Discoveries with the help of Citizen Science

Anupreeta More

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Self-Introduction

- + Grew up in India
- Research allowed me to travel across continents -Europe, USA and East Asia
- Love Ghibli Animation
 my daughter loves them too
- Enjoy interacting with public and school students
 gave a talk in a high school in Yamanashi prefecture
 - gave a talk at the US Embassy, Tokyo hosted by National Science Foundation, US

Background

Galaxy and Dark Matter



Galaxy and Dark Matter



Light

 In astronomy, light is our primary means to study the vast and distant Universe





Light

Interesting properties

- Light travels in straight line
 - can't see around the corner
- Light rays converge, diverge or deflect
 - from mirrors / water surface
 - + through a lens













Gravitational lensing

Gravity and light



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Einstein:

- Gravity manifests itself as curvature in the space-time continuum
- + Gravity deflects light

Gravity deflects light

Everyday experience

 hide behind Totoro
 (massive object - BUT not massive enough)

Gravity deflects light

Everyday experience

 hide behind Totoro
 (massive object - BUT not massive enough)

In the Universe

hide behind Totoro
 (massive enough like a galaxy)

Not possible always

What is Gravitational lensing

 Light from very distant galaxies gets deflected by nearby massive galaxies and focused towards us

Real lens system captured by Hubble Space Telescope

 Under right conditions, multiple, magnified images of the same background source are seen

Which one has a lens system?

Credit: Hubble Space Telescope

Why are lenses important

Why are lenses important

Lensing measures **mass** of the foreground galaxy enclosed within the Ring / Arc

Important for studying **Dark Matter** which is the most dominant matter component in the Universe (~ 85%)

Why are lenses important

Study of very distant, young galaxies is possible through the lensing magnification

Lens search

- Lens systems
 - rare and difficult to find
 - show a variety of image patterns, brightness, number of images, shapes
- Automated methods for finding lenses are not as efficient as we'd like them to be
- Humans are good at finding patterns amidst a wide range of background noise
 - good at finding lenses while minimising the false positives

a citizen science project to find lenses

SW TEAM

ZOONIVERSE

Principal Investigators: Phil Marshall (US), Aprajita Verma (UK), Anupreeta More (Japan)

Science Team: Chris Davis, Mike Baumer (US), Surhud More (Japan), Prasenjit Saha, Rafael Kueng, Tom Collett, Matthias Tecza (Europe)

Tech Team (Zooniverse): A. Kapadia, M. Parrish, C. Snyder, R. Simpson, D. Miller, A. Smith, E. Paget, K. Borden, C. Lintott (US and UK)

Citizen Scientists: J. Wilcox, E. Baeten, C. Macmillan, C. Cornen, L. Wright, T. Jennings and 50,000+ volunteers (World)

SW1: First lens search in the C-F-H Telescope Legacy Survey (CFHTLS)

- Data: Color images of sky taken with Canada-France-Hawaii
 Telescope were shown
 - Total: 400,000 images about 400 pixels across
- + Activity: Blind lens search
 - images have no specific targets/objects at the centre of an image
 - identify anything that could look like a lens
- Aim: Beat the robots
 - + Find lenses that are missed by lens finding algorithms

SW Interface

SW Interface

SW Interface

Lens candidates from SW1

About 60 new lens candidates discovered About 100 known lens candidates recovered

Marshall et al. 2016 (arxiv.org/abs/1504.06148) and More et al. 2016 (arxiv.org/abs/1504.05587)

SW2 with BBC Stargazing Live

- 3-day event on TV on data from
 VICS82 survey (Optical
 +InfraRed)
- Images of 40,000 candidates
- Record breaking classification rate (One million per hour) in the history of Zooniverse

SW2 with BBC Stargazing Live

- Extensive follow up of 9io9 with optical, submillimetere and radio telescopes across the world (Geach, More et al. 2015, arxiv.org/abs/1503.05824)
 - impossible without the support of thousands of citizen scientists

9io9

Zooniverse (sub) community

Location of ALL zooniverse volunteers

** based on a survey of 300 volunteers

Zooniverse (sub) community

Employment

View of their own participation

** based on a survey of 300 volunteers

What next?

Next lens searches

- Lens search in the Hyper-Suprime Cam Survey (HSC) led by Japan
 - Status of observations: First year data (130 sq. deg.) is available and can be used for citizen science
 - Status of SW: updating interface and software for faster analyses
 - + Plans to translate website to Japanese
- Extraordinary times ahead !!!!!
 - Total number of lenses known since the discovery of first lens: ~ 500 (in 35yrs)
 - + HSC survey will find ~ a few 1000s (in 5yrs)
 - allow us to answer many important scientific questions with YOUR help

Thanks!

Credits (for the template used in this presentation)

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- Presentation template by <u>SlidesCarnival</u>
- Photographs by Unsplash
 - Paper backgrounds by <u>SubtlePatterns</u>

Useful Links

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