

# 公众科学和强引力 透镜星系团查找

李楠（国家天文台）

合作者：张震、何紫朝、杨嘉宁、吴莹、邹虎、崔辰洲、贾鹏等



# 内容提纲

工作动机

项目介绍

未来计划

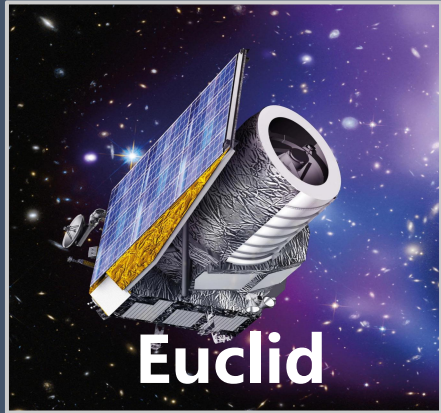
# 内容提纲

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# 大数据天文学时代



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## Sky Survey Projects

SDSS (The Sloan Digital Sky Survey)

Euclid (The Euclid dark Universe mission)

CSST (The China Space Station Telescope)

LSST (The Large Synoptic Survey Telescope)

SKA (The Square Kilometer Array)

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## Data Volume

~ 40 TB, > 3 m objects

~ 50 PB expected

~ 60 PB expected

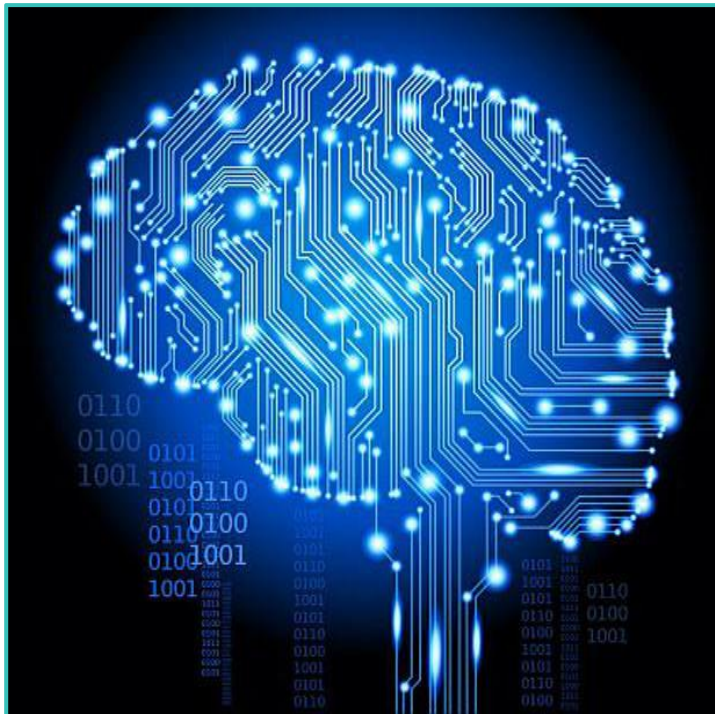
~ 200 PB expected

~ 4.6 EB expected, ~5TB/s

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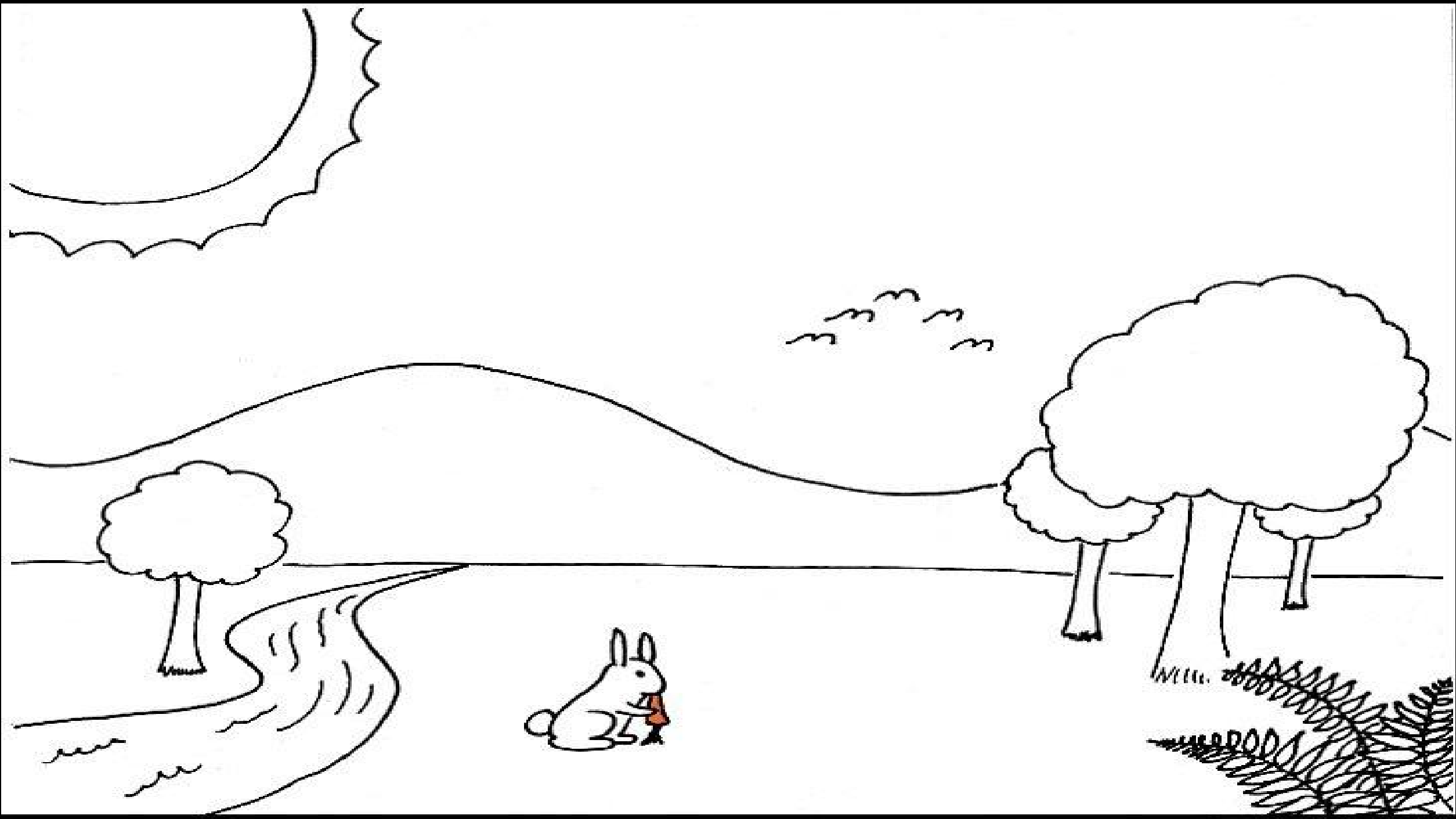
# Mining Data in the Big Data Era

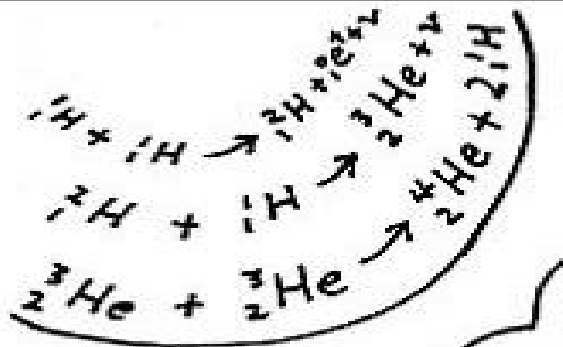
## Machine Learning



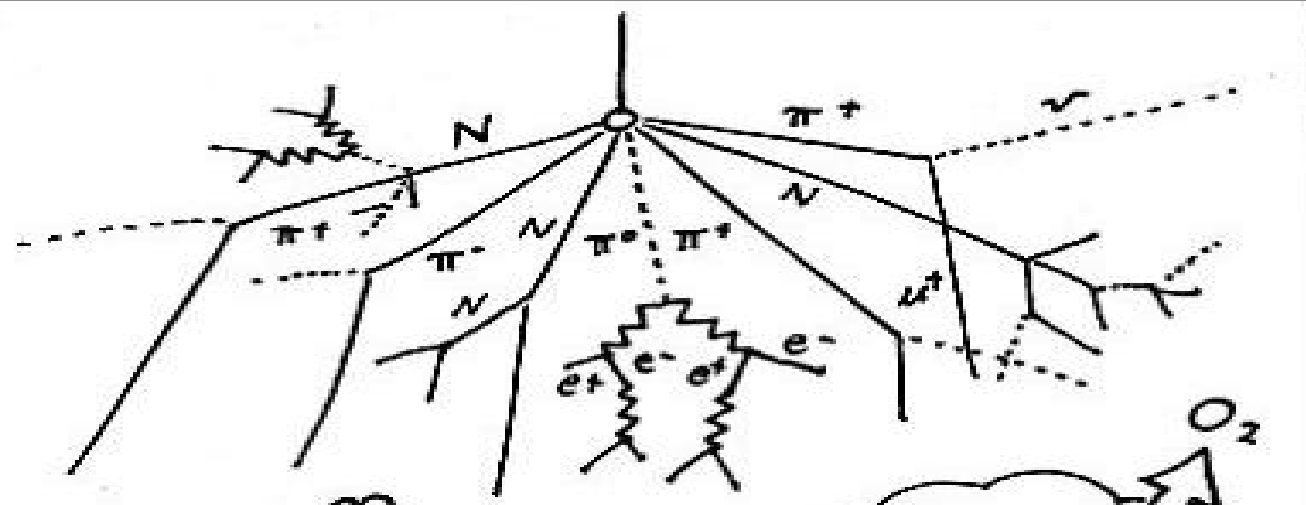
## Citizen Science







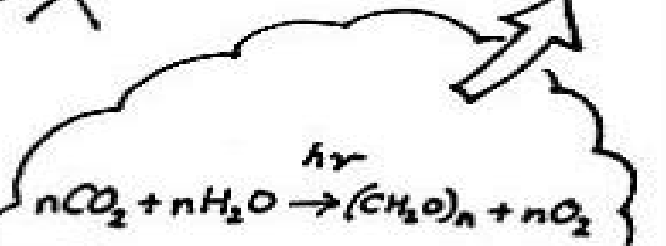
$\nabla \cdot \mathbf{E} = \frac{\rho}{\epsilon_0}$   
 $\nabla \cdot \mathbf{B} = 0$   
 $\nabla \times \mathbf{E} + \frac{\partial \mathbf{B}}{\partial t} = 0$



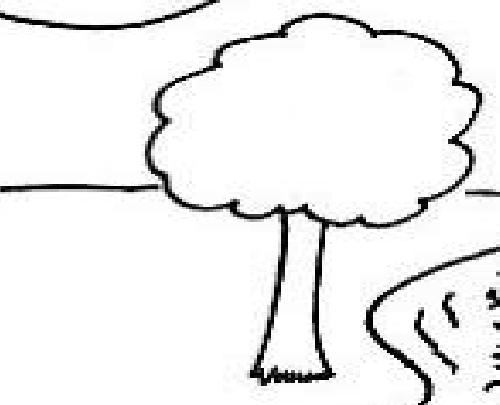
$F = G \frac{m_1 m_2}{r^2}$

$R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} = 8\pi G T_{\mu\nu}$

$P + \frac{1}{2} \rho v^2 + \rho g h = C$



$y(x) = a_0 + \sum_{n=1}^{\infty} (a_n \cos nx + b_n \sin nx)$

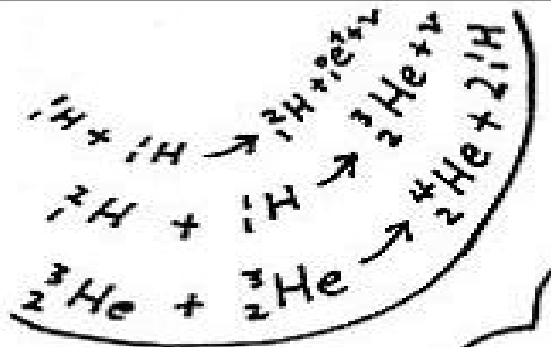


$[\frac{-\hbar^2}{2m} \nabla^2 + V] \psi = i\hbar \frac{\partial}{\partial t} \psi$



$f_1(x, y) = \begin{bmatrix} 0.95 & 0.04 \\ -0.04 & 0.95 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$   
 $f_2(x, y) = \begin{bmatrix} -0.15 & x \\ 0.26 & y \end{bmatrix}$

$\frac{\partial}{\partial t} u_i + \dots$



$$\nabla \cdot \mathbf{E} = \frac{\rho}{\epsilon_0}$$

$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{E} + \frac{\partial \mathbf{B}}{\partial t} = 0$$

$$F = G \frac{m_1 m_2}{r^2}$$

$$R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} = 8\pi G T_{\mu\nu}$$

$$\nabla_{\mu} \epsilon_0 \frac{\partial E}{\partial x^{\mu}} = \mu_0 \rho$$

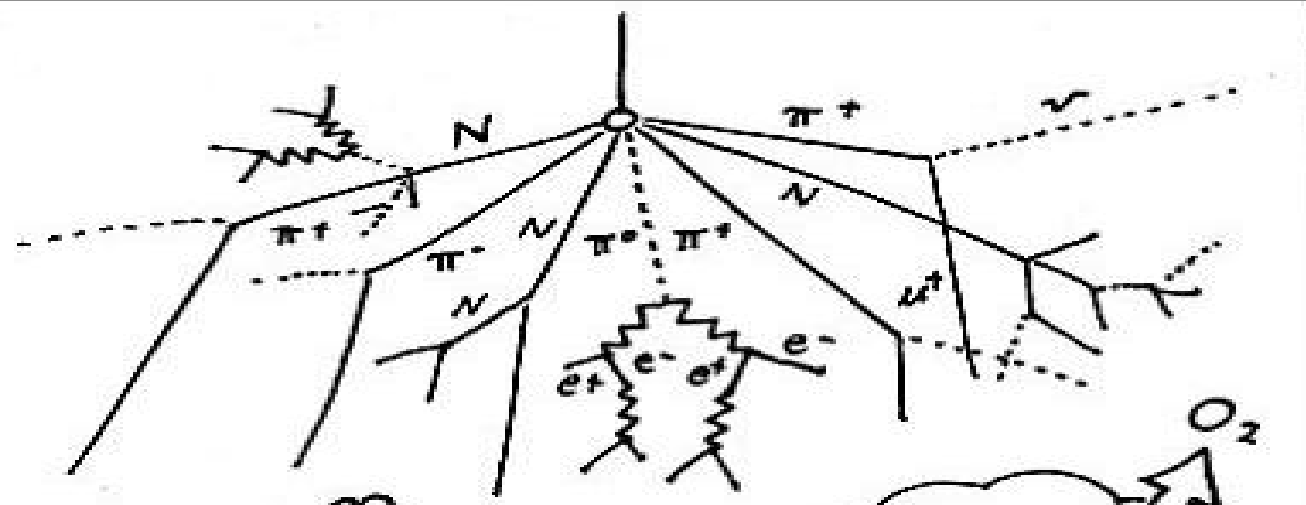
$$y(x) = a_0 + \sum_{n=1}^{\infty} (a_n \cos nx + b_n \sin nx)$$

$$\left[ \frac{-\hbar^2}{2m} \nabla^2 + V \right] \psi = i\hbar \frac{\partial}{\partial t} \psi$$

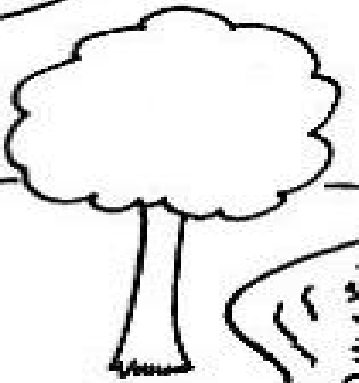
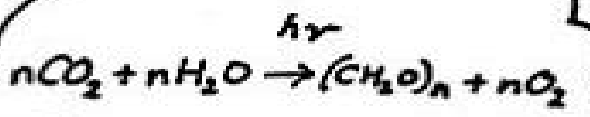
$$\nabla^2 \text{CO}_2$$

$$f_1(x, y) = \begin{bmatrix} 0.15 & 0.04 \\ -0.04 & 0.15 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

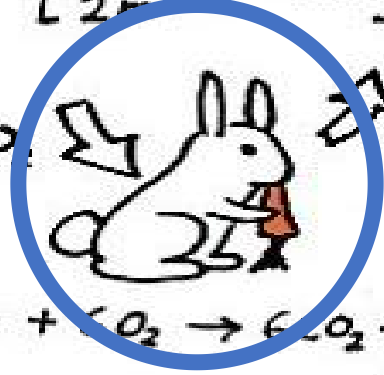
$$f_2(x, y) = \begin{bmatrix} -0.15 & 0.04 \\ 0.04 & -0.15 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$



$$P + \frac{1}{2} \rho v^2 + \rho gh = C$$



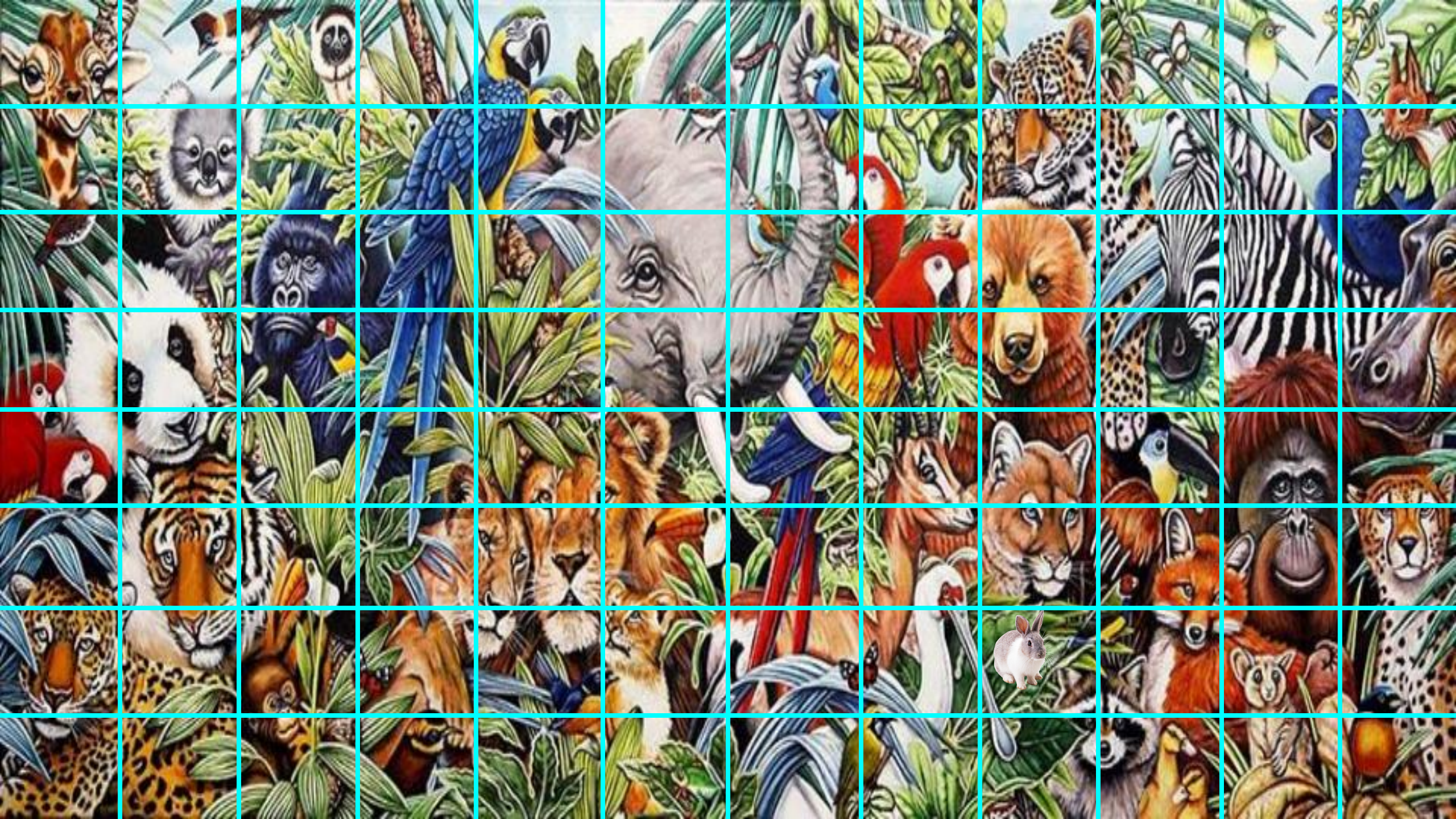
$$\frac{\partial}{\partial t} \mu_i + \dots$$

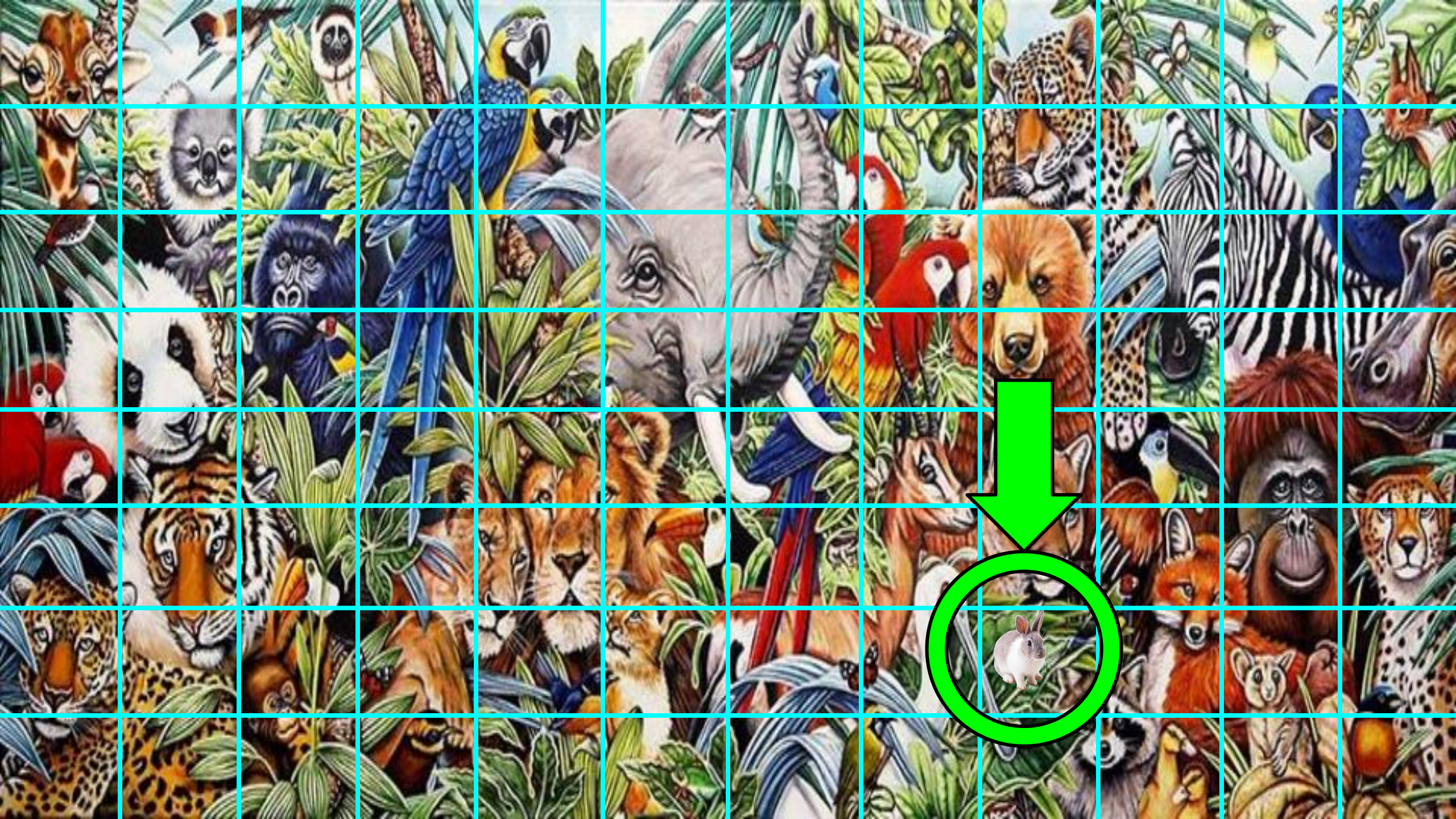


金吉呀







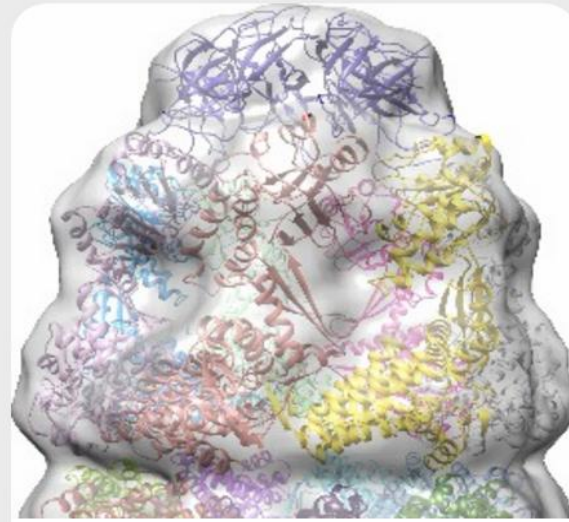




**COMPUTER VISION:  
SERENGETI**



**WESTERN SHIELD — CAMERA  
WATCH**



**MICROSCOPY MASTERS**

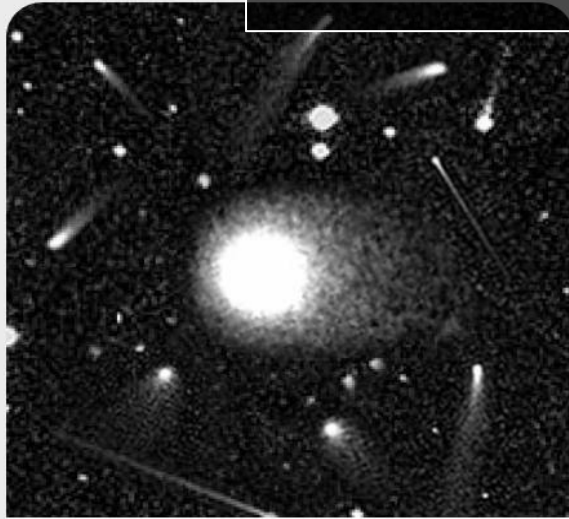


**POPPIN' GALAXY**

[www.zooniverse.org](http://www.zooniverse.org)



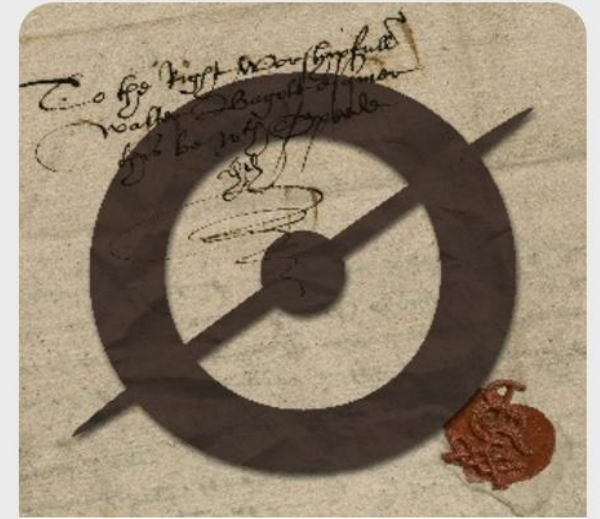
**SNAPSHOTS AT SEA**



**COMET HUNTERS**



**JUNGLE RHYTHMS**



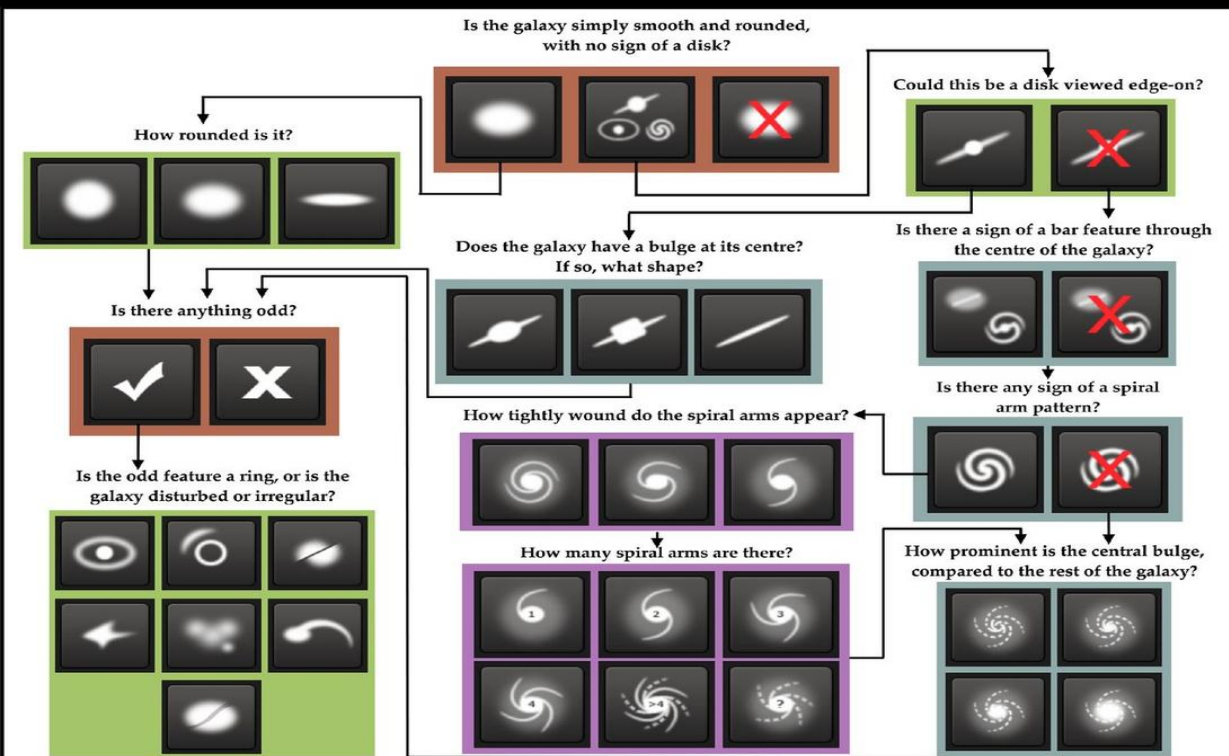
**SHAKESPEARE'S WORLD**

# Galaxy-Zoo and Spacewarps

<https://www.galaxyzoo.org/>

<https://spacewarps.org/>

**14,003**  
Participants Worldwide  
**3,511,973**  
Images Classified



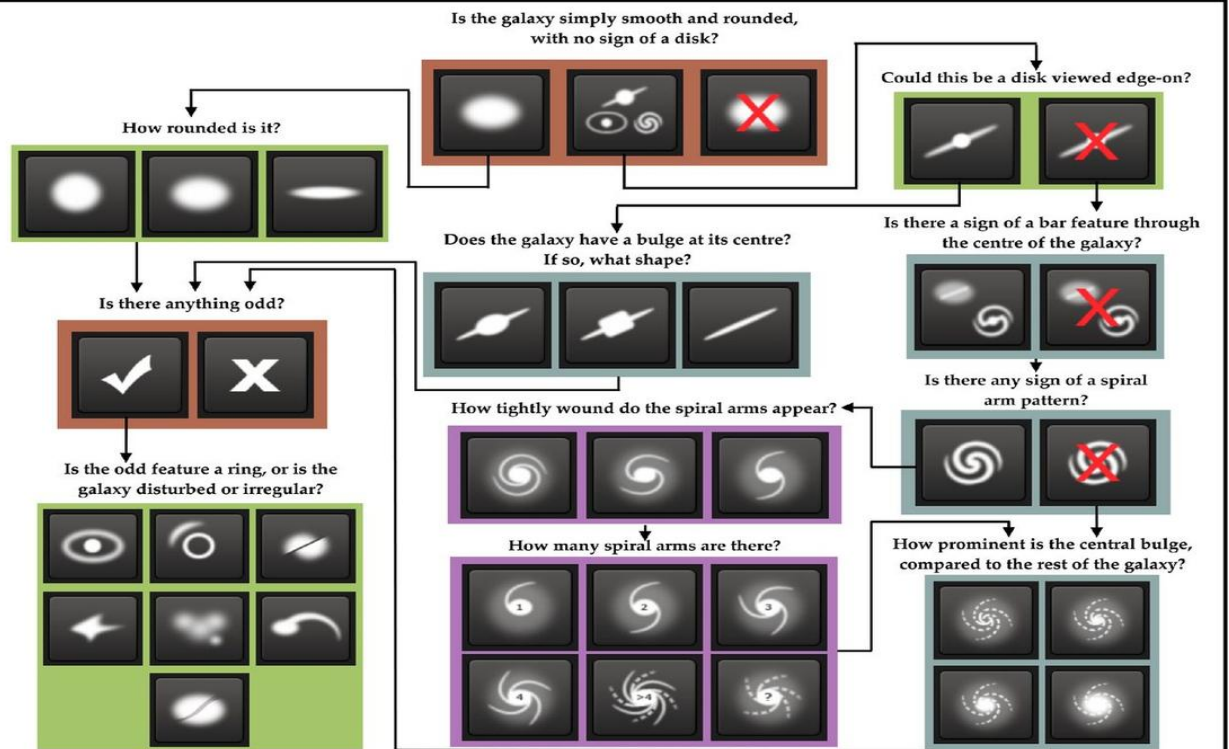
The Spacewarps interface includes a navigation menu on the left with options: Classify, Science, Spotter's Guide, Discuss, Profile, and FAQ. The main area shows a galaxy image with a pop-up notification: "Marvelous! You spotted a simulated lens. Unlike most little blue galaxies you see, lensed galaxies appear stretched and curved around the lens." The interface also displays statistics: 2 IMAGES VIEWED, 1 POTENTIAL LENSES, 0 FAVORITE IMAGES, and 1 in 5 SIMULATION FREQUENCY. On the right, there is a "Spotter's Guide" section with "LENSES" and "NON-LENSES" categories, each showing a grid of galaxy images.

# Galaxy-Zoo and Spacewarps

<https://www.galaxyzoo.org/>



<https://spacewarps.org/>



SPACEWARPS

2 IMAGES VIEWED | 1 POTENTIAL LENSES | 0 FAVORITE IMAGES | 1 in 5 SIMULATION FREQUENCY

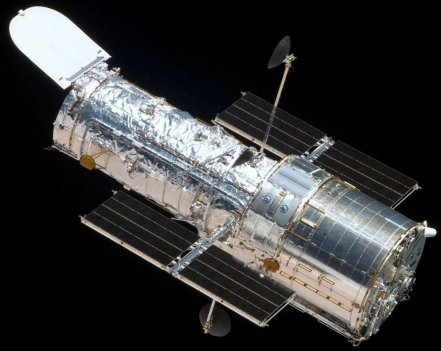
Spotter's Guide

Marvelous! You spotted a simulated lens. Unlike most little blue galaxies you see, lensed galaxies appear stretched and curved around the lens.

LENSES

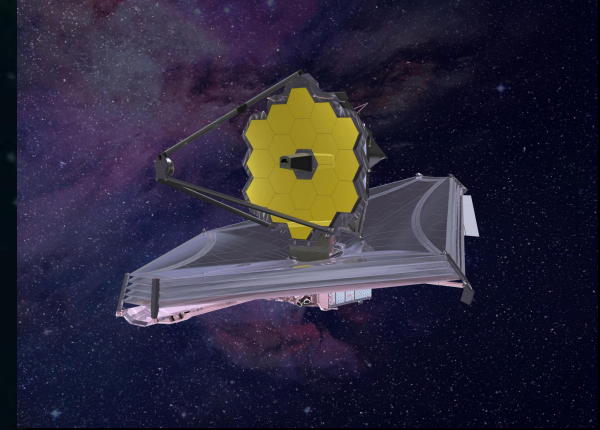
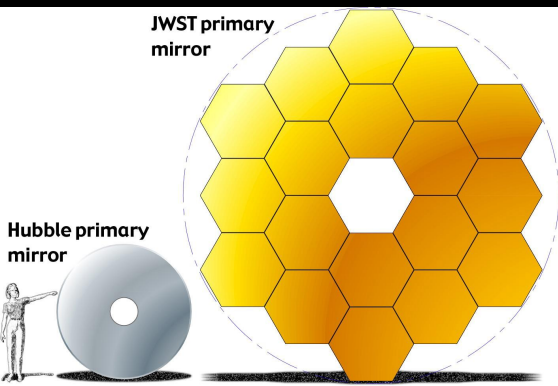
NON-LENSES

A Zooniverse project



## Hubble Space Telescope

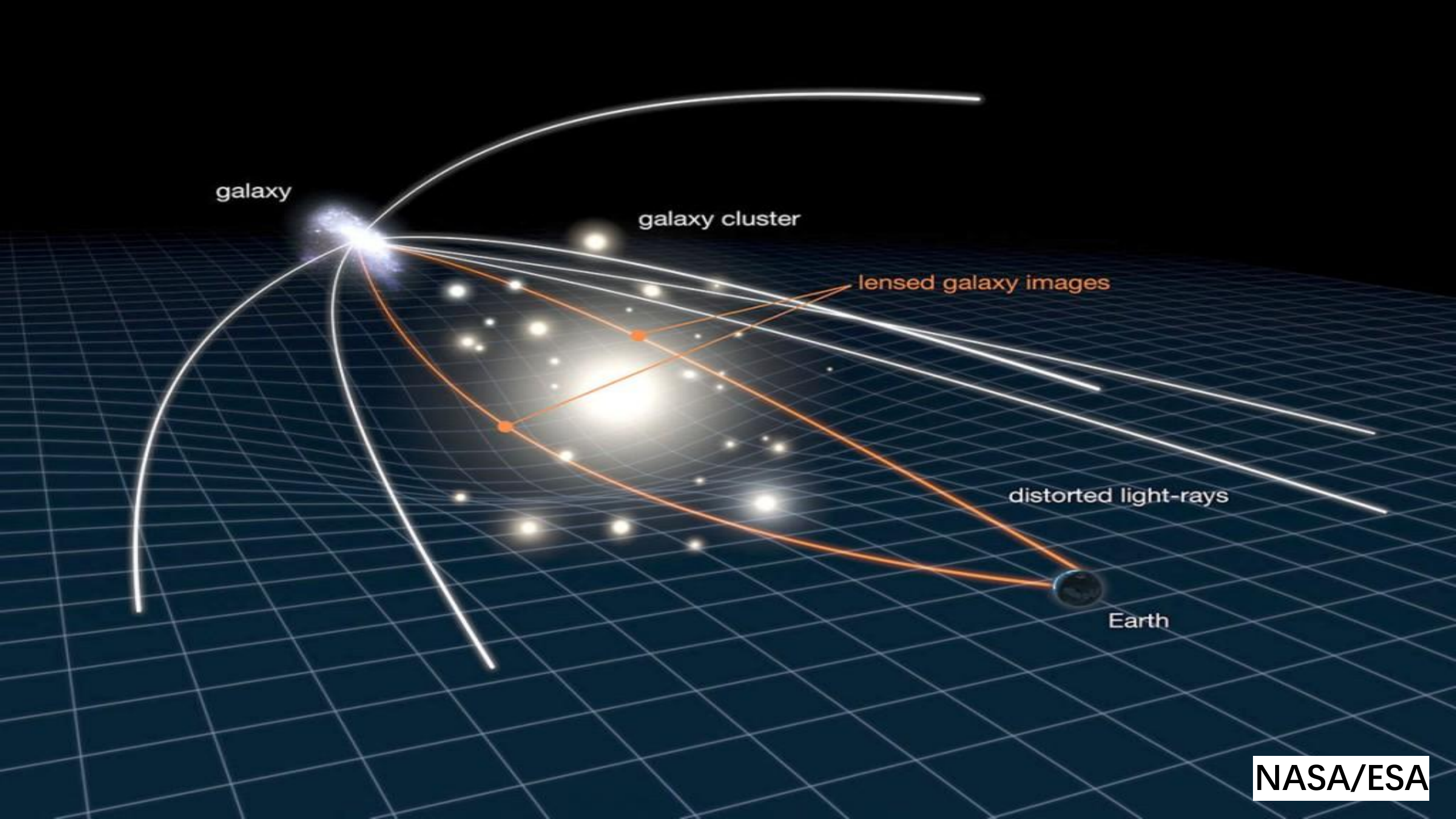
LEO : 560 km  
D : 2.4 m



## James Webb Space Telescope

L2 : 1.5m km  
D : 6.5 m

<https://www.webbcompare.com/>



galaxy

galaxy cluster

lensed galaxy images

distorted light-rays

Earth



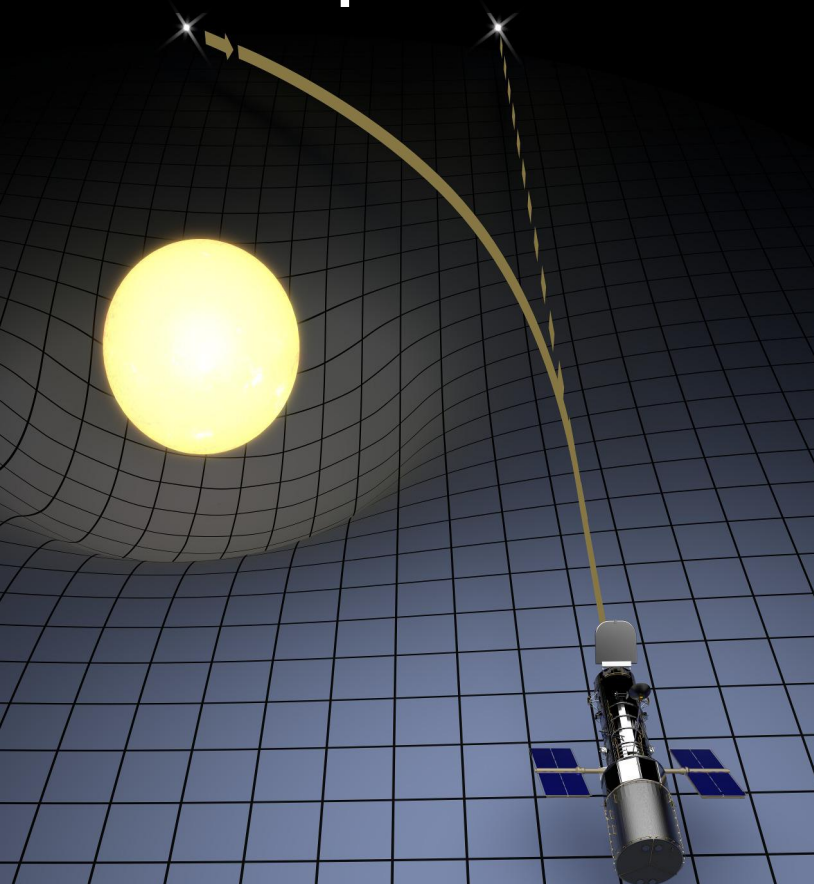
# Strong Lensing in Galaxies & Galaxy Clusters



*HST, Prof. Michael Gladders*

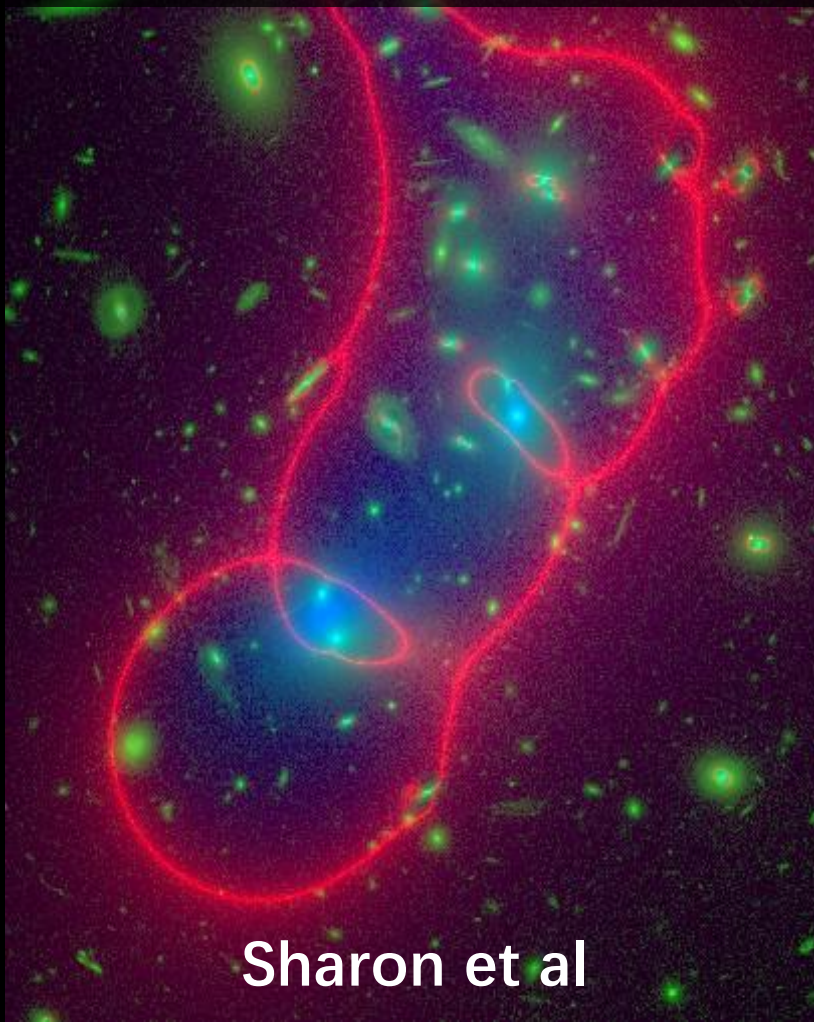
# Applications of Gravitational Lensing

- Test the theory of GR
- Find exo-planets



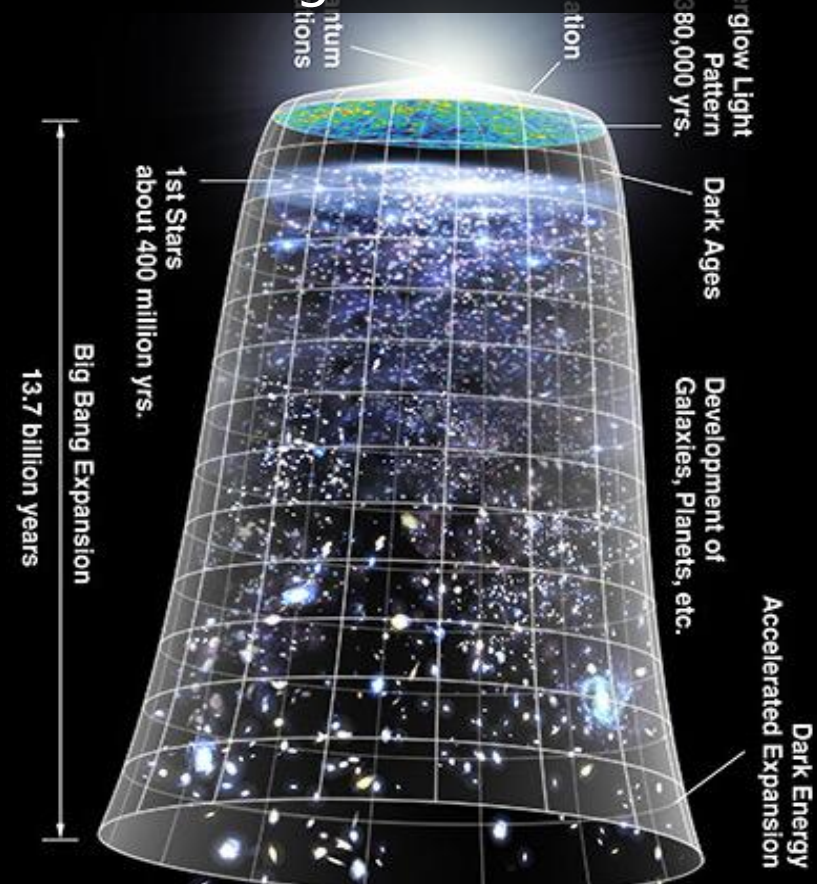
Artwork by Dave Jarvis

- Mass distribution of lenses
- Dark matter substructures



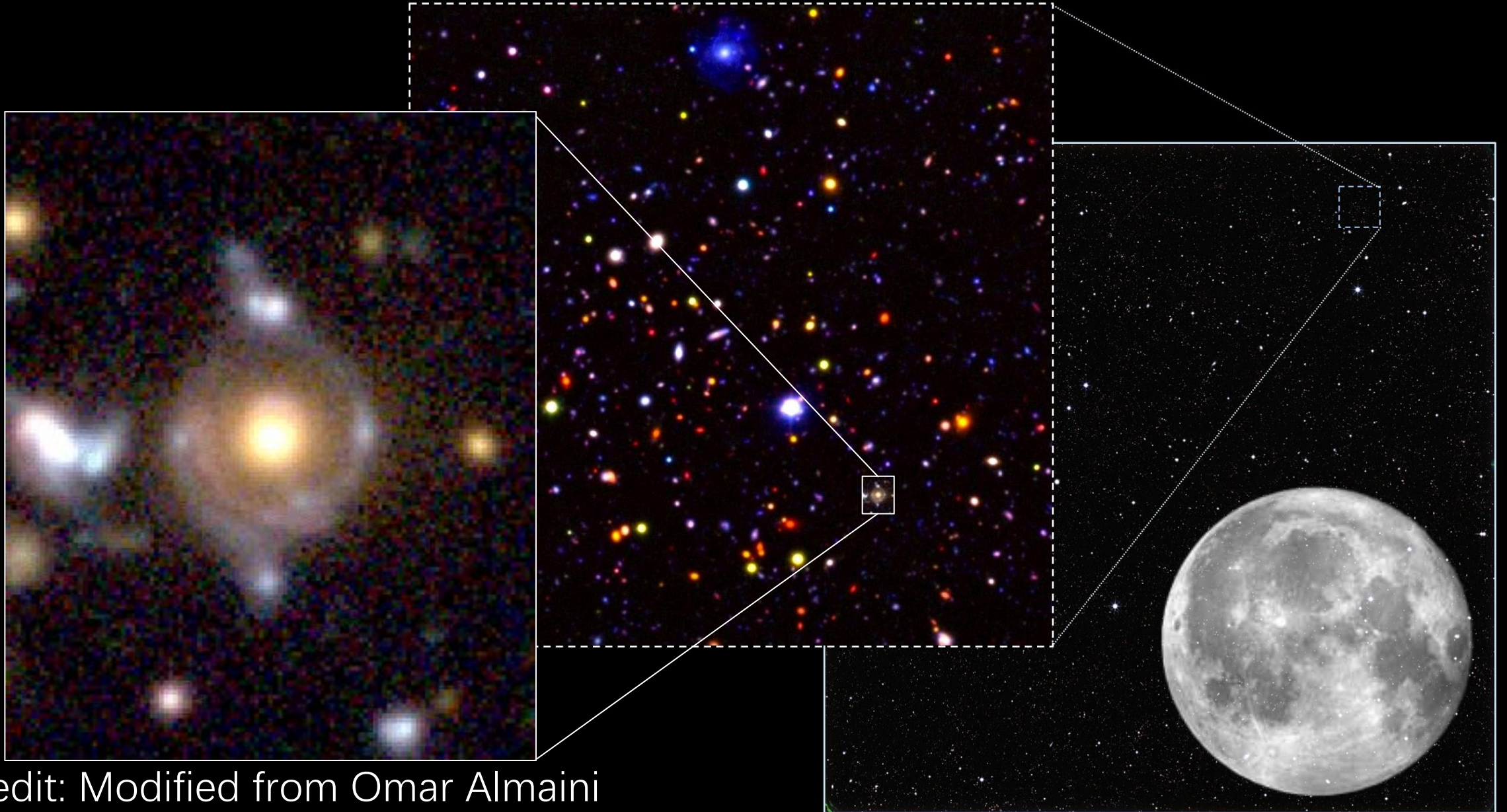
Sharon et al

- Structure Formation History
- Cosmological Parameters

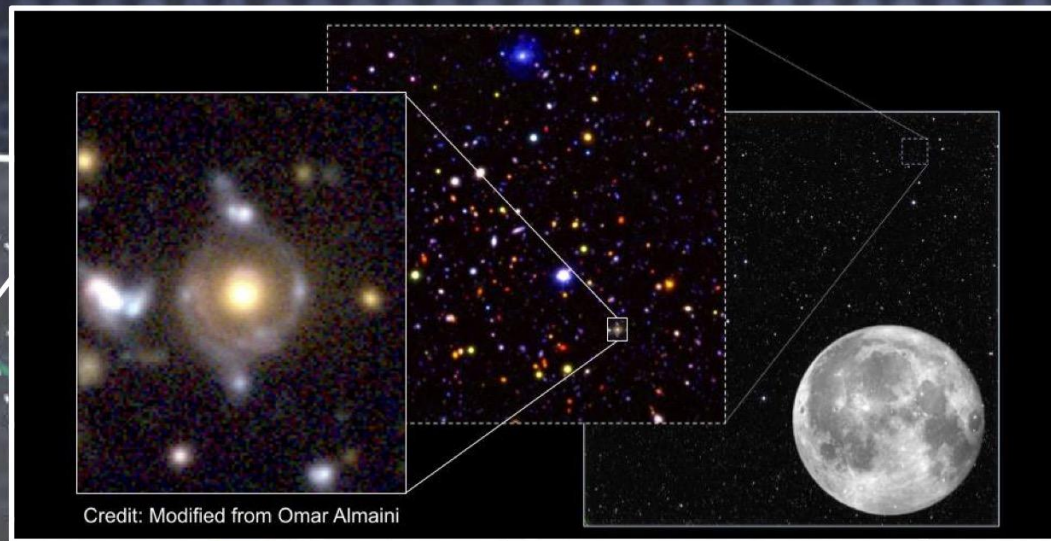
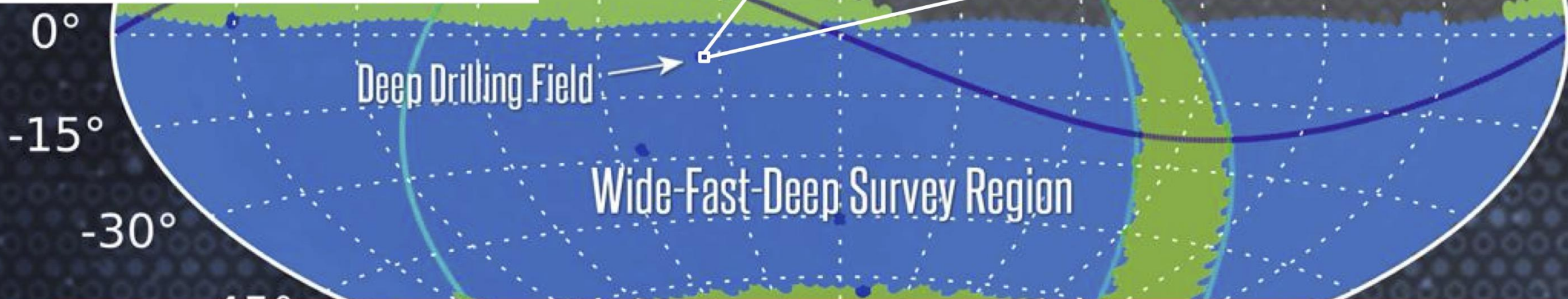
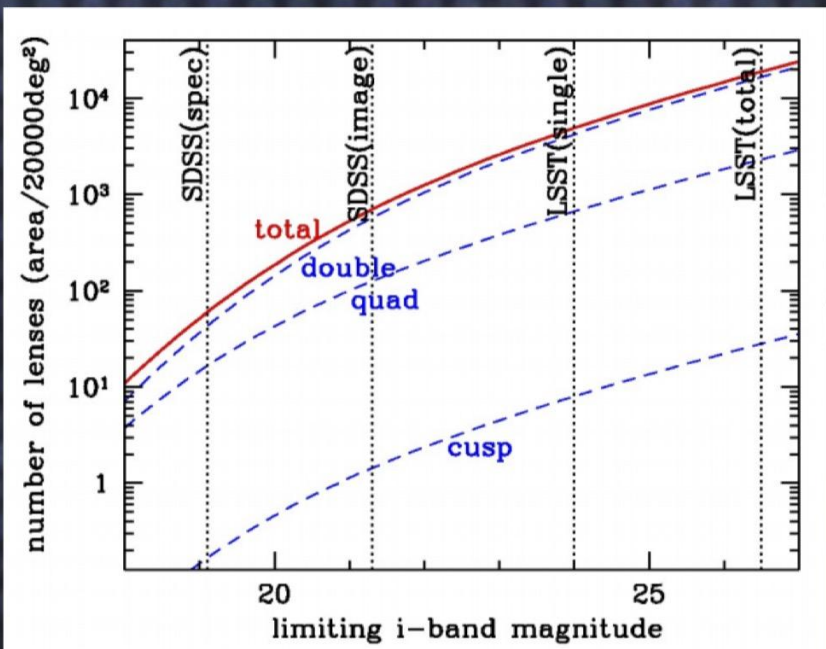


NASA/WMAP Science Team

*“Looking for needles in a haystack.”*



Credit: Modified from Omar Almaini



大数据天文学时代，如何高效自动化地从十亿计的天体中辨认并建模数以万计的强引力透镜系统？？？

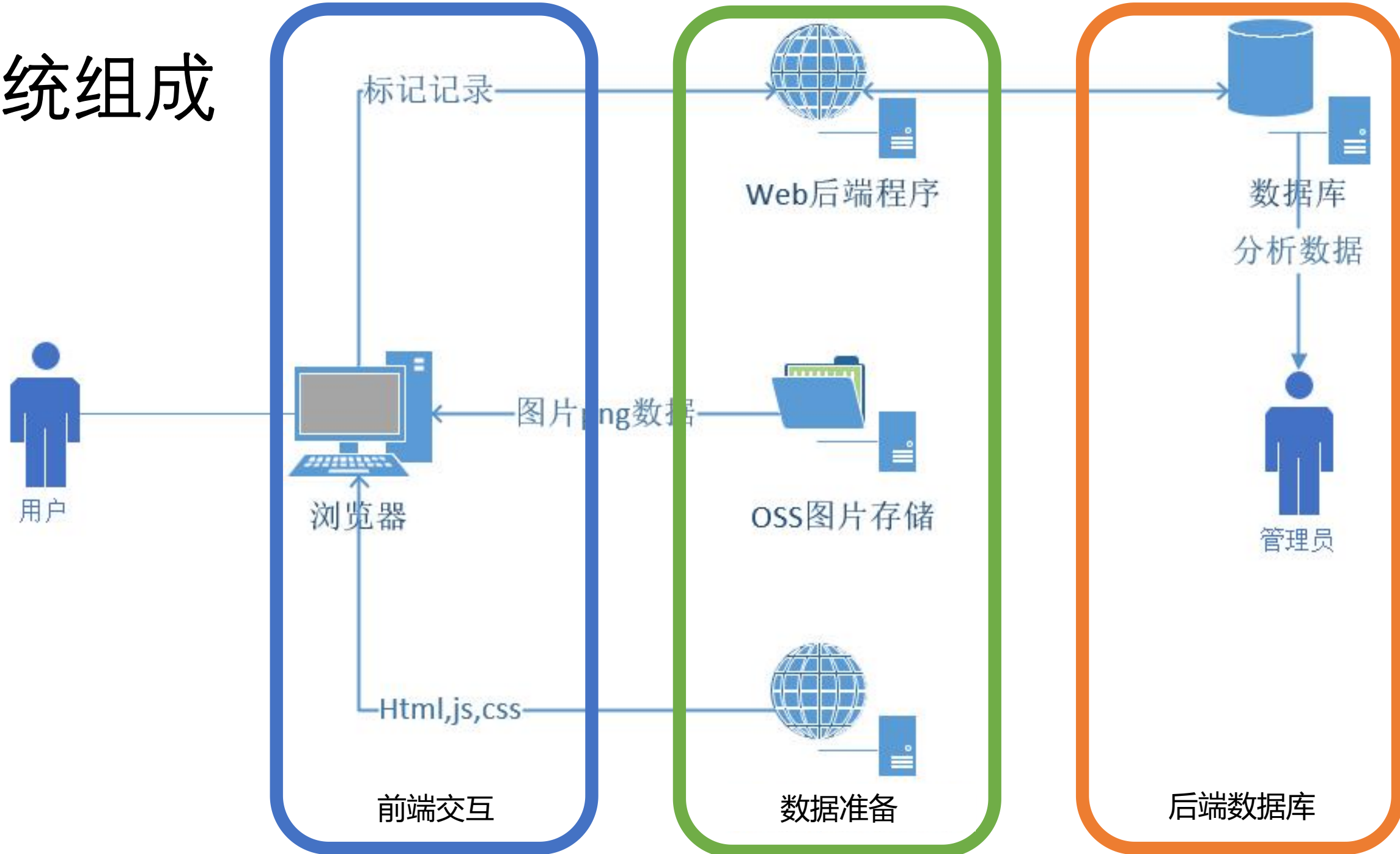
# 内容提纲

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未来计划

# 系统组成



# 团队成员

人员	负责模块
杨嘉宁	Web前端（用户接口）
邹虎	观测数据准备
吴莹	Web后端（数据收集与分析）
何紫朝	仿真数据生成
张震	系统各模块的集成、部署、和维护
崔辰州	给大家发工资

# 前端



- 教学界面
- 交互界面
- 用户中心

基于公众科学的星系团强透镜查找

操作指南

测试

团队成员

马鹏辉 邹虎 吴莹 何紫朝 李楠 杨嘉宁 张震 崔辰州

<> 排名

编号	用户名	发现数目
1	parkma1	1
2	parkma2	2
3	parkma3	3

<> Lens 成果&新闻

Lens 成果

1. 成果1
2. 成果2
3. 成果3

Lens 新闻

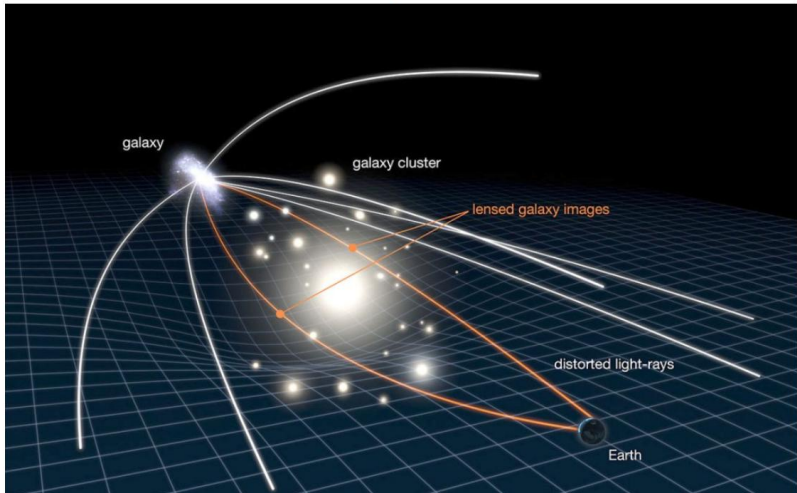
1. 新闻1
2. 新闻2
3. 新闻3



# 教学界面

引力透镜介绍 公众科学介绍 操作指南 已知目标


## What is Gravitational Lensing?



The diagram illustrates gravitational lensing. A galaxy is shown on the left, emitting light rays. These rays pass through a galaxy cluster, which acts as a gravitational well, bending the light rays. The light rays then reach Earth, appearing as distorted light rays and lensed galaxy images.

引力透镜介绍 公众科学介绍 操作指南 已知目标

## Citizen Science?



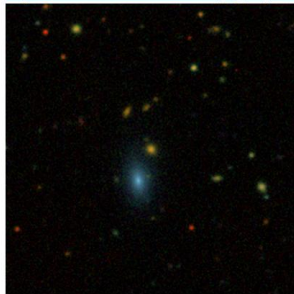
The illustration shows several people sitting at desks with computers, representing citizen scientists. They are connected to a central hub labeled 'SCIENCE', symbolizing collaborative research.

引力透镜介绍 公众科学介绍 操作指南 已知目标


1. 教程部分的引力透镜介绍、公众科学介绍可以帮助您快速了解我们
2. 已知目标包含了本项目在过去发现的目标
3. 答题通过测试获得透镜搜寻权限
4. 进入寻找页面开始引力透镜搜寻
5. 可以进入个人中心查看历史记录哦!

引力透镜介绍 公众科学介绍 操作指南 已知目标

<https://china-vo-lens.oss-cn-beijing.aliyuncs.com/images/1.png>

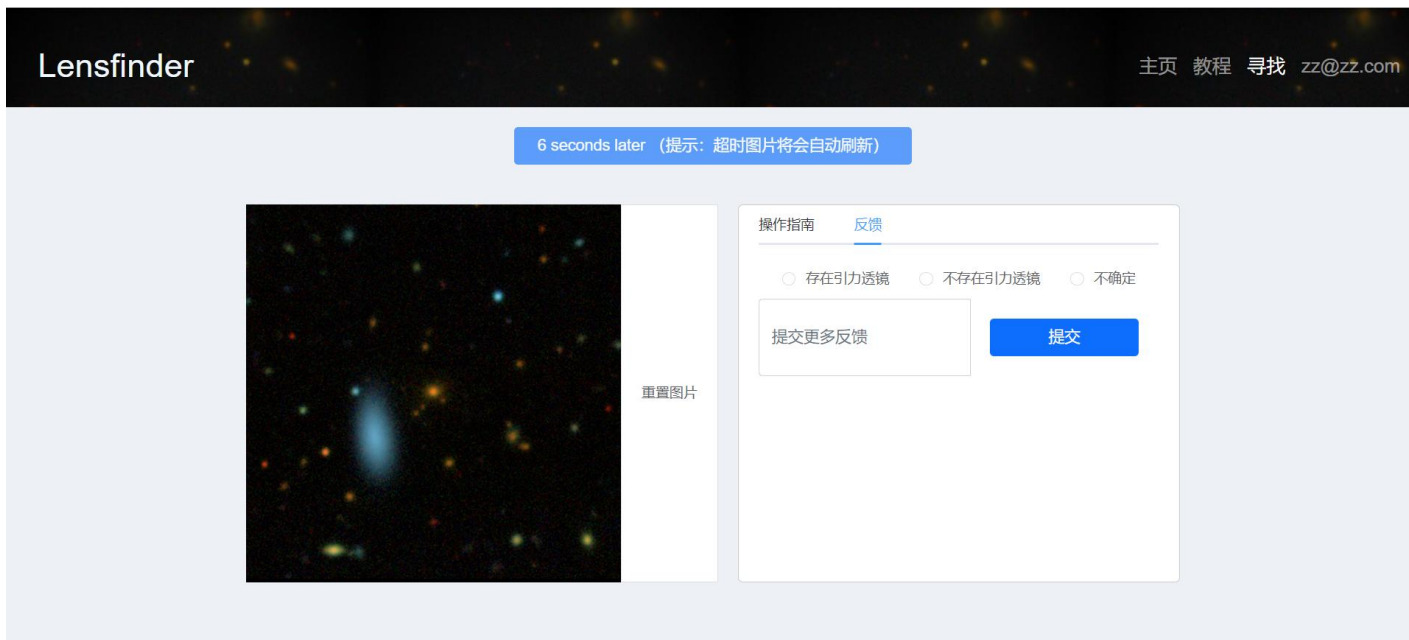
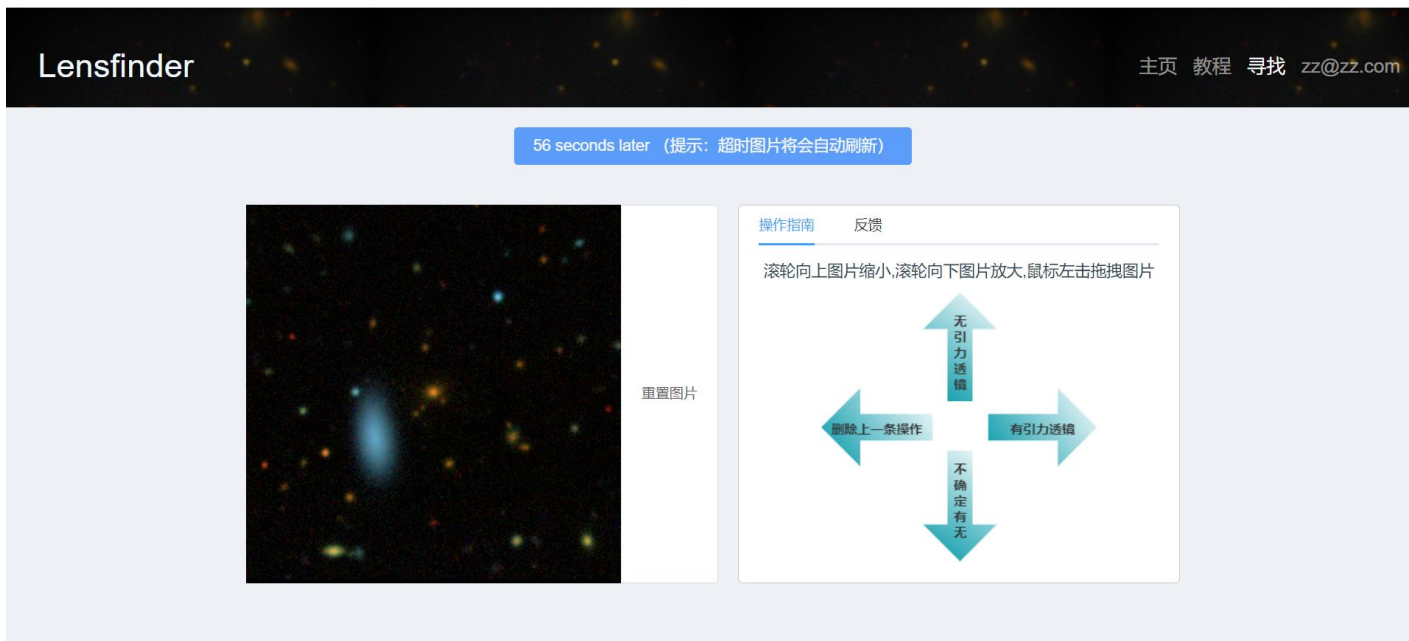


<https://china-vo-lens.oss-cn-beijing.aliyuncs.com/images/1.png>



# 交互界面:

- 快捷判断
- 提交反馈



# 个人中心

- 操作记录
- 查找成绩

Lensfinder 主页 教程 寻找 zz@zz.com

历史提交

我的成绩

编号	图片	标记	反馈	时间
628	17	false		Tue, 23 Nov 2021 14:13:23 GMT
627	47	true		Tue, 23 Nov 2021 14:13:23 GMT
626	67	true		Tue, 23 Nov 2021 14:13:23 GMT
625	15	true		Tue, 23 Nov 2021 14:22:50 GMT
624	48	true		Tue, 23 Nov 2021 14:22:50 GMT
623	72	true		Tue, 23 Nov 2021 14:13:23 GMT
622	41	true		Tue, 23 Nov 2021 14:13:23 GMT
621	67	false		Tue, 23 Nov 2021 14:13:23 GMT
620	10	true		Tue, 23 Nov 2021 14:13:23 GMT

< 1 2 3 4 5 6 ... 31 >

Lensfinder 主页 教程 寻找 zz@zz.com

历史提交

我的成绩

您的成绩是 80 分

# 数据组成

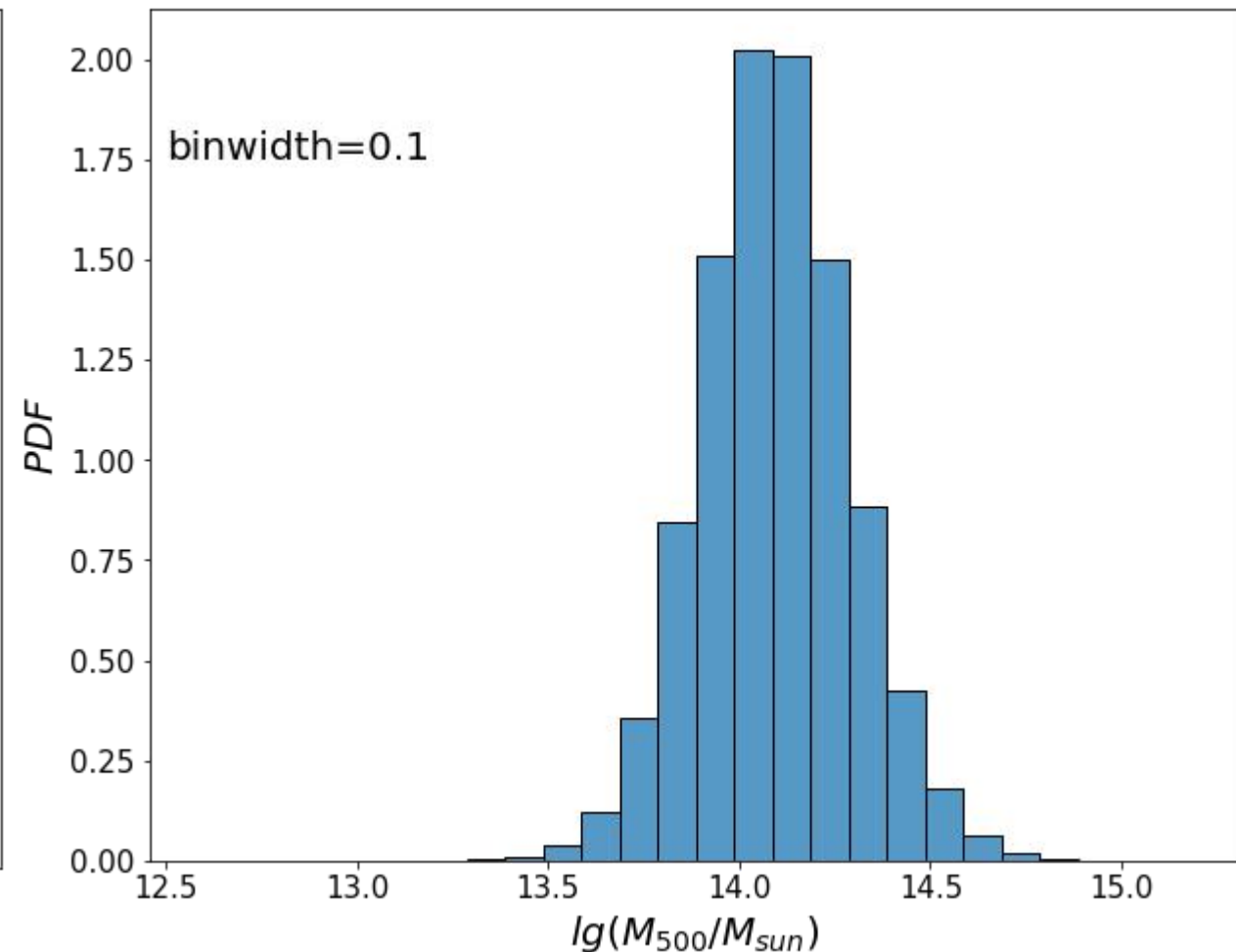
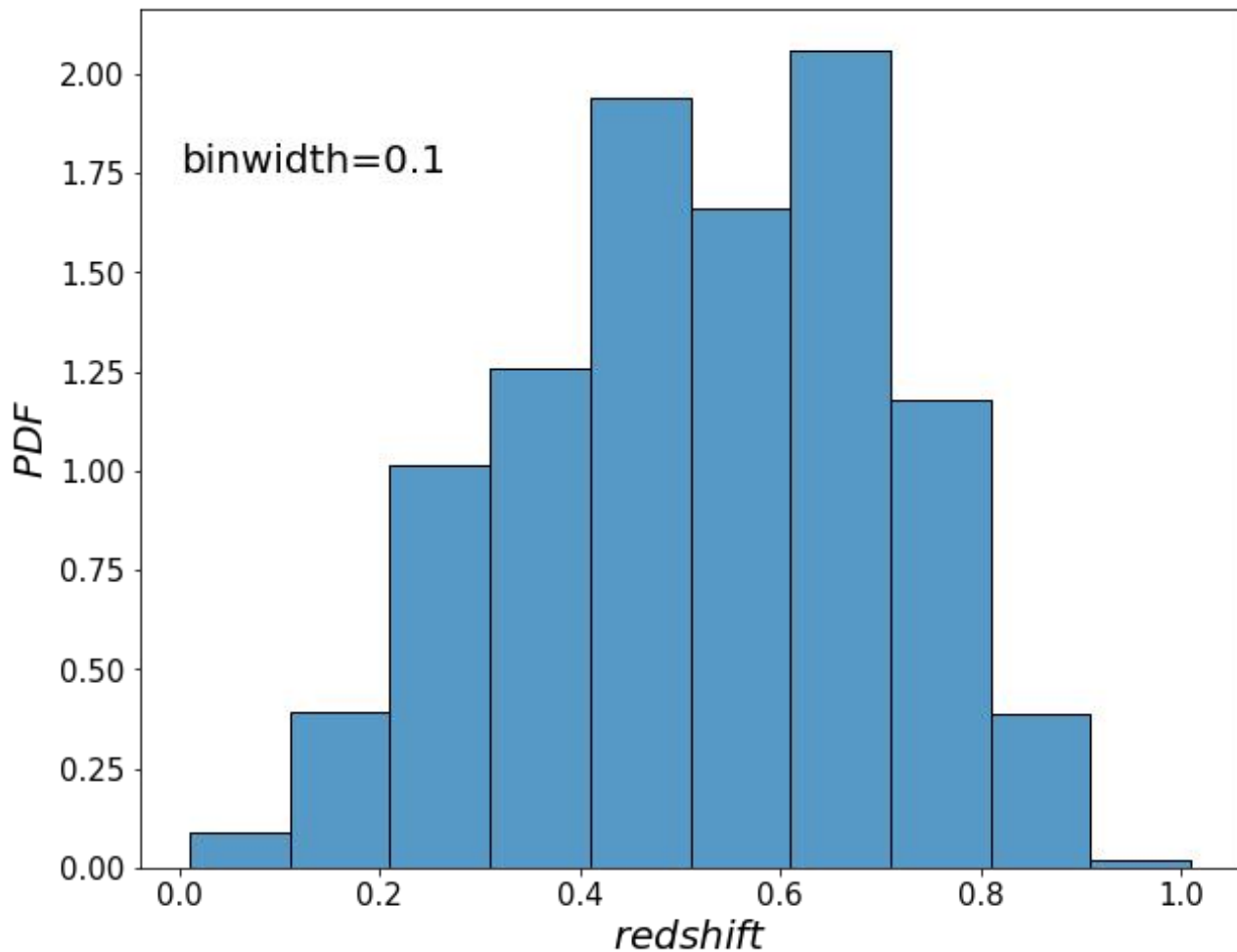
- 准备图像数据/数据分析
  - label 0: 确认过不是强透镜的Image
  - label 1: 基于真实观测叠加模拟arc的Mock Lens
  - label -1: 留待公众进行查找的Image
- 数据来源:
  - 图像: DESI Imaging Legacy Surveys DR8/DR9
  - 星表<sup>1</sup>: galaxy\_clusters\_members/desi\_galaxy\_cluster
- 具体操作:
  - 根据星表提取Image Cutouts
  - 选取Cutouts生成强透镜仿真数据

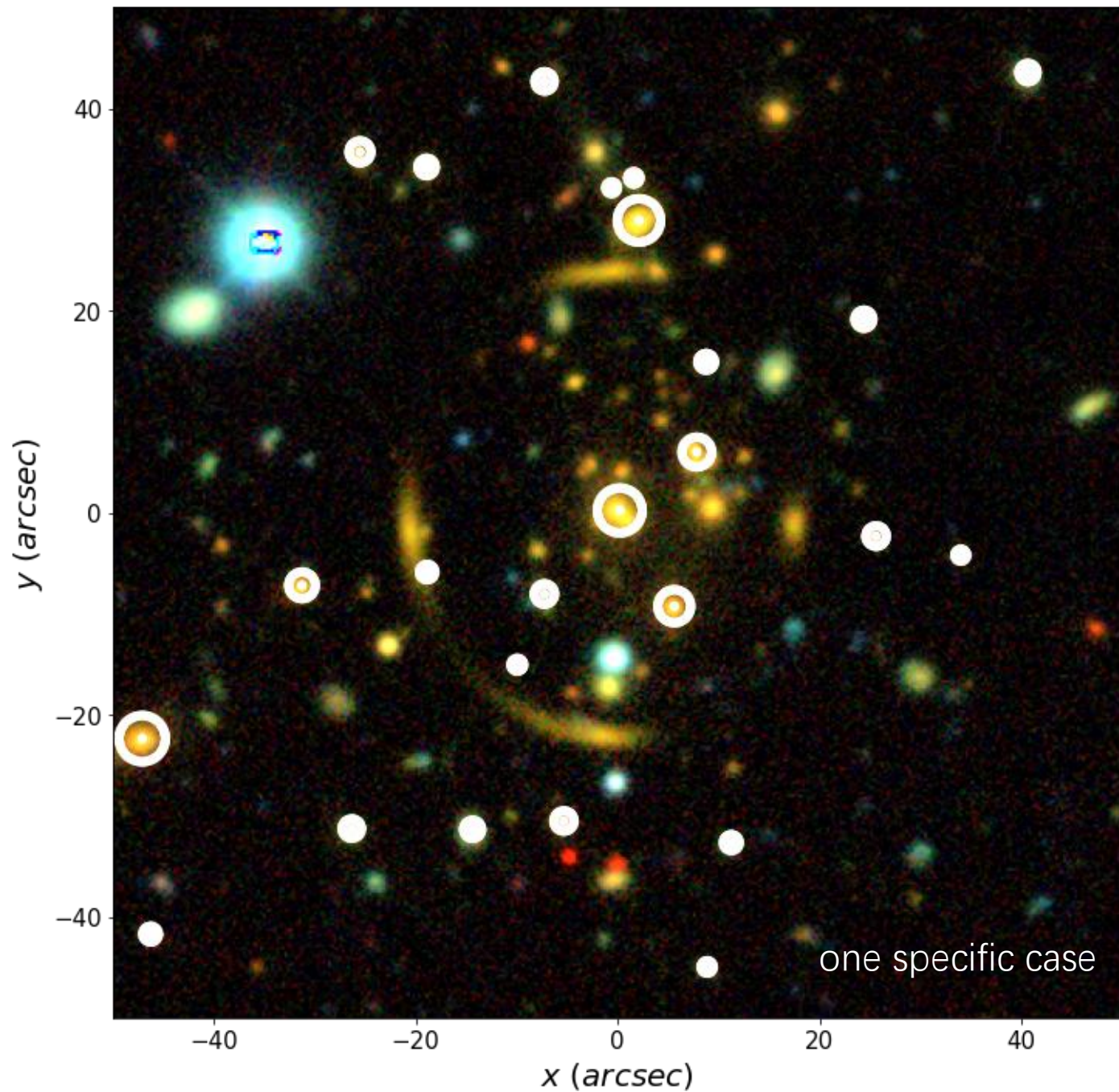
<sup>1</sup>[http://batc.bao.ac.cn/~zouhu/doku.php?id=projects:desi\\_clusters:start](http://batc.bao.ac.cn/~zouhu/doku.php?id=projects:desi_clusters:start)

星系团总数: 540432

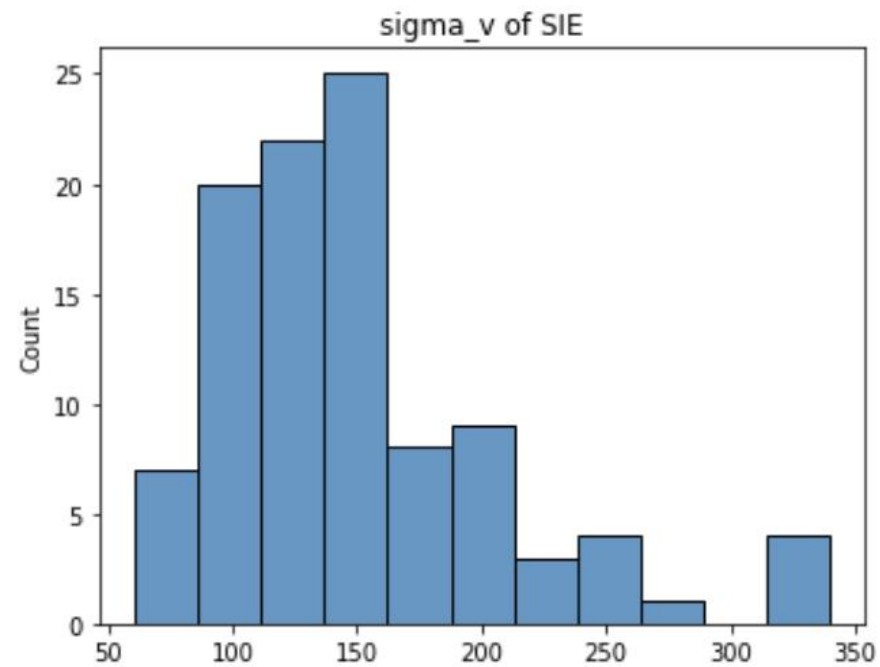
大于 $10^{14}M_{\text{sun}}$ : **369738**

number of mocks	png (color image) size	fits (3-band) size
5000	1400 MB	5500 * 3 MB

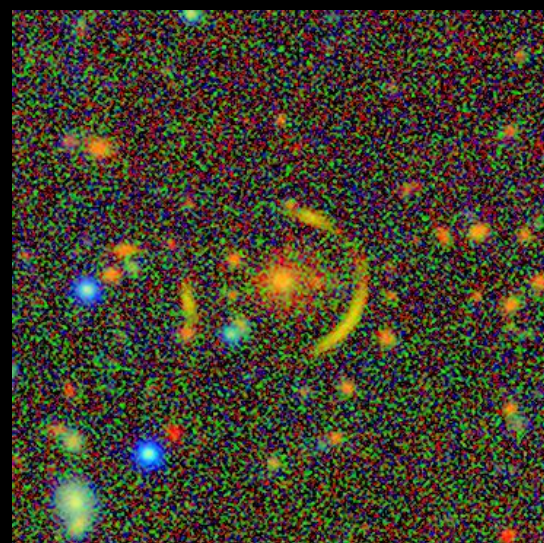
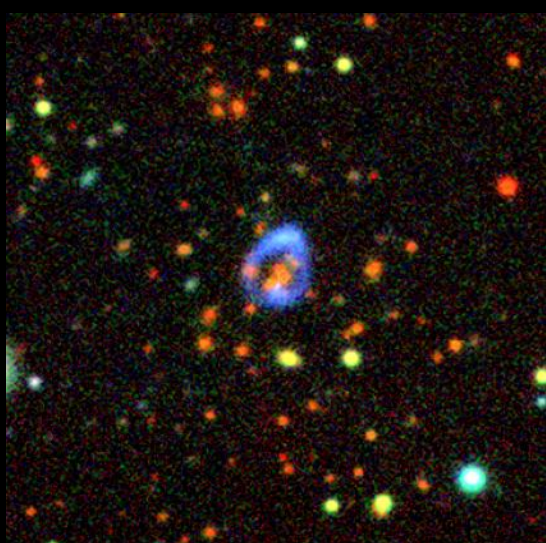
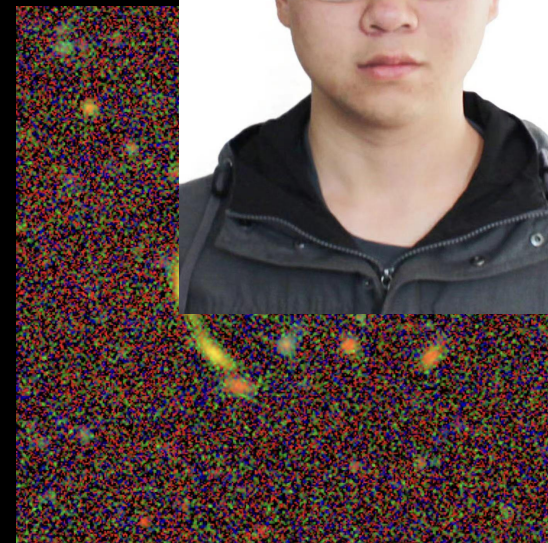
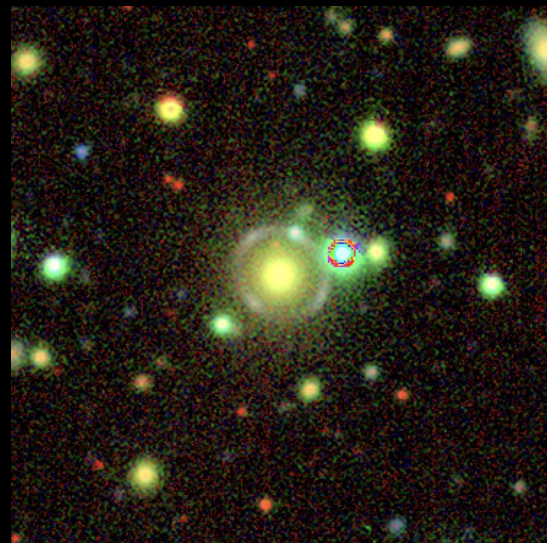




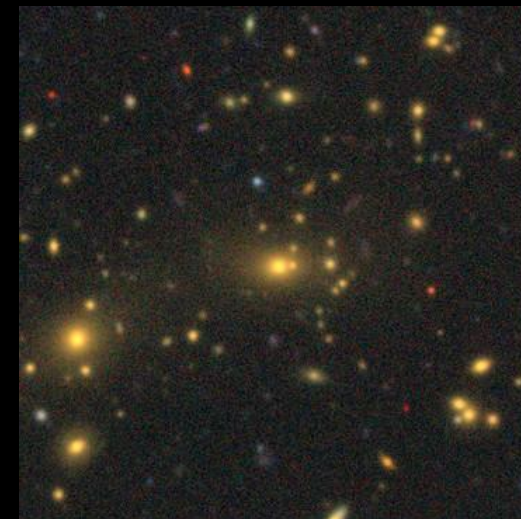
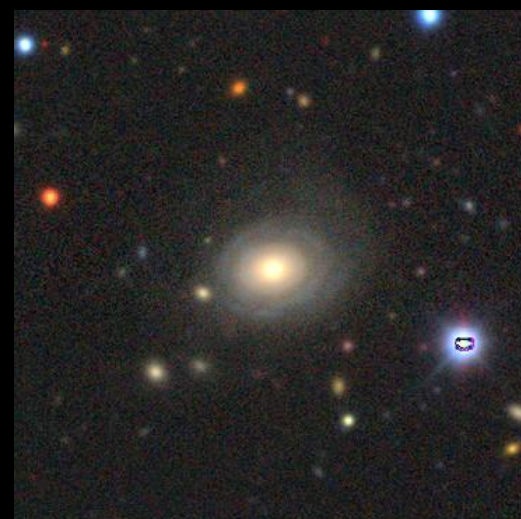
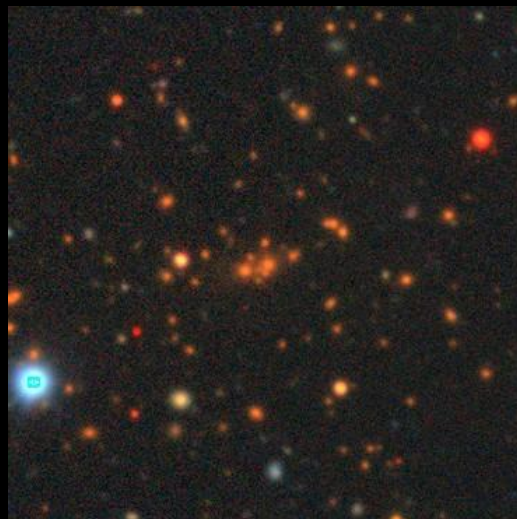
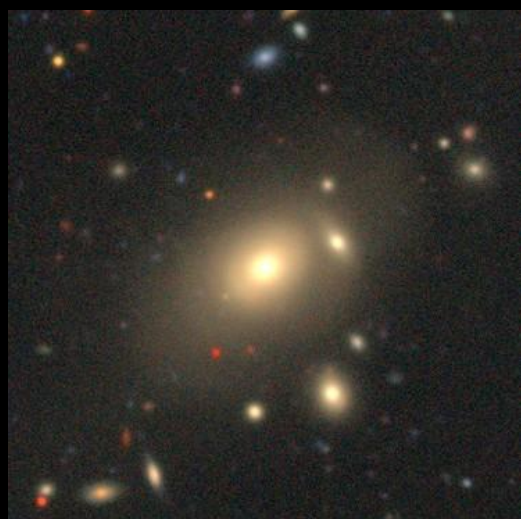
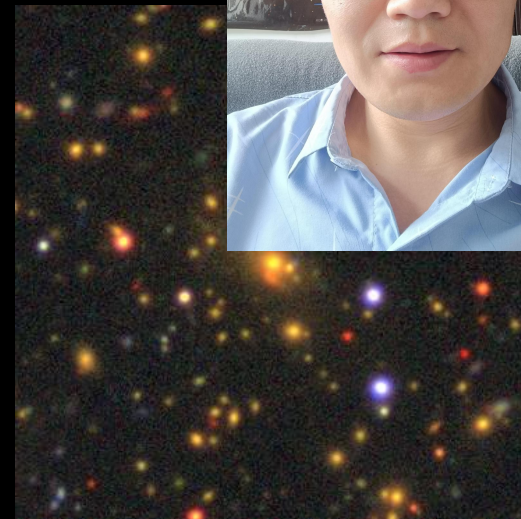
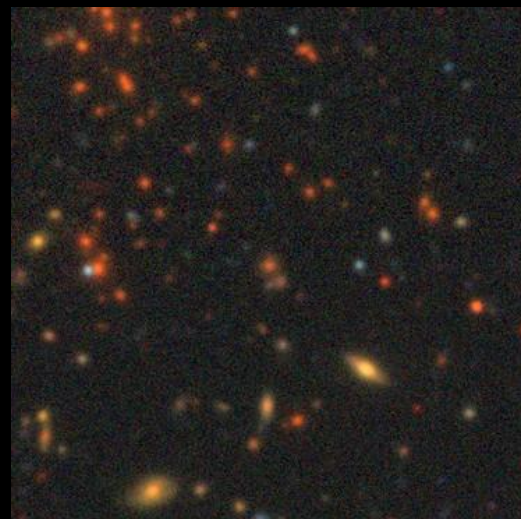
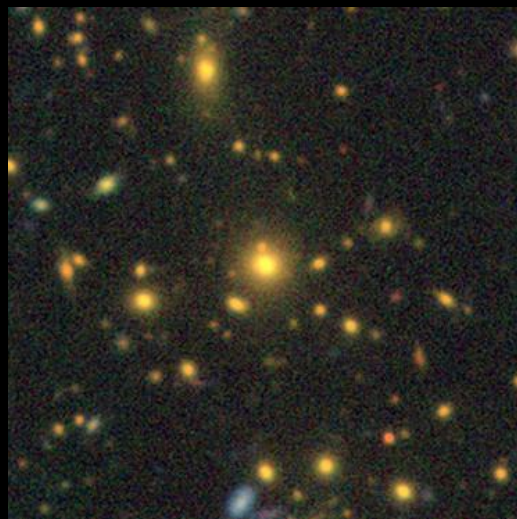
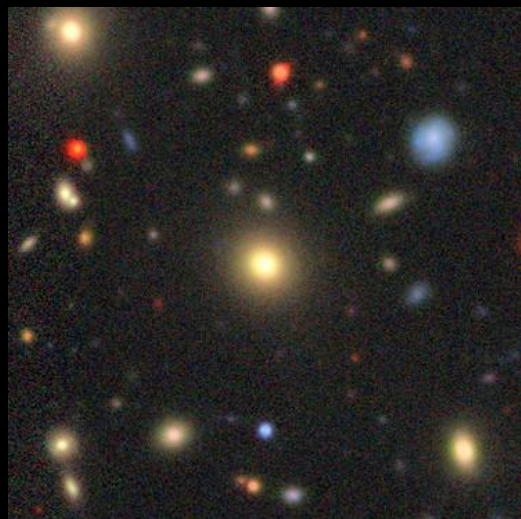
```
pixel_size: 0.27 arcsec  
q_pa_of_nfw: (0.90,11.57)  
cluster_redshift: 0.53  
cutout_size: 100 * 100 arcsec^2  
fwhm_seeing(g,r,z): (1.27,1.14,1.11) arcsec  
src_mag (gband): 26.71  
src_mag_magnified (gband): 20.92  
bcg_magg: 20.20  
cluster_idx: 3447800046  
source_position: (0.09,0.27)  
source_eff_radi: 0.52 arcsec  
source_position_angle: 142.09 deg  
source_redshift: 1.06  
m200_c200: (15.01,6.91)
```



# 仿真图像展示 (label 1)

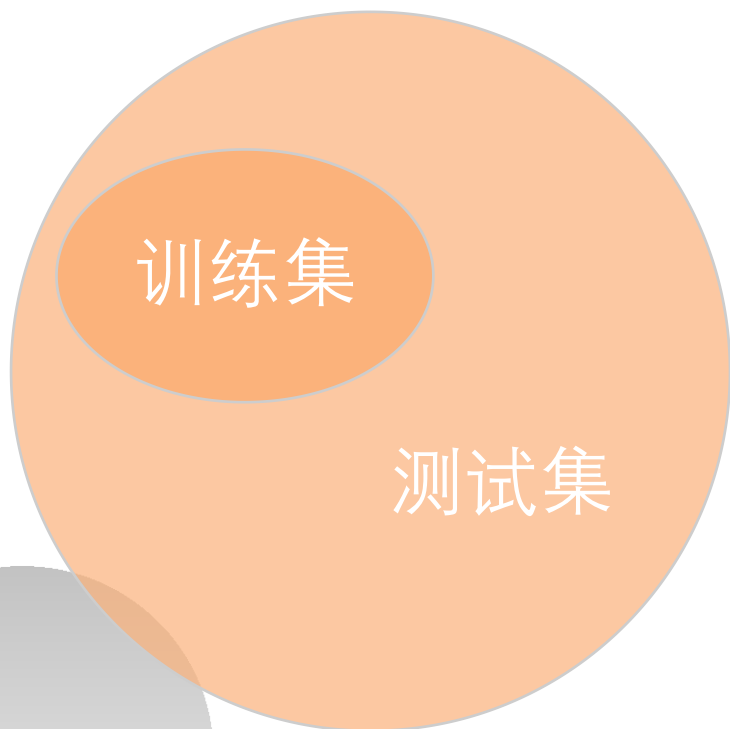
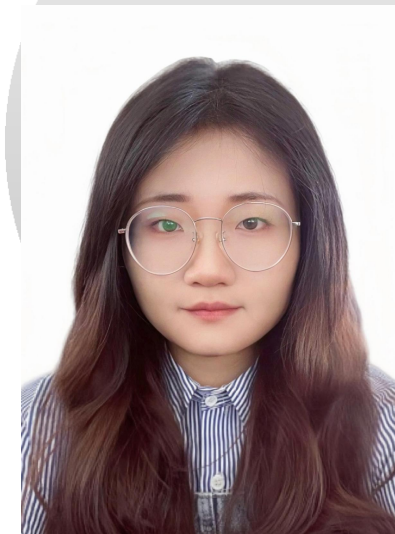


# 观测图像展示 (label 0/-1)



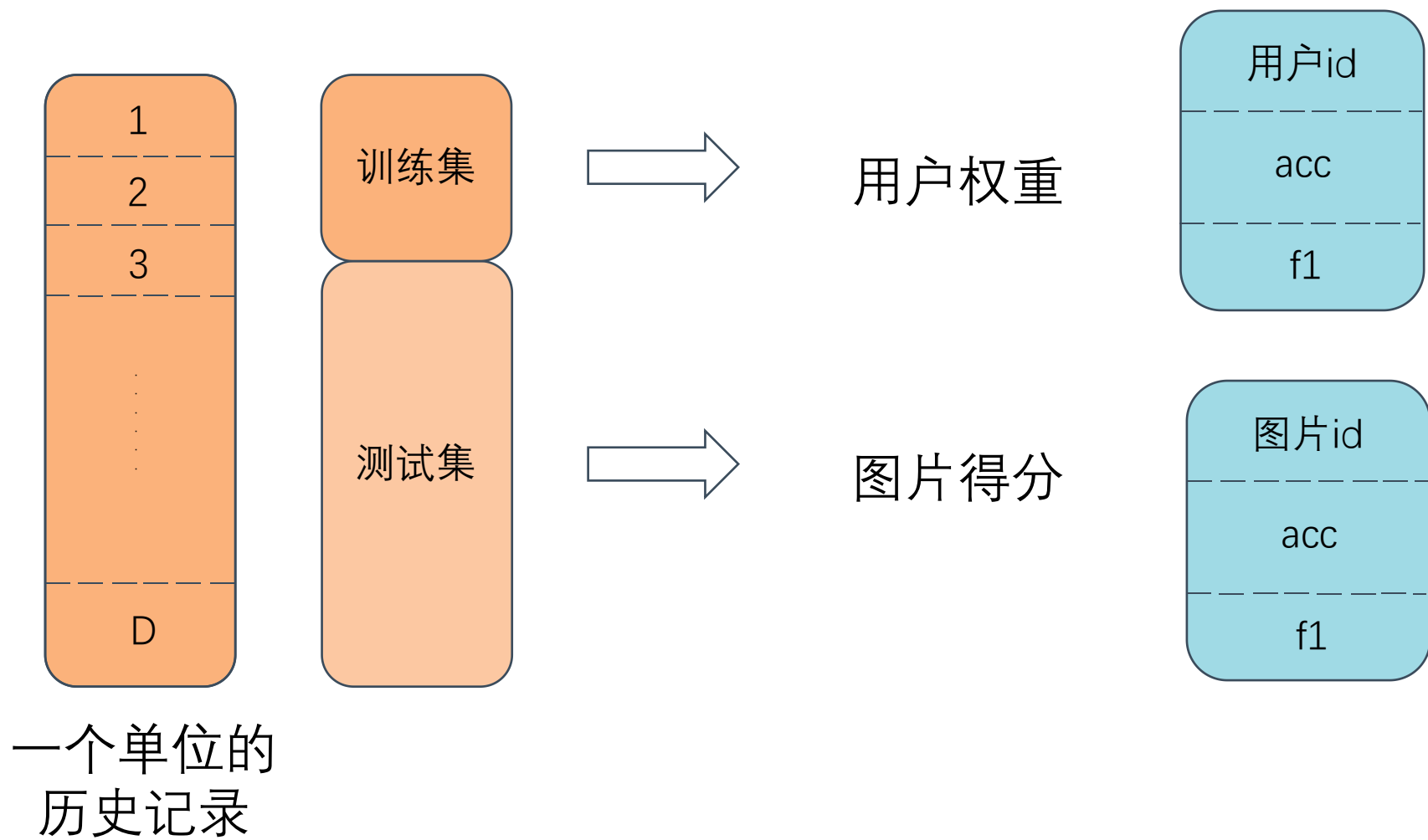


# 评估模块



	答案	用户权重	图片得分
训练集	√	√	×
测试集	×	×	√

# 评估策略



# 评估指标

		预测值	
		Positive	Negative
真实值	Positive	TP	FN
	Negative	FP	TN

准确率

$$acc = \frac{TP + FN}{TP + FP + TN + FN}$$

精确率

$$P = \frac{TP}{TP + FP}$$

召回率

$$R = \frac{TP}{TP + FN}$$

F1

$$F1 = 2 \cdot \frac{precision \cdot recall}{precision + recall} = \frac{2TP}{2TP + FP + FN}$$



47 seconds later (提示: 超时图片将会自动刷新)



重置图片

[操作指南](#)

[反馈](#)

滚轮向下图片缩小,滚轮向上图片放大,鼠标左击拖拽图片

无引力透镜

删除上一条操作

不确定有无

有引力透镜

欢迎试用和反馈  
建议到下面网页

[dpurl.org/ktbE5](http://dpurl.org/ktbE5)

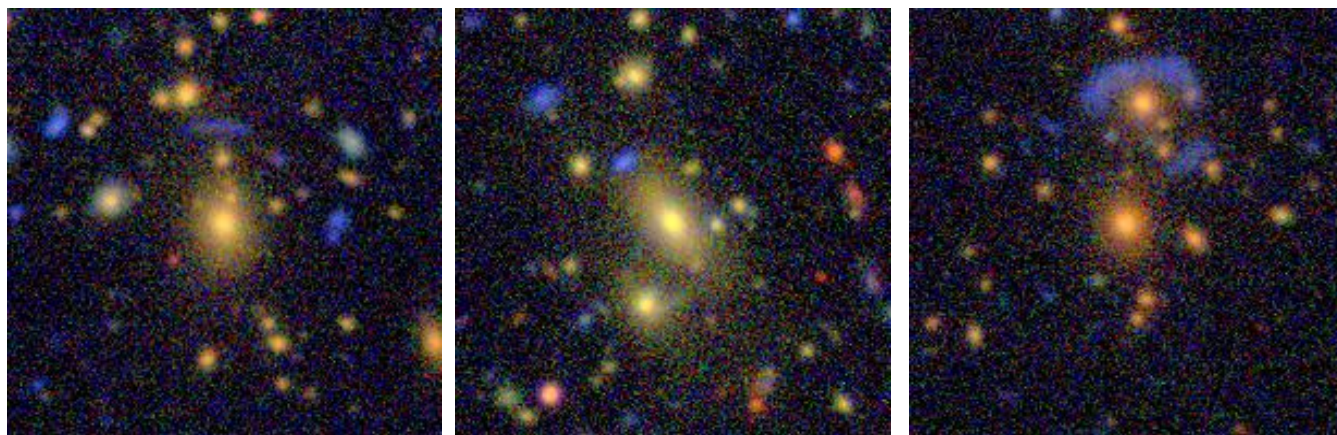
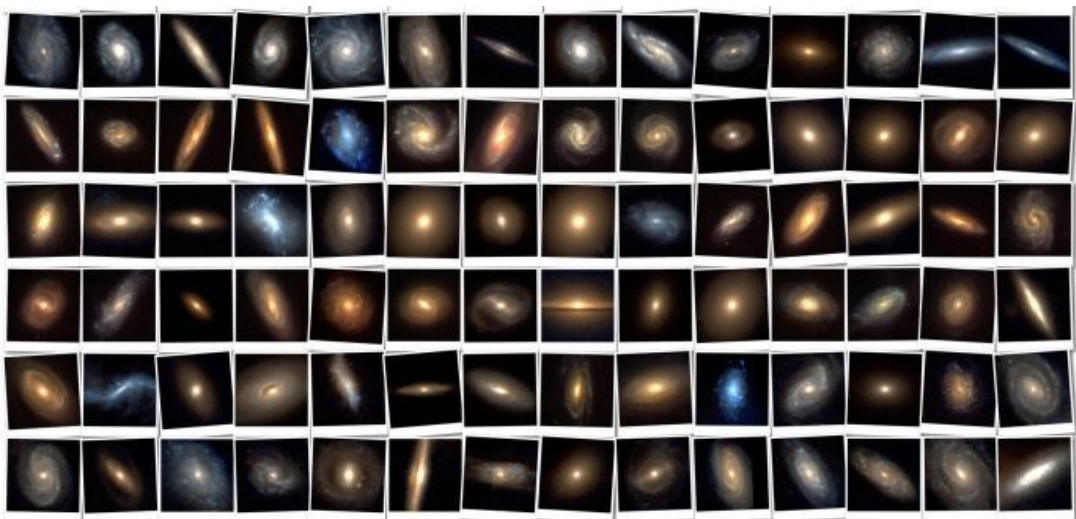
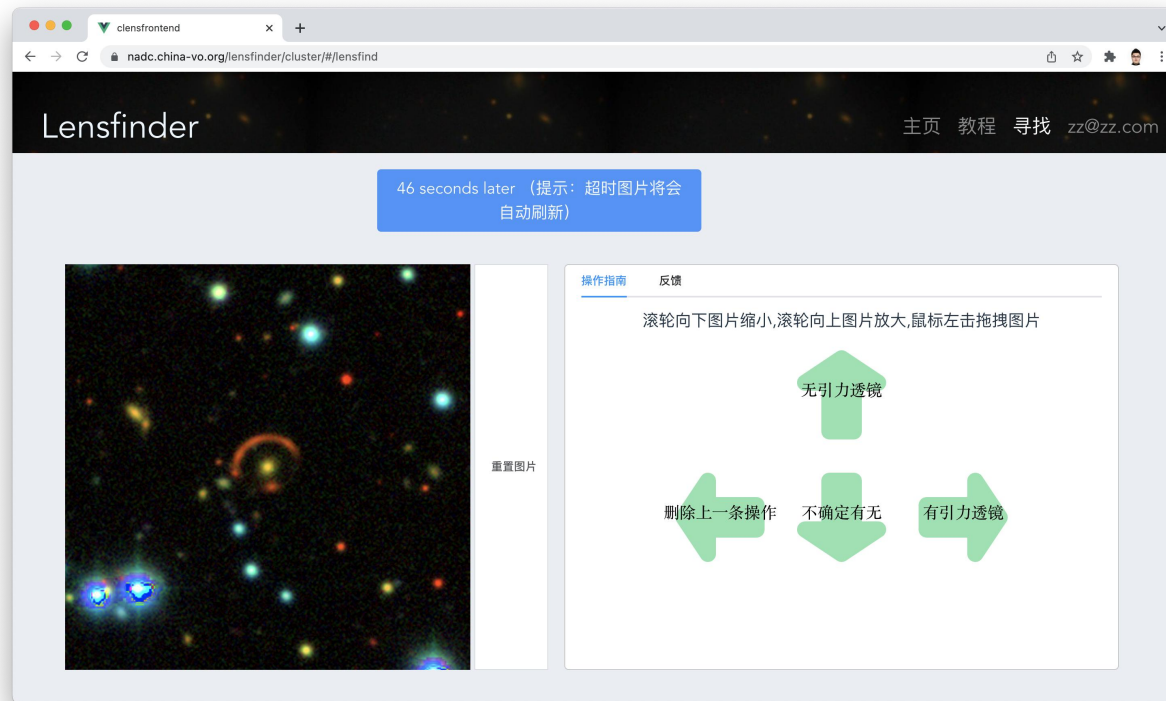
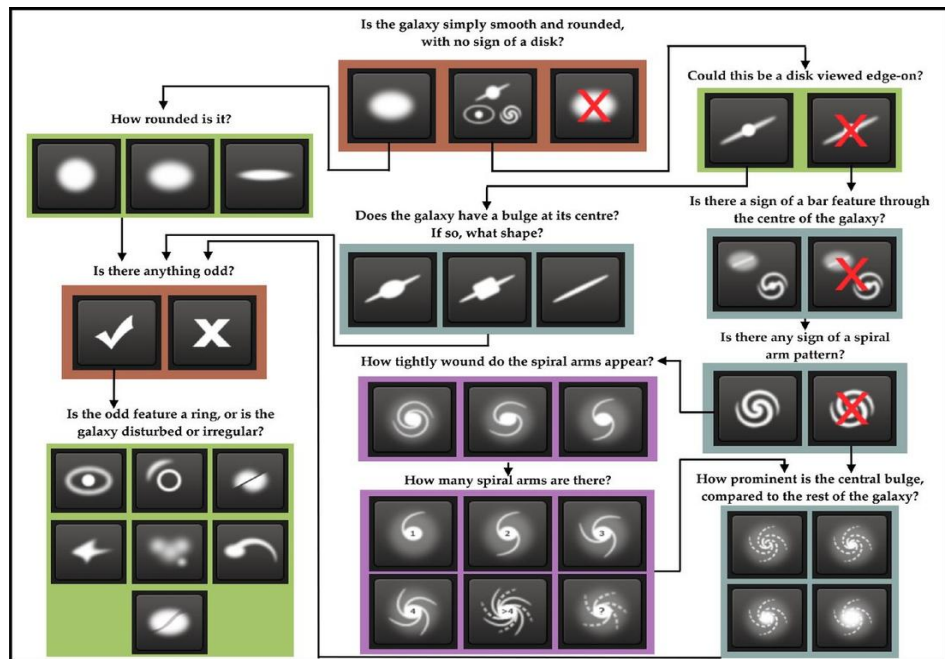
# 内容提纲

工作动机

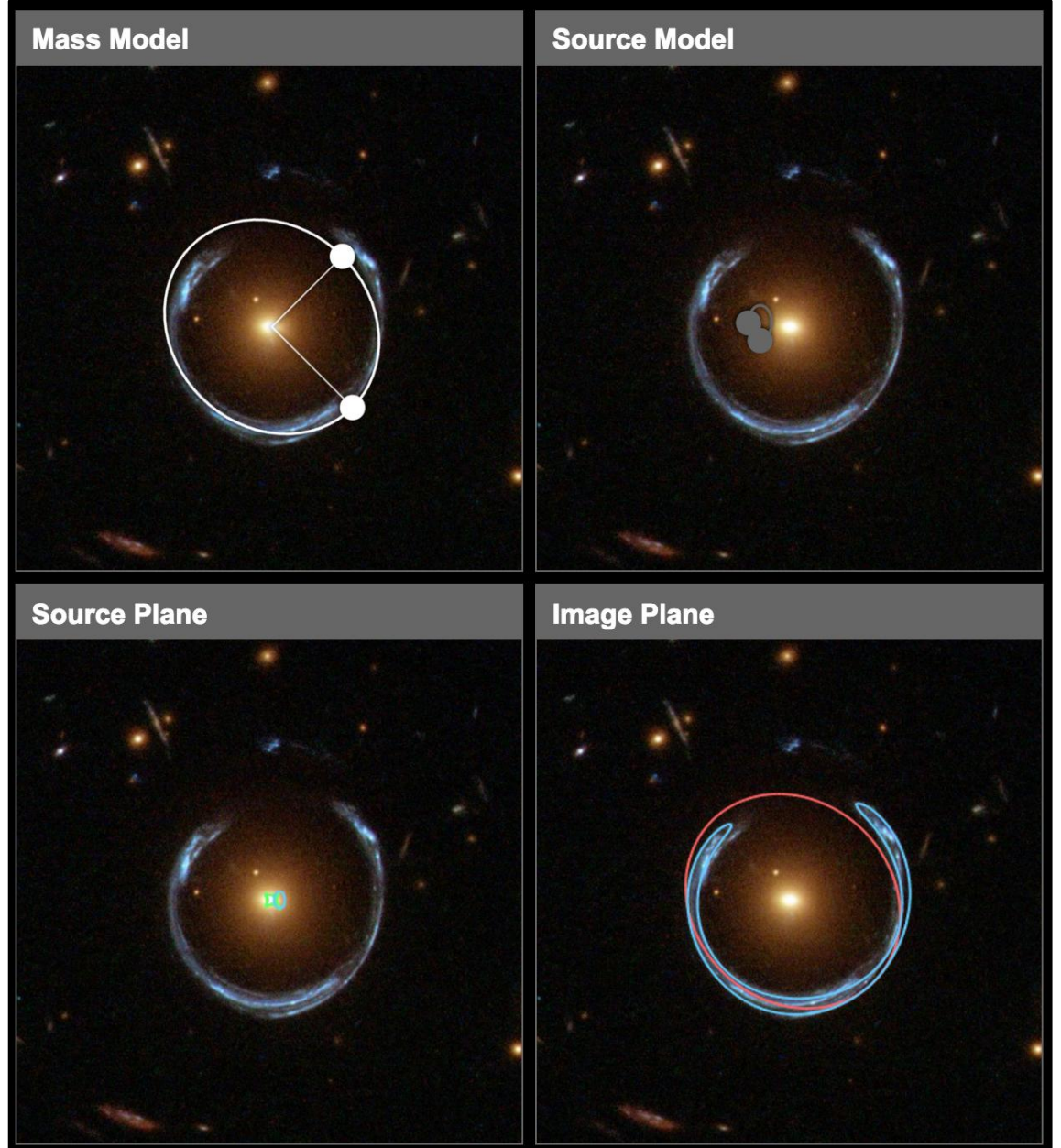
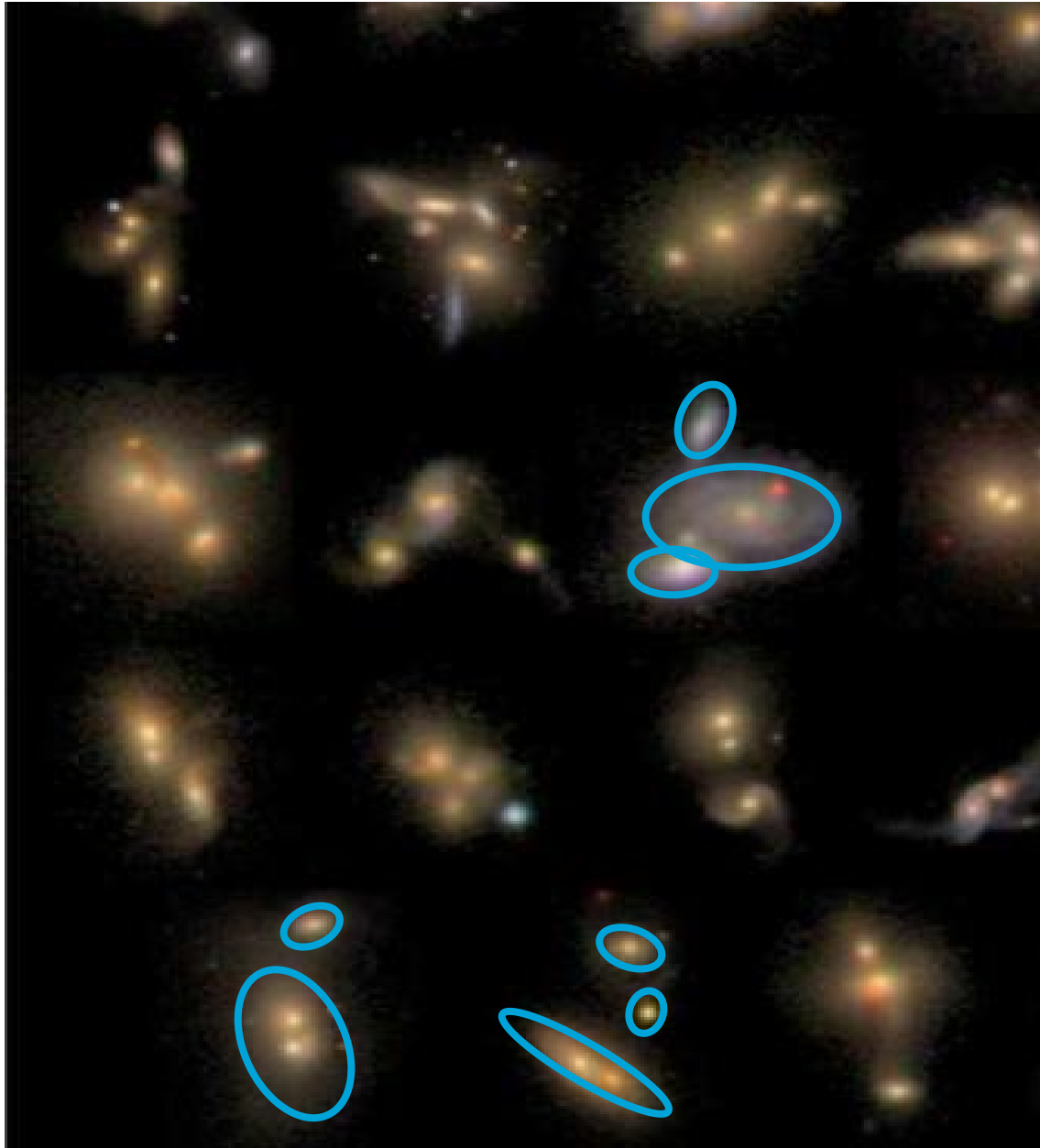
项目介绍

未来计划

# Classifying Astronomical Objects



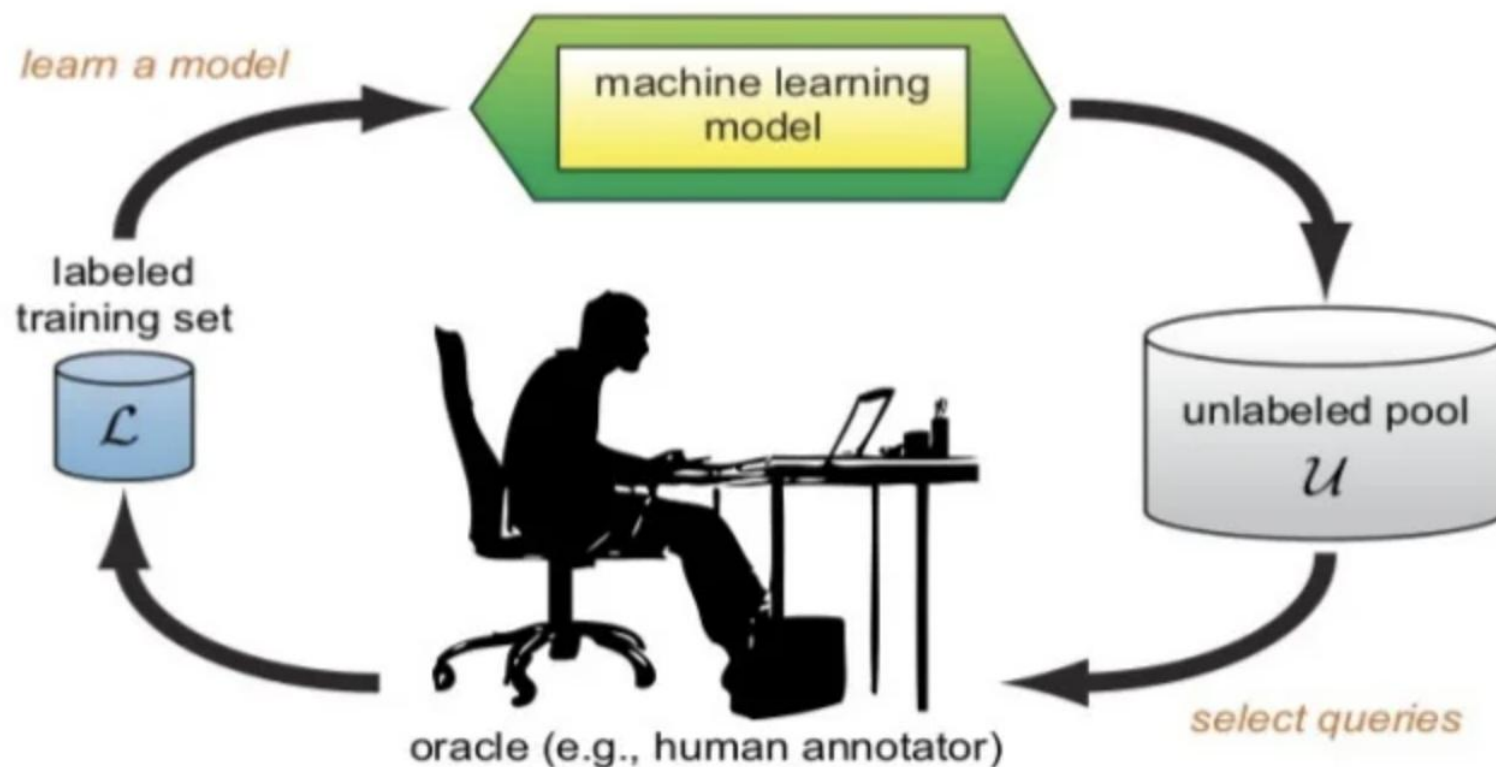
# Modeling Astronomical Objects



# Human-Machine Cooperation

## Active Learning

Somehow make the set of training examples smaller & results, more accurate.



让每一个人都  
能使用机器学  
习工具开展天  
文学研究

