Cosmography with Double Source Plane Lensing

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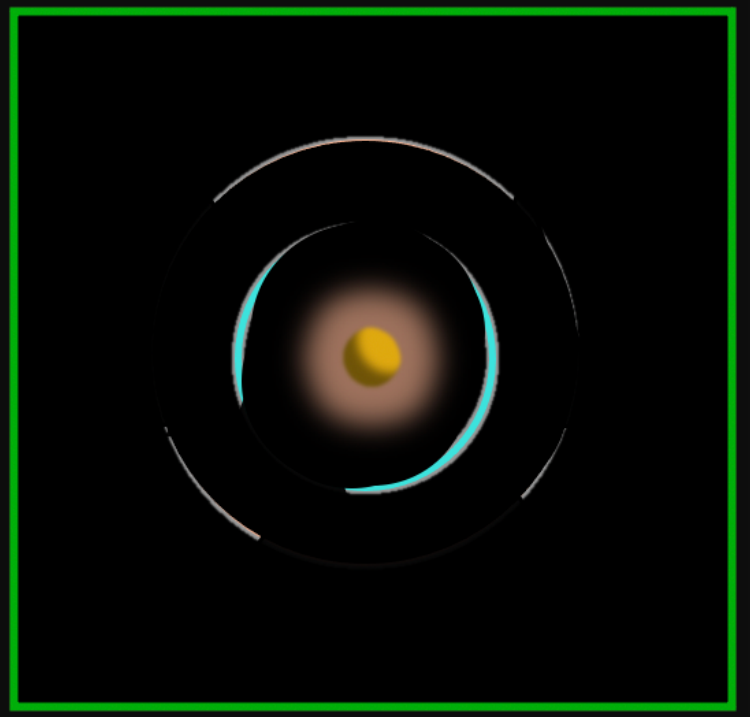

FROGS: November 10, 2020

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Background: Dark Energy

What is causing the accelerated expansion of the universe?

What is Dark Energy? And how it is related to the evolution of the universe?

Dark Energy

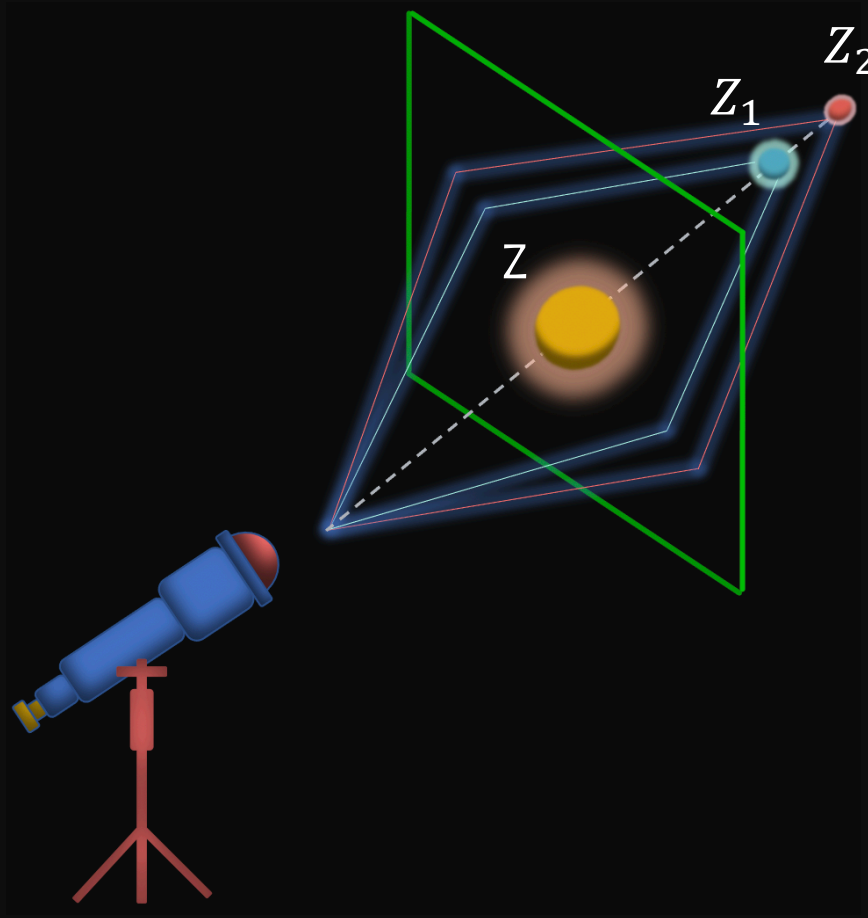
We can study Dark Energy by studying how it evolves -> how its energy density changes by the expansion of the universe.

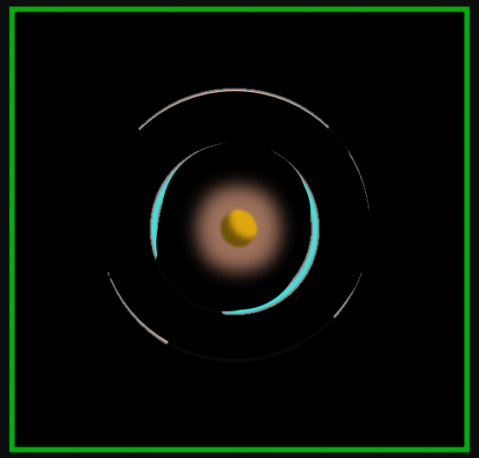
Possibilities:

1- Constant: it doesn't depend on redshift.

2- Parametrization: $w(z) = w_0 + w_a z / (1+z)$

Double Source Plane Lensing (DSPL)





Two background sources and a heavy foreground galaxy.

Very rare systems

Only a few recently detected.

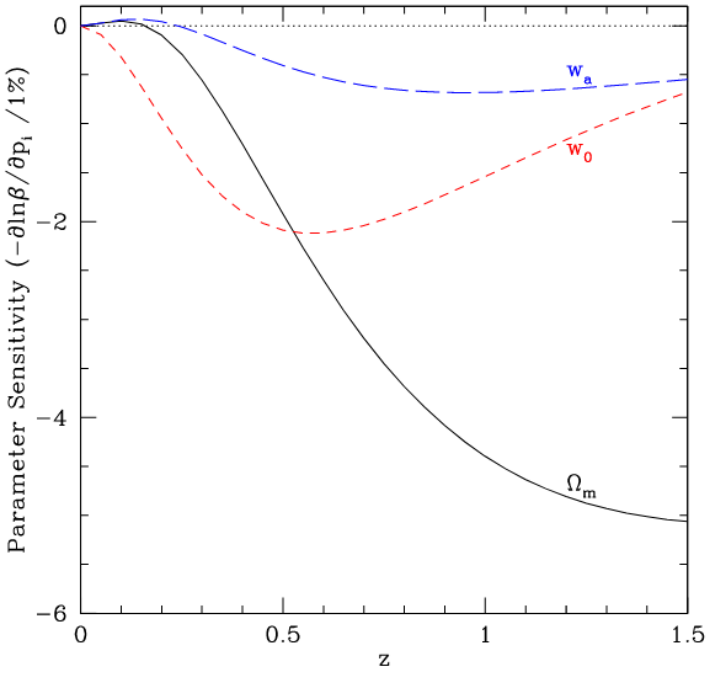
Motivation for this method

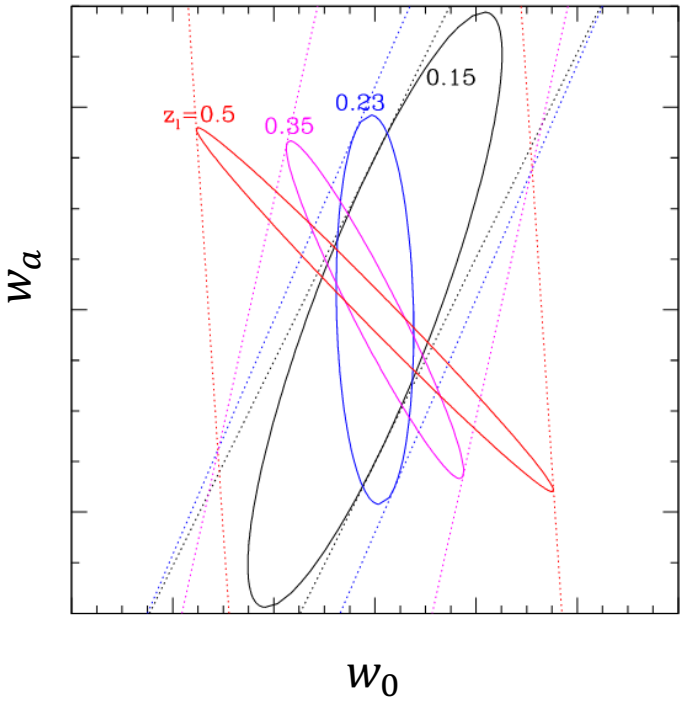
Einstein Angular Radius:

$$\theta_E^2 = \frac{4GM}{c^2} \frac{D_{LS}(z, z_1)}{D_L(z) D_S(z_1)}$$

Ratio of distance ratios:

$$\beta = \frac{D_{LS}(z, z_1)}{D_S(z_1)} \frac{D_S(z_2)}{D_{LS}(z, z_2)}$$



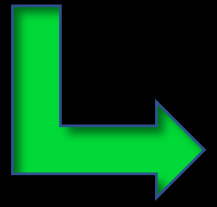


Doubling Strong Lensing as a Cosmological Probe. Linder, 2019.

We need to find systems of **double Source Plane Lensing**!

However, we a looking for a needle in a haystack.

But we can leave this tedious search for a machine learning algorithm .

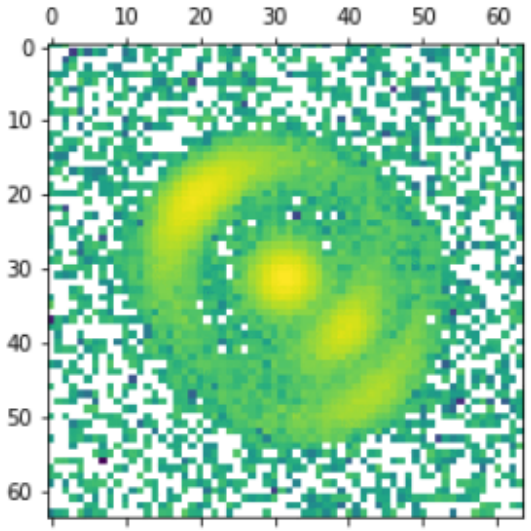


Teach the machine what to look for.

Project Overview

1

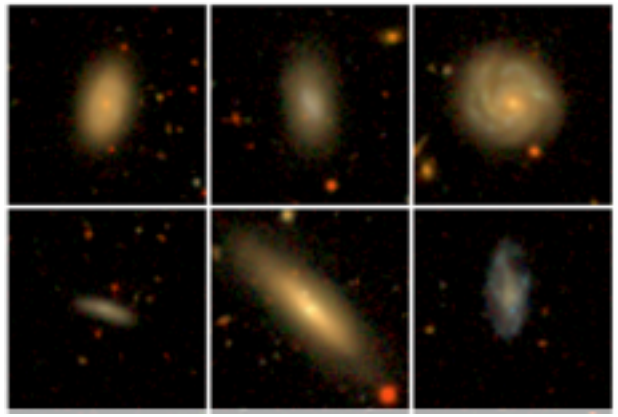
Signal of DSPL



Produced using Lenstronomy

2

Background



Anything except DSPL

3

Train a Convolutional Neural Network to find DSPL in the Dark Energy Survey

4

Statistical Analysis and Interpretation of results

Simulations

Idea: Simulate system with Lenstronomy and only display sources. Then overlap on top a real image of a galaxy as the lens. Advantages: More realistic lens & already have noise properties.

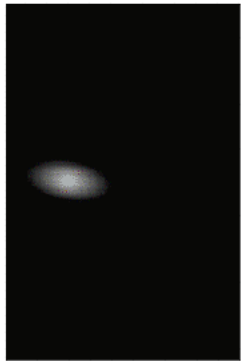
For lens modeling: Need redshift, velocity of dispersion, and some description of its mass distribution.

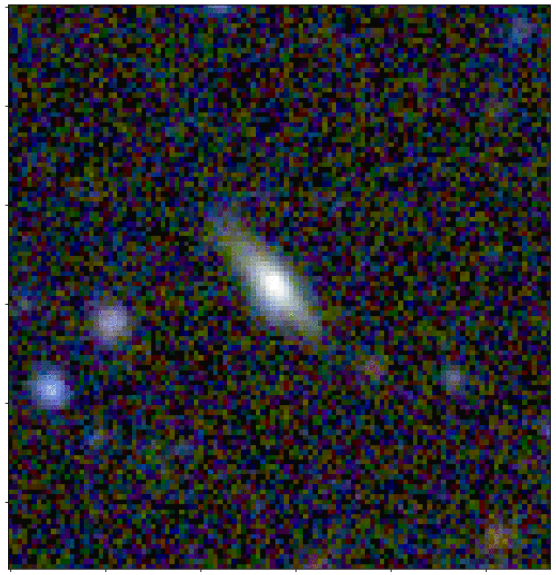
For lens real image: Need DES ID.

Solution for our needs: Galaxies in DES and SDSS as lenses.

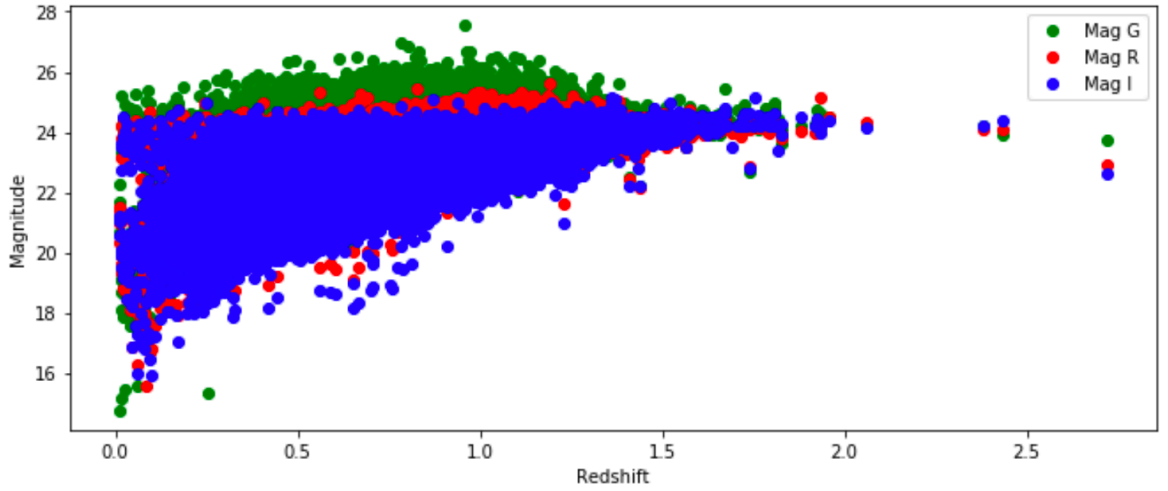
Simulations: Important details

Mass distribution (Simulations) ≠ Luminosity distribution (image)

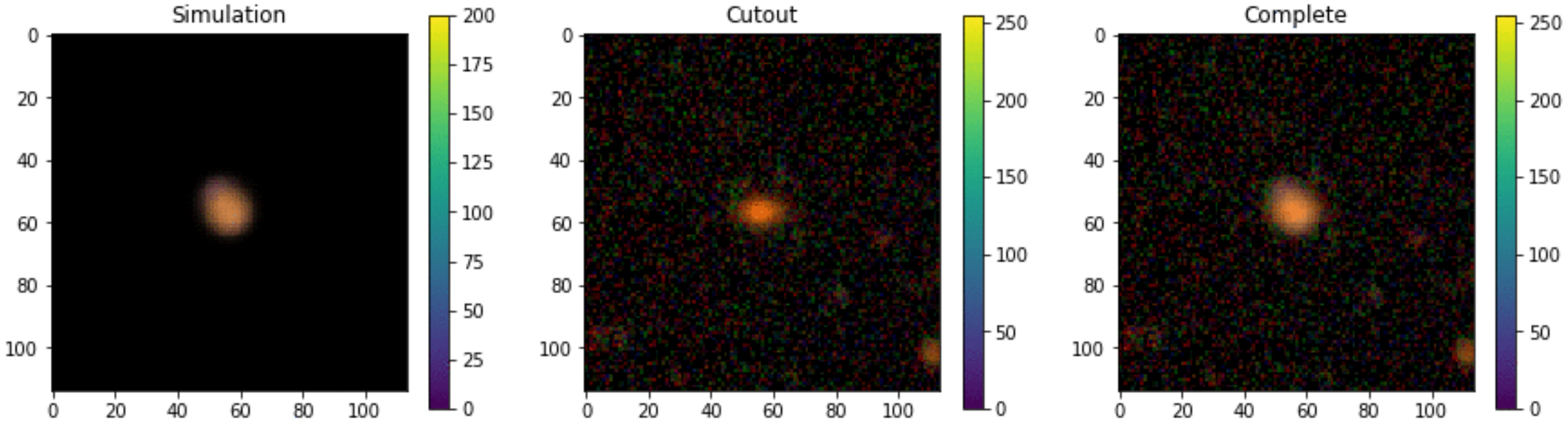




Color distribution



Simulations: Complete Result



Next Steps

Train Convolutional Neural Network:

- Positive cases: DSPL Simulations
- Negative cases: Everything except DSPL. Maybe first search single rings?
- Find DSPL in real data.

Next Steps

Statistical Analysis:

$$D = \frac{d_h}{1+z}\int_0^z \frac{1}{E(z')}dz' \qquad E(z) = \sqrt{\Omega_m a^{-3} + \Omega_{DE} a^{-3(1+\omega_0+\omega_a)} e^{-3\omega_a(1-a)}}$$

$$\omega(a) = \omega_0 + \omega_a \frac{z}{z+1}$$

$$\beta = \frac{\theta_{E,1}^2}{\theta_{E,2}^2} = \frac{D_{LS}(z,z_1)}{D_s(z_1)} \frac{D_s(z_2)}{D_{LS}(z,z_2)}$$

Any questions?

Thank you!