Interrogating Methodologies
UCSB April 18, 2014
Exploring Boundaries in Art & Science

GalaxyZoo and the Zooniverse of Astronomy Citizen Science

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ZOONIVERSE

1,061,027 people taking part worldwide

All | Space | Climate | Humanities | Nature | Biology

Space

Sort by Category

How do galaxies form?

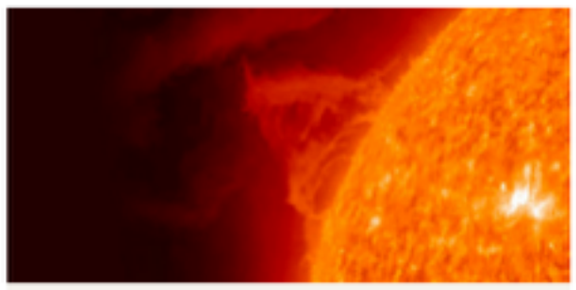
NASA's Hubble Space Telescope archive provides hundreds of thousands of galaxy images.

GALAXY ZOO

Explore the surface of the Moon

We hope to study the lunar surface in unprecedented detail.

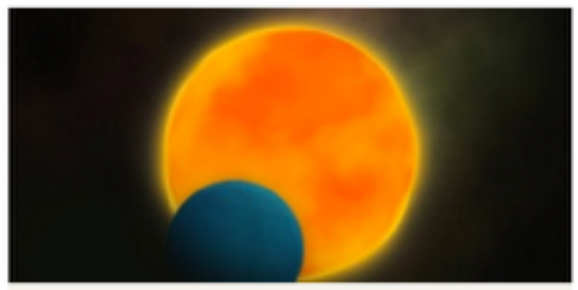
MOON ZOO



Study explosions on the Sun

Explore interactive diagrams to learn about the Sun and the spacecraft monitoring it.

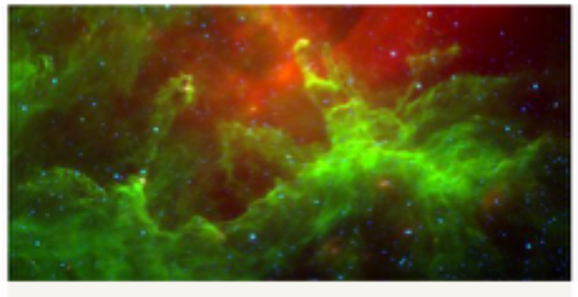
SOLAR STORMWATCH



Find planets around stars

Lightcurve changes from the Kepler spacecraft can indicate transiting planets.

planethunters.org



How do stars form?

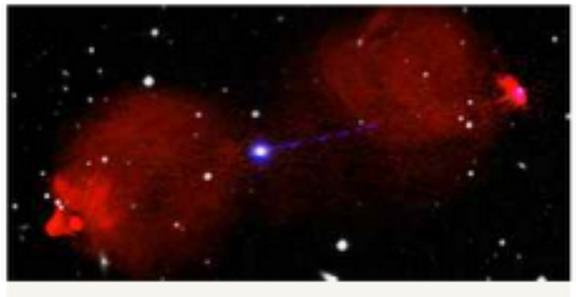
We're asking you to help us find and draw circles on infrared image data from the Spitzer Space Telescope.

THE MILKY WAY PROJECT

Explore the Red Planet

Planetary scientists need your help to discover what the weather is like on Mars.

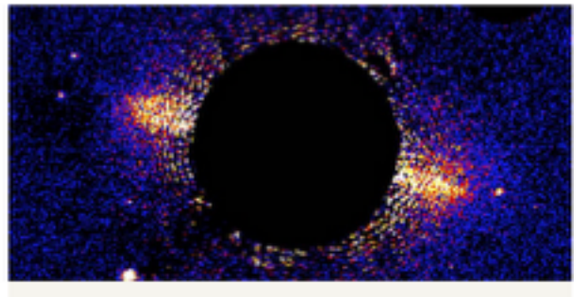
PLANET FOUR



Match growing black holes to their jets

We need help to compare infrared and radio data to spot black holes in the Universe.

RADIO GALAXY ZOO



Find the Birthplace of Planets

Help comb our galaxy, looking for stars that could be harbouring planet-forming disks.

DISK DETECTIVE

Few have witnessed what you're about to see

Experience a privileged glimpse of the distant universe as observed by the SDSS, the Hubble Space Telescope, and UKIRT

GALAXY ZOO QUENCH

We are trying something new! Come help us understand a very specific type of galaxy and experience science from start to end. Take part

Classify Galaxies

To understand how galaxies formed we need your help to classify them according to their shapes. If you're quick, you may even be the first person to see the galaxies you're asked to classify.

Begin Classifying

How Do Galaxies Form?

Roughly one hundred billion galaxies are scattered throughout our observable Universe, each a glorious system that might contain billions of stars. Many are remarkably beautiful, and the aim of Galaxy Zoo is to study them, assisting astronomers in attempting to understand how the galaxies we see around us formed, and what their stories can tell us about the past, present and future of our Universe as a whole. MORE

History of Galaxy Zoo

The launch of this new version of Galaxy Zoo, the 4th, comes just a few weeks after the site's 5th birthday. It all started back in July 2007, with a data set made up of a million galaxies imaged by the Sloan Digital Sky Survey, who still provide some of the images in the site today. With so many galaxies, we'd assumed it would take years for visitors to the site to work through them all, but within 24 hours of launch we were stunned to be receiving almost 70,000 classifications an hour. In the end, more than 50 million classifications were received by the project during its first year, contributed by more than 150,000 people. MORE

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That meant that each galaxy was seen by many different participants. This is deliberate; having multiple independent classifications of the same object is important, as it allows us to assess how reliable our results are. For example, for projects where we may only need a few thousand galaxies but want to be sure they're all spirals before using up valuable telescope time on them, there's no problem - we can just use those that 100% of classifiers agree are spiral. For other projects, we may need to look at the properties of hundreds of thousands of galaxies, and can use those that a majority say are spiral.

In that first Galaxy Zoo all we asked volunteers to do was to split the galaxies into ellipticals, mergers and spirals and - if the galaxy was spiral - to record the direction of the arms. But it was enough to show that the classifications Galaxy Zoo provides were as good as those from professional astronomers, and were of use to a large number of researchers. Perhaps the most exciting sign of success is the fact that we've been successful in bidding for time on some of the largest telescopes in the world to follow up on many Galaxy Zoo discoveries, including the Hubble Space Telescope.

Galaxy Zoo 2 was inspired by our newfound confidence in the ability of our volunteer classifiers, and so we asked for a closer look at just over 200,000 of the brightest of the Sloan galaxies. We asked about the number of spiral arms, the size of the galaxies' bulges and much else besides. In the 14 months the site was up we received a little more than 60 million classifications.

The site's third incarnation, **Galaxy Zoo: Hubble** drew from surveys conducted by the Hubble Space Telescope to view earlier epochs of galaxy formation. In these surveys, which involve many, many days of dedicated observing time, we can see light from galaxies which has taken billions of years to reach us. The idea behind Galaxy Zoo: Hubble was to be able to compare galaxies then to galaxies now, giving us a clear understanding of what factors influence their growth, whether through mergers, active black holes or simply star formation.

Galaxy Zoo 4 combines new imaging from Sloan with distant images from Hubble's CANDELS survey. The CANDELS survey makes use of the new Wide Field Camera 3 - installed during the final shuttle mission to Hubble - to take ultra-deep infrared images of the Universe. CANDELS is sending my group's simulated galaxy images to Galaxy Zoo to be classified and compared with real Hubble galaxy images, to help us see how similar (or different) they are.

If you decided that the galaxy is spiral, then you will also be asked to determine whether it spins clockwise or anti-clockwise with respect to an observer in our galaxy.

With face-on spiral galaxies, this is a very easy task. The clockwise and anti-clockwise rotating galaxy look like this:

This is a **clockwise**, face-on spiral galaxy

This is an **anti-clockwise**, face-on spiral galaxy

And, by the way, you are right, we did use just two mirror images of the same galaxies to make the difference clear. Note how the arms of both kinds of spiral galaxies point the opposite way to their motion, as if they are being dragged behind.

With galaxies that are observed at some angle with respect to the angle of rotation, the task might be more difficult. Below are images of two such galaxies, but one can still discern the direction of the rotation:

This is a **clockwise**, on-edge spiral galaxy

This is an **anti-clockwise**, on-edge spiral galaxy

This is a **clockwise**, face-on spiral galaxy

This is an **anti-clockwise**, face-on spiral galaxy

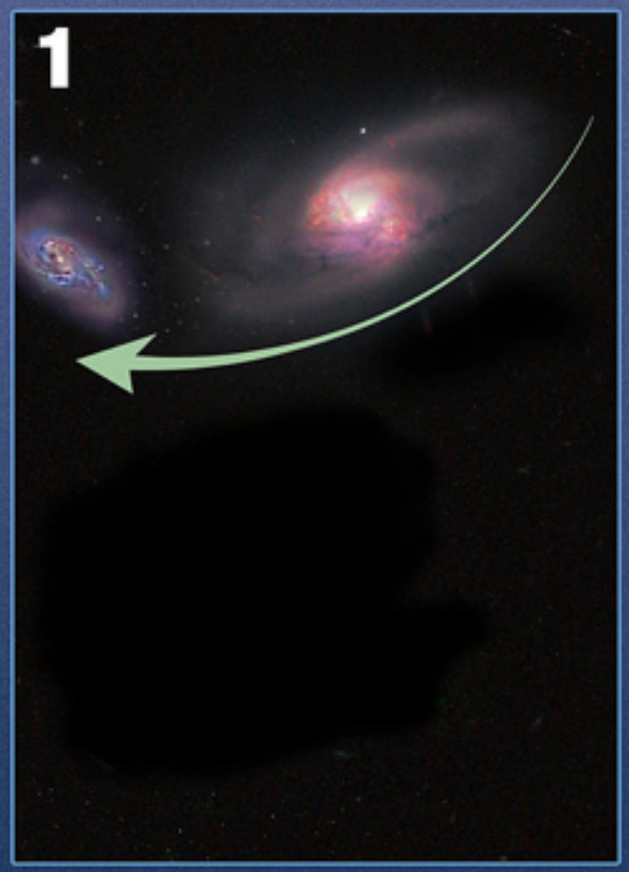
Q. Why record the rotation of the galaxy when it depends on your position? A different observer on the other side of the galaxy would observe it rotating the opposite way. And shouldn't they all be random?

A. Yes, they should be, but a recent investigation, involving many fewer galaxies, suggested that the odds of seeing a clockwise or an anticlockwise galaxy changed depending on where you look in the sky. If this is true, it suggests we're missing something about how the Universe is organised on large scales, and so we decided to see if the effect is real. It turned out that both professional astronomers and Citizen Science volunteers are biased — they slightly prefer classifying galaxies as anti-clockwise (S), as we found by comparing classifications of mirror-image galaxy images. We are also interested in the correlations between neighbouring galaxies, for example whether a close pair of galaxies rotate the same way, as this contains information about the way galaxies form and the large-scale forces acting on them.

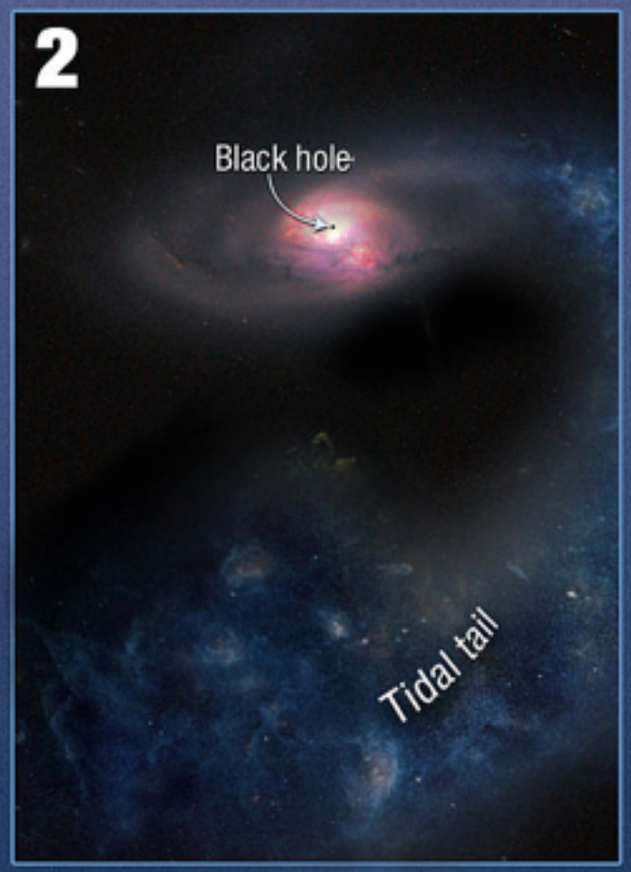
Hannys voorwerp,

Dutch for Hanny's object, is an astronomical object of unknown nature. It was discovered in 2007 by Dutch school teacher Hanny van Arkel, while she was participating as an amateur volunteer in the Galaxy Zoo project. Photographically, it appears as a bright blob close to spiral galaxy IC 2497 in the constellation Leo Minor. is about the size of our Milky Way galaxy and has a huge central hole over 16,000 light years across. In the image, the voorwerp is colored green, a false color that is standardly used to represent the presence of several luminous emission lines of glowing oxygen. It has been shown to be at the same distance from Earth as the adjacent galaxy, both about 650 million light-years away.

Hanny's Voorwerp* — A Space Oddity

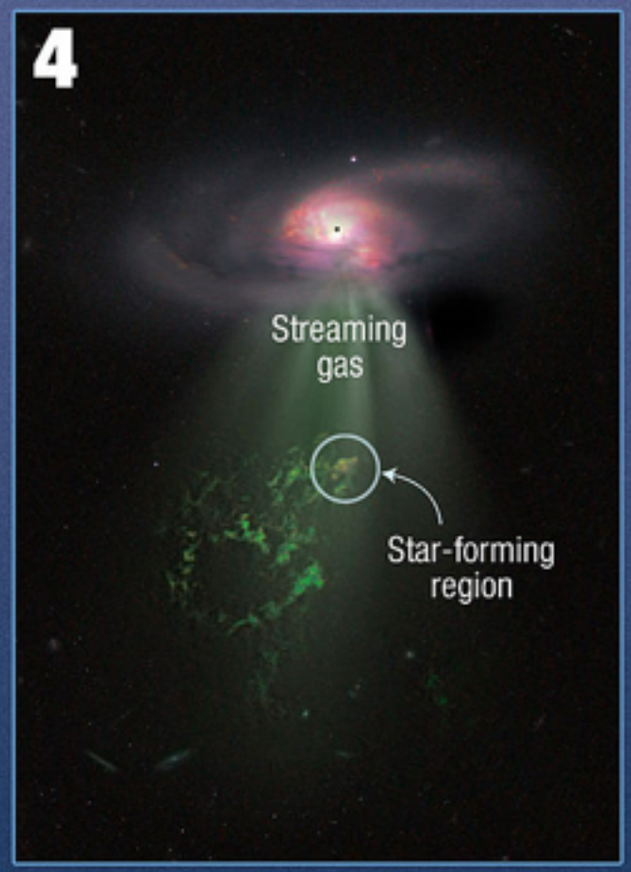


Spiral galaxy IC 2497 gravitationally interacts with a bypassing galaxy.



A large tidal tail of gas is pulled out of the spiral galaxy.

Engorged with gas, a black hole at the center of IC 2497 "turns on" as a quasar and emits a powerful cone of light, which ionizes a portion of the tidal tail, creating Hanny's Voorwerp.



Gas streaming out from the galaxy's center impacts the tidal tail and triggers star formation.

*Hanny's Object

Galaxy Zoo started in 2007 because astronomers had 1,000,000 galaxies that needed to be sorted, classified, and examined. After the incredible response from the public, the zookeepers realized that this kind of problem wasn't limited to galaxies, nor even just to astronomy, and the Zooniverse was born.

Now, after seven years, close to 30 projects, more than 60 publications, and hundreds of years' worth of human effort later, on 24 February 2014 the Zooniverse has just registered its 1,000,000th volunteer. Given that Galaxy Zoo was the project that led to the creation of the Zooniverse, it seems fitting that its millionth citizen scientist joined to classify galaxies! That volunteer joins 400,000 others who have classified galaxies near and far.

AstroComputing is Prototypical Scientific Computing

Astronomy has several advantages:

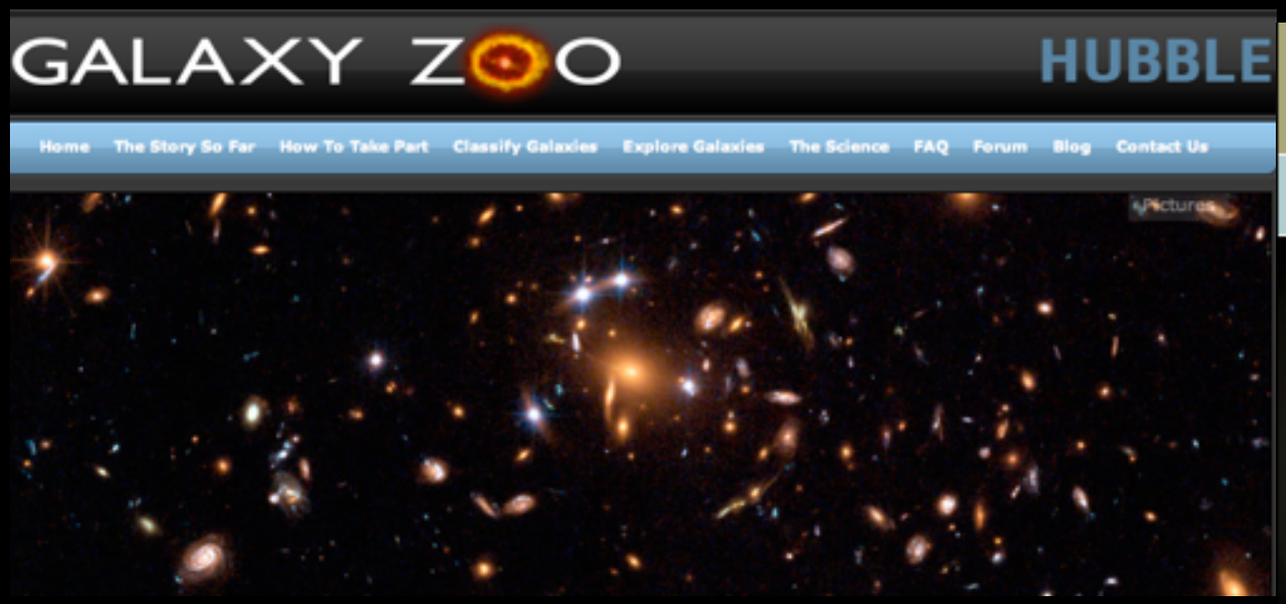
The big data tends to be pretty **clean**

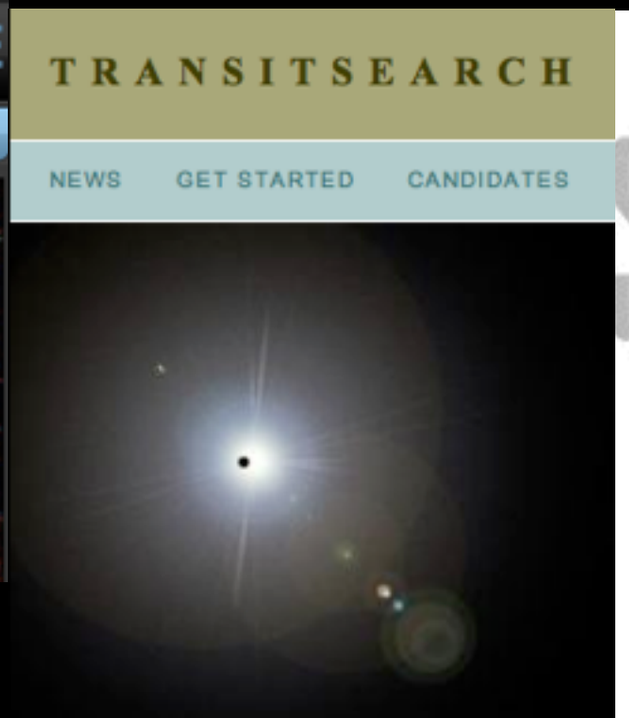
The big data is (mostly) **non-proprietary**

The research is (mostly) **funded**

The data is pretty **sexy**

There's a lot of **public involvement**:





Thanks!