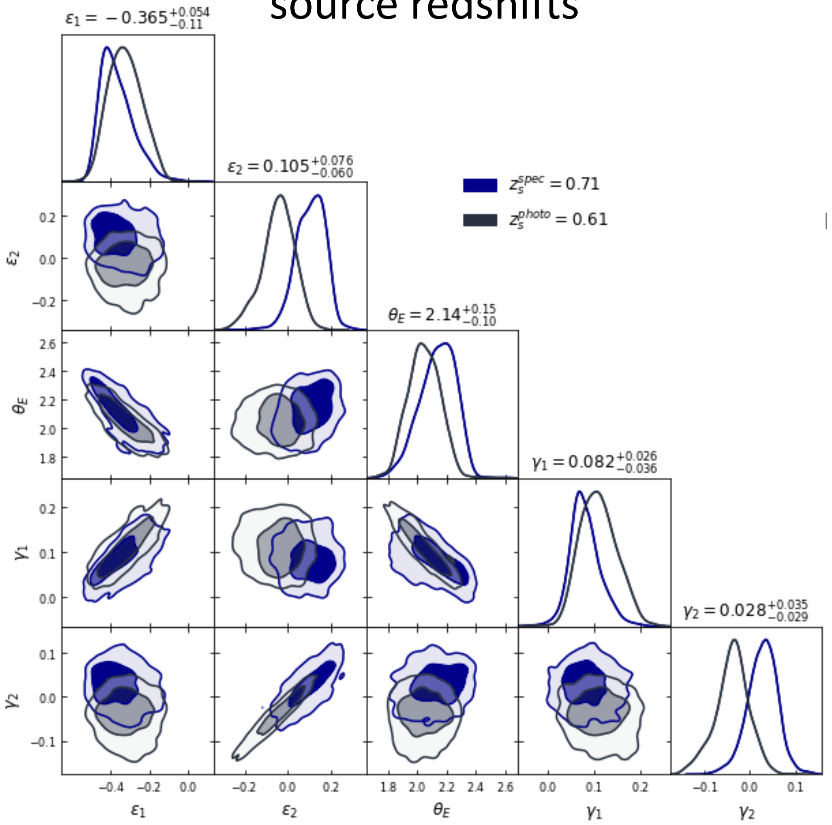
(Inverse) modelling results

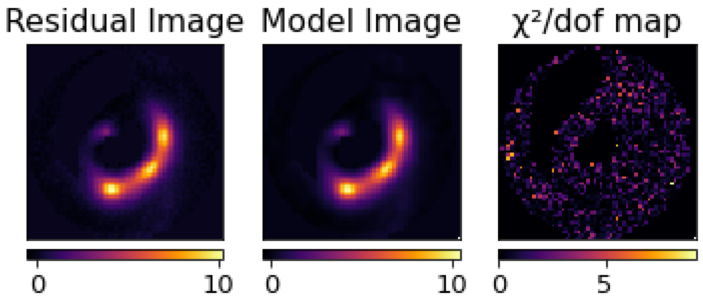
Results for photometric and spectroscopic source redshifts



(Inverse) modelling results

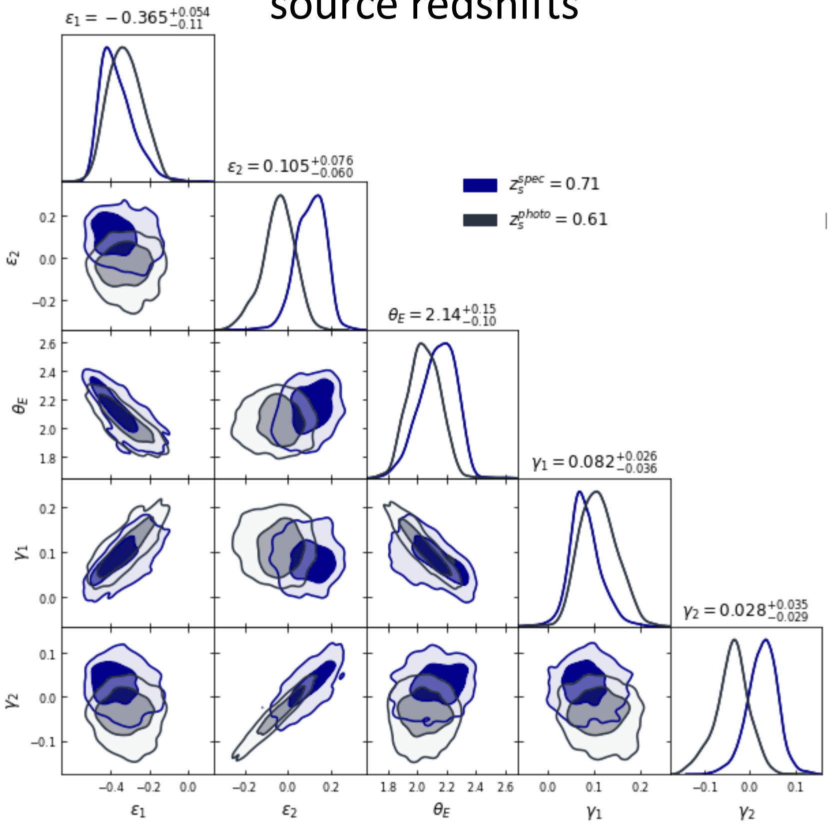
Results for photometric and spectroscopic source redshifts

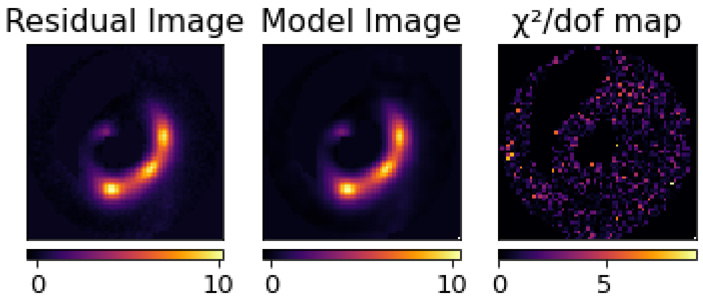




(Inverse) modelling results

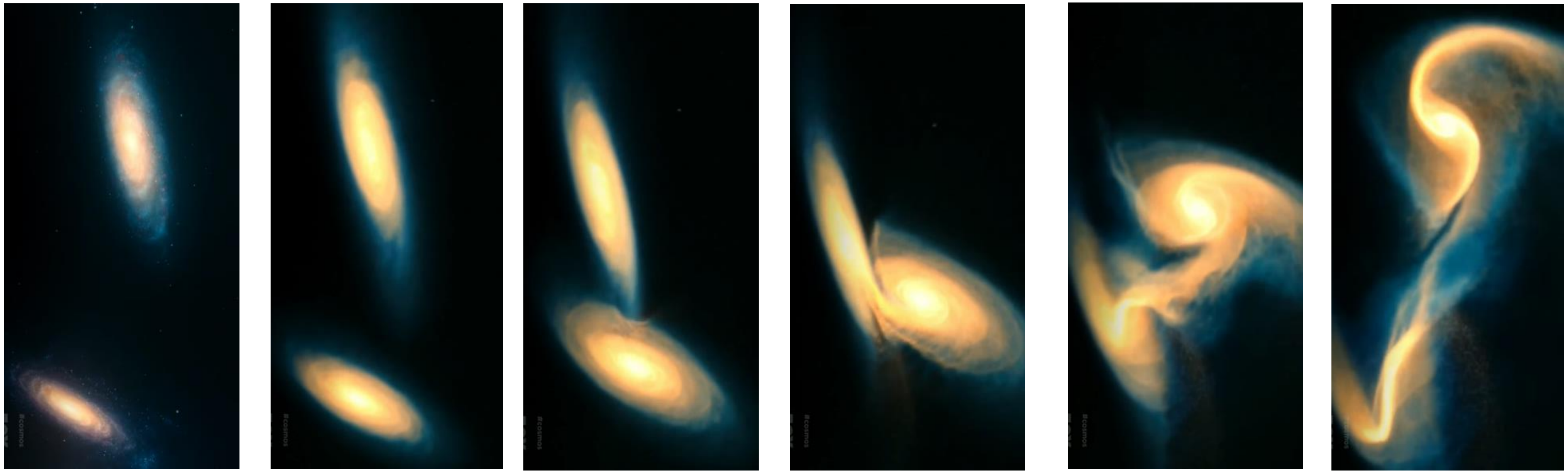
Results for photometric and spectroscopic source redshifts





$$\sigma_v = 367 \ \pm 6 \text{ km/s}$$

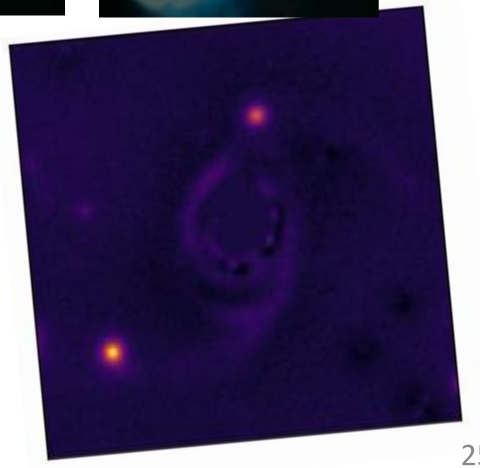
(Inverse) modelling results



Cosmos: A Spacetime Odyssey, 2014

(Inverse) modelling results

Cosmos: A Spacetime Odyssey, 2014



Summary

- We obtained the spectroscopic velocity dispersion of the lens (which is a convolution of σ_v, weighted by the galaxy luminosity and accounting for the seeing and aperture size)
- We obtained the velocity dispersion of the mass model using a (inverse) modelling process
- Tidal features highlighted

Future work

- Obtain the redshifts of the dwarf spheroidals to confirm the collision interpretation
- Improve our modelling pipeline (include NFW, spheroidals galaxy masses, dynamics?)
- Derive physical properties of the lens and the source

E-mail: joaofranca@cbpf.br/joao.contato505@gmail.com

github.com/joaofrancafisica

github.com/CosmoObs

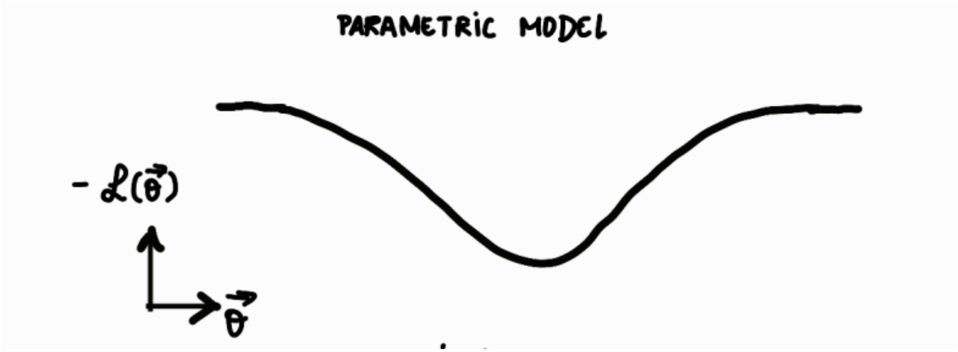
Backup-slides

$$ds^2 = -(1 + 2\Phi)dt^2 + (1 - 2\Psi)h_{ij}dx^i \mathrm{d}x^j$$

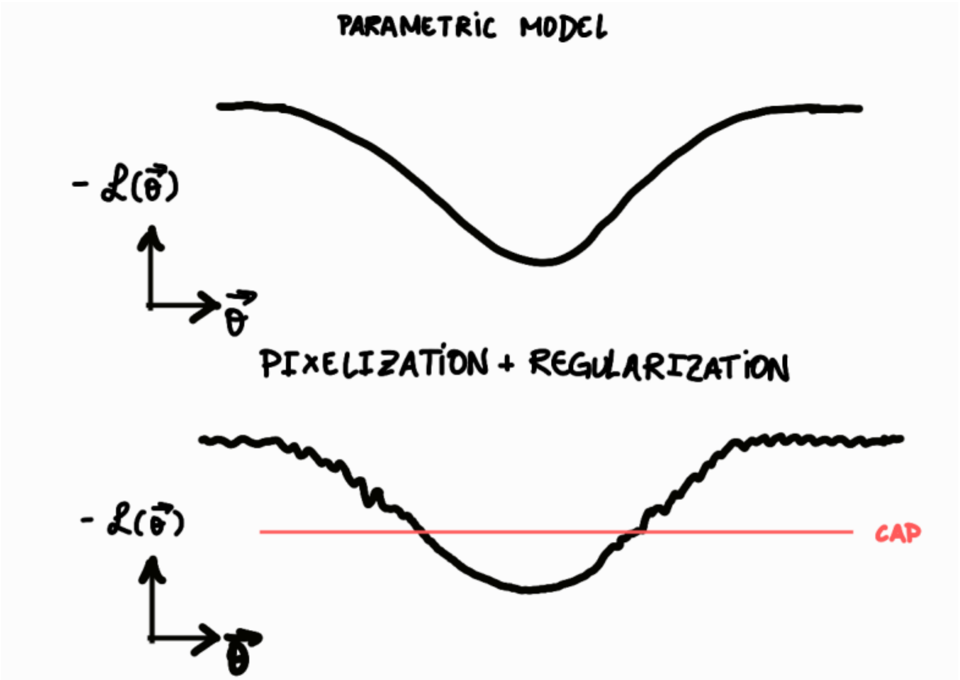
$$\Upsilon_{ppn} \coloneqq \frac{\Psi}{\Phi}$$

$$\theta_E = \left[\frac{2(1 + \gamma_{ppn})GM_E D_{LS}}{D_S D_L}\right]^{1/2}$$

Backup-slides



Backup-slides



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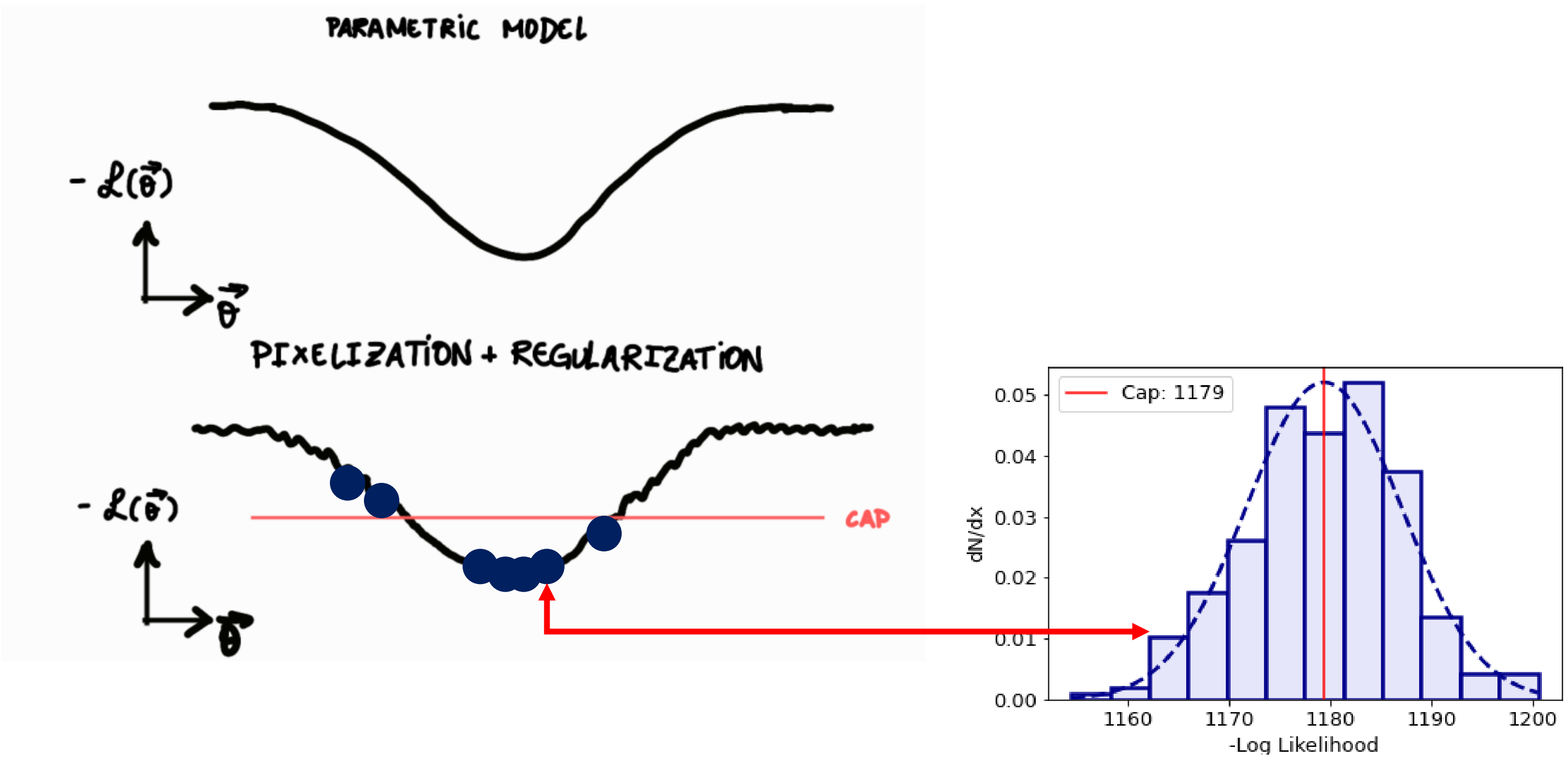

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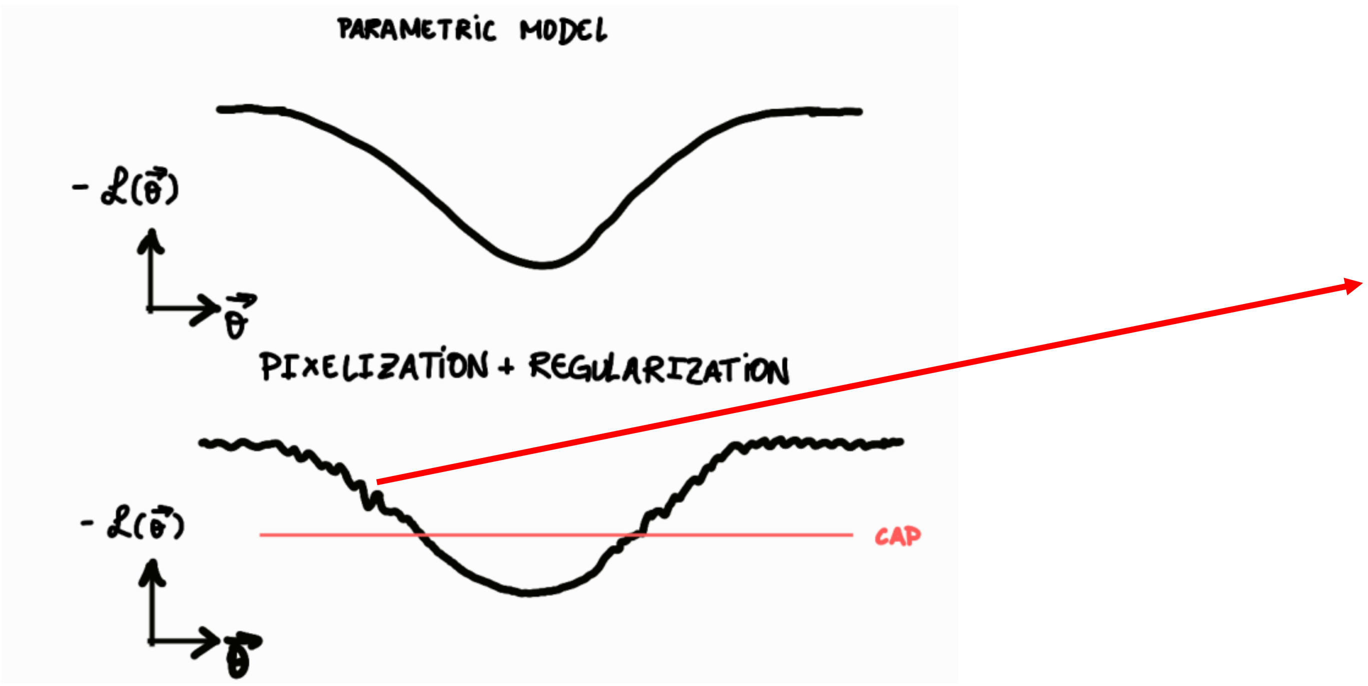

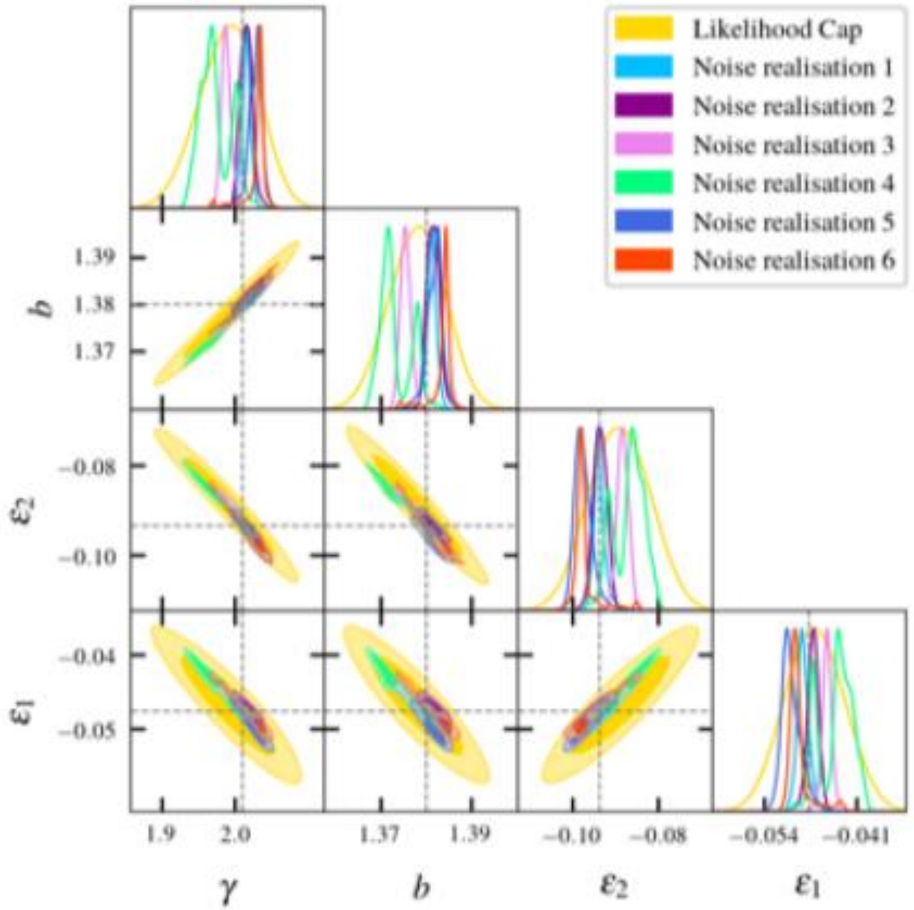

Etherington, *et al* (2022)