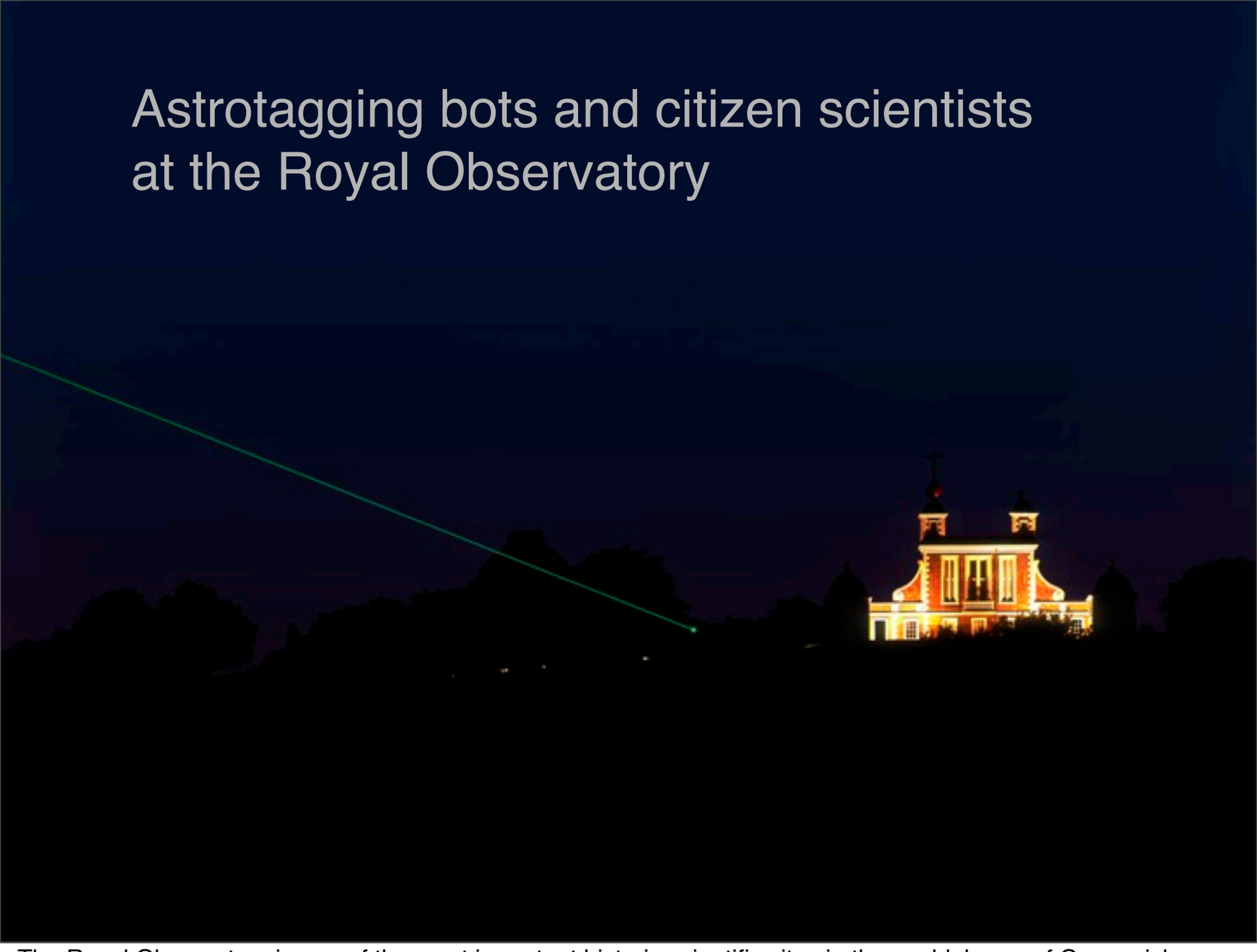
Astrotagging bots and citizen scientists at the Royal Observatory

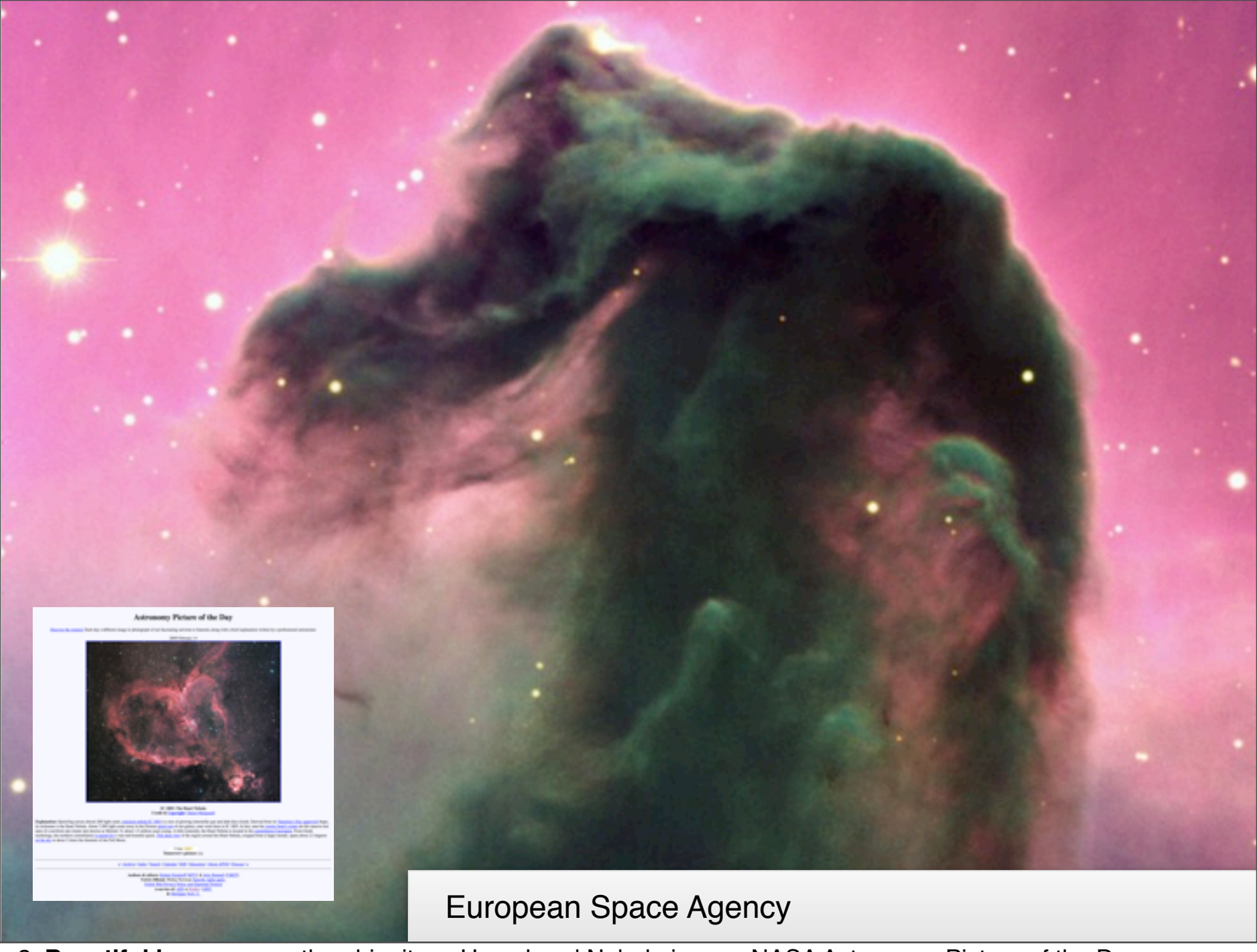


The Royal Observatory is one of the most important historic scientific sites in the world; home of Greenwich Mean Time and the Prime Meridian line. You can see the prime meridian there, carved out across the sky by a green laser. The Observatory was established to find out the longitude of places by mapping the stars.

This talk will outline how digital media and the availability of huge quantities of data are creating new opportunities for the public's participation in astronomy.

Brief history of public engagement with astronomy...
18th century astronomy: precise measurement of position and the classification of heavenly bodies. Expected accomplishment of a ‘gentleman’.
19th century: astronomy applying developments in maths, physics, chemistry and geology to understand the make-up of these bodies and the origins of the Universe. From data collection to research. At the same time, the 19th century was a time for mass involvement in astronomy – popular books, lectures, expeditions to observe eclipses, astronomy clubs and societies. There were also popular board games, toys and models made to teach a broader audience about astronomy. This picture shows an orrery – a very beautiful but expensive model of the solar system.

So how has the practice of astronomy changed: big science, abstract research, huge data-sets…
And what are the new digital opportunities: cheap and mobile hardware, both digital cameras and telescopes.
Looking at public engagement with astronomy today, I think that a broader public interest in astronomy can be inspired by 3 main things
1. **Breaking news**, often related to research, e.g. Moon landing, life on Mars...

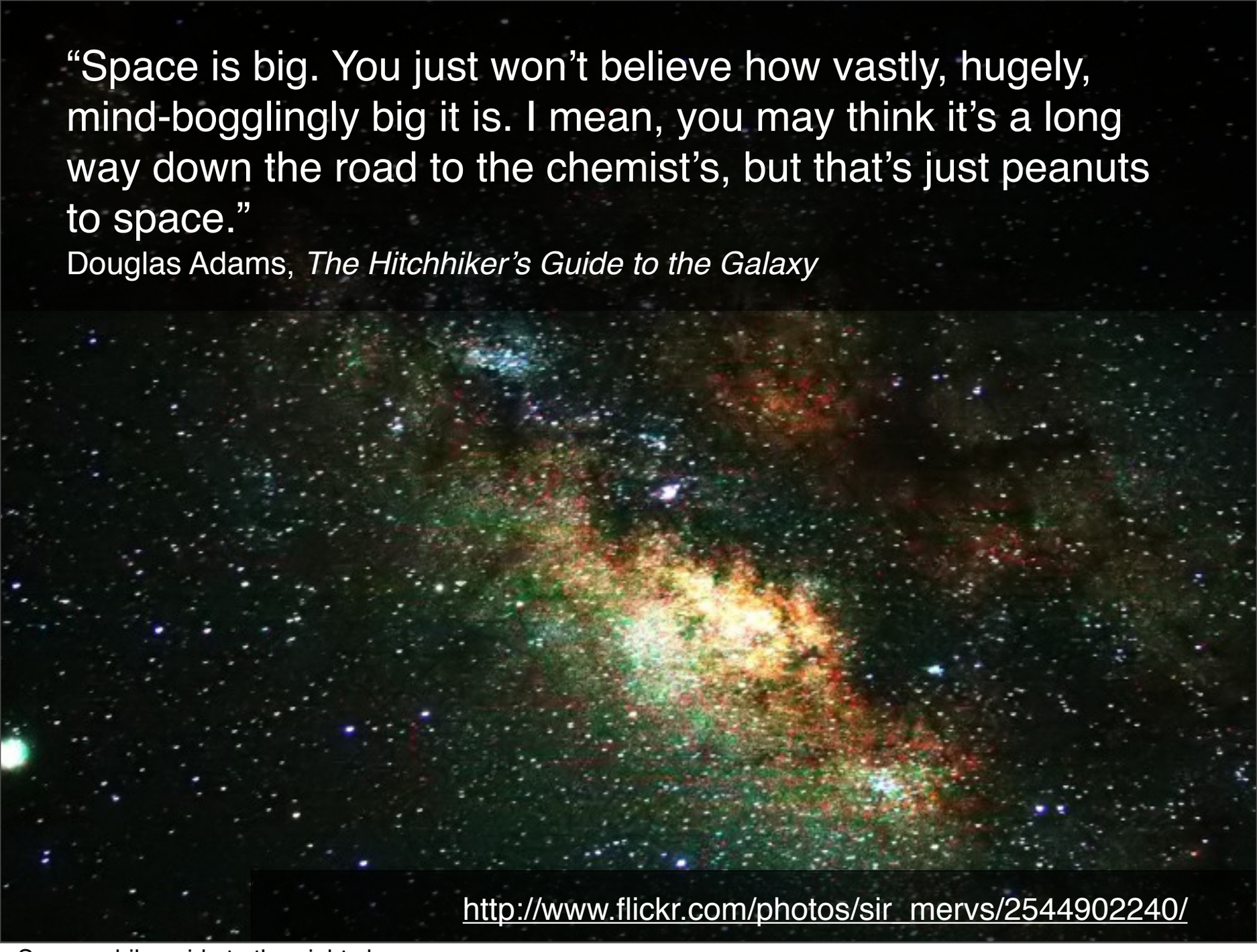


2. **Beautiful images**, e.g. the ubiquitous Horsehead Nebula image, NASA Astronomy Picture of the Day

3. **Big astronomical events**, such as eclipses or comets or meteor showers
This is an image taken from a presentation by George Oates. It shows a lunar eclipse bubbling up on Flickr.

So, what we've been thinking about at the Royal Observatory is how to take advantage of these three catalysts to develop a more sustained interest in astronomy. i.e. How to convert the casual planetarium visitor into an amateur astronomer. Today, I'm going to talk about three projects at the Royal Observatory, each one maps to one of these three routes to engagement.

1. **Prime Sky**, our guide to the night skies above Britain
2. An annual **Astronomy Photographer of the Year** competition and exhibition
3. A new programme of **citizen science**



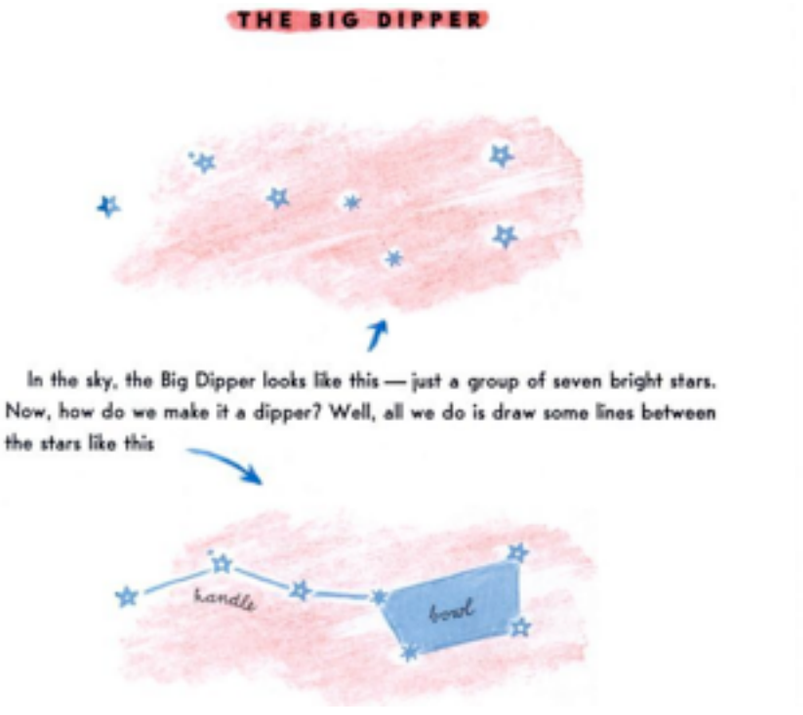
So, a mobile guide to the night sky…

Space is big.

'Historia Coelestis', Flamsteed's catalogue of Fixed Stars

And astronomers want to be both precise and comprehensive…

So, as I've already mentioned, the Royal Observatory was founded to produce accurate tables of star positions for navigators. This image is taken from the catalogue produced by the Royal Observatory's first Astronomer Royal, Jo Flamsteed. Its observations were urgently needed by Newton and Halley, so the catalogue was rushed into publication, despite being incomplete - and Flamsteed's furious objections. Flamsteed later managed to burn 300 copies on a bonfire in Greenwich Park, declaring 'I make a sacrifice to Heavenly Truth'. The final version did not appear until after Flamsteed's death in 1725. It contains information on nearly 3000 stars and is the fundamental wo of British astronomy.



THE BIG DIPPER

In the sky, the Big Dipper looks like this — just a group of seven bright stars. Now, how do we make it a dipper? Well, all we do is draw some lines between the stars like this

handle

bowl

BRIGHT STARS AND FAINT STARS

We can't make the stars in our book look all alike because the *real* stars in the sky don't look alike. Some are bright, some just fairly bright, some are very faint. Just watch the sky tonight and see for yourself how different they are.

Now, when you want to find a constellation in the sky you always pick the bright stars first and then you go on to the fainter ones. That is the easiest way. From the constellations in the book you can tell which stars are bright, which faint, and which in-between.

The stars have "grades" according to their brightness. Those grades are called "magnitudes." The brightest stars are called "1st-magnitude stars." The fairly bright ones are of 2nd magnitude, then 3rd, then 4th, and the very faint ones are of 5th magnitude (as you see, these grades run the opposite way from grades at school). Here's a list to show how the different magnitudes are marked on our constellation figures:

very bright	1st magnitude ("mag." for short)
bright	
fairly bright	2nd mag.
medium	3rd mag.
faint	4th mag.
very faint	5th mag.

Great Bear has no 1st-mag. star!

Herdsman and Lion have 1st-mag. stars!

H. A. Rey, *Find the Constellations*

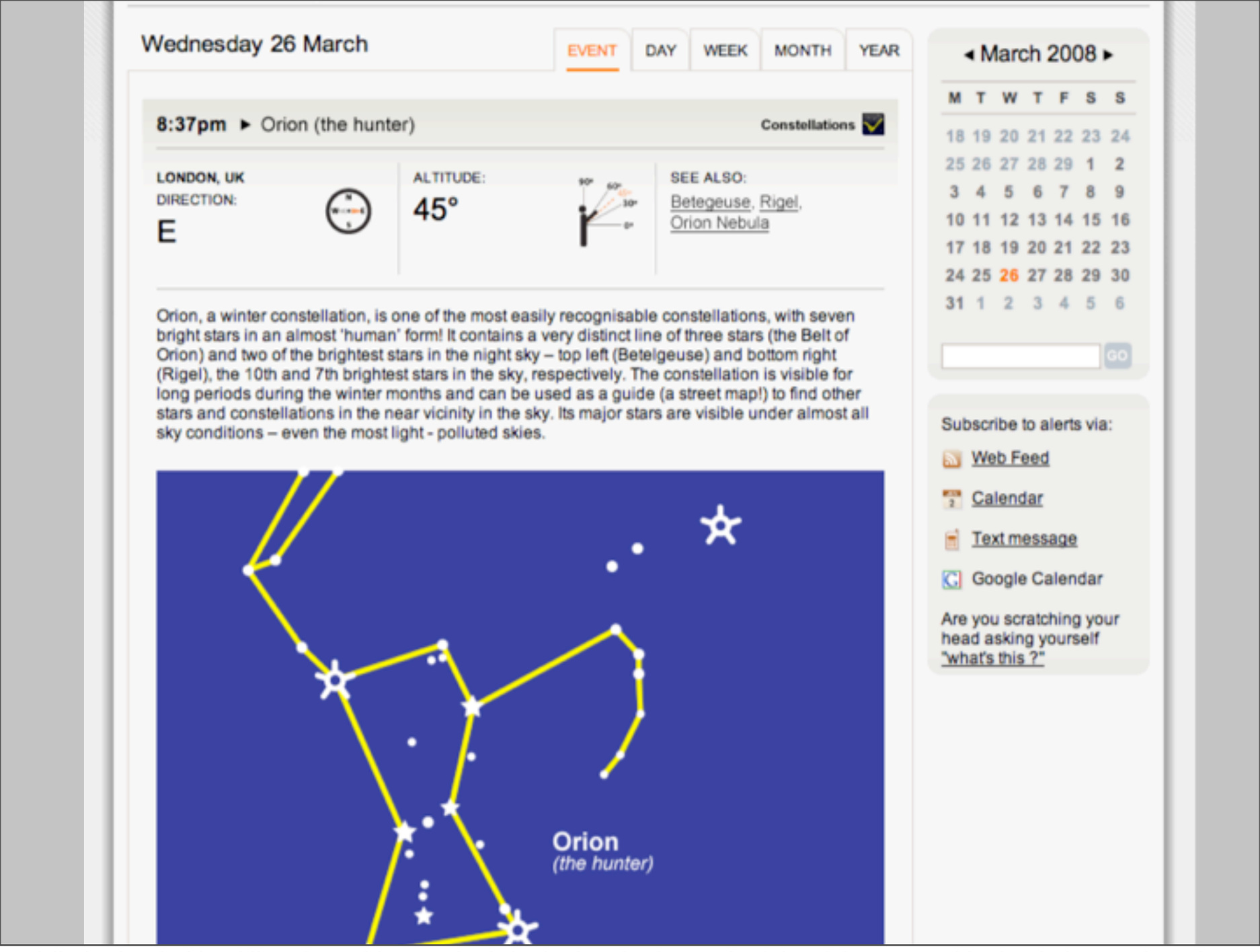
So, we had to really work against both of those things – vast scale and complexity, comprehensiveness and precision. And for that, we were inspired by H. A. Rey, who published an astronomy book for children in the 1940s. He invented a new set of constellation diagrams that:

- Corresponded to what could be seen with the naked eye by an amateur observer (including children)
- Removed extraneous detail to focus attention
- Included guide lines to indicate the overall shape

http://www.flickr.com/photos/peresanz/3039293246

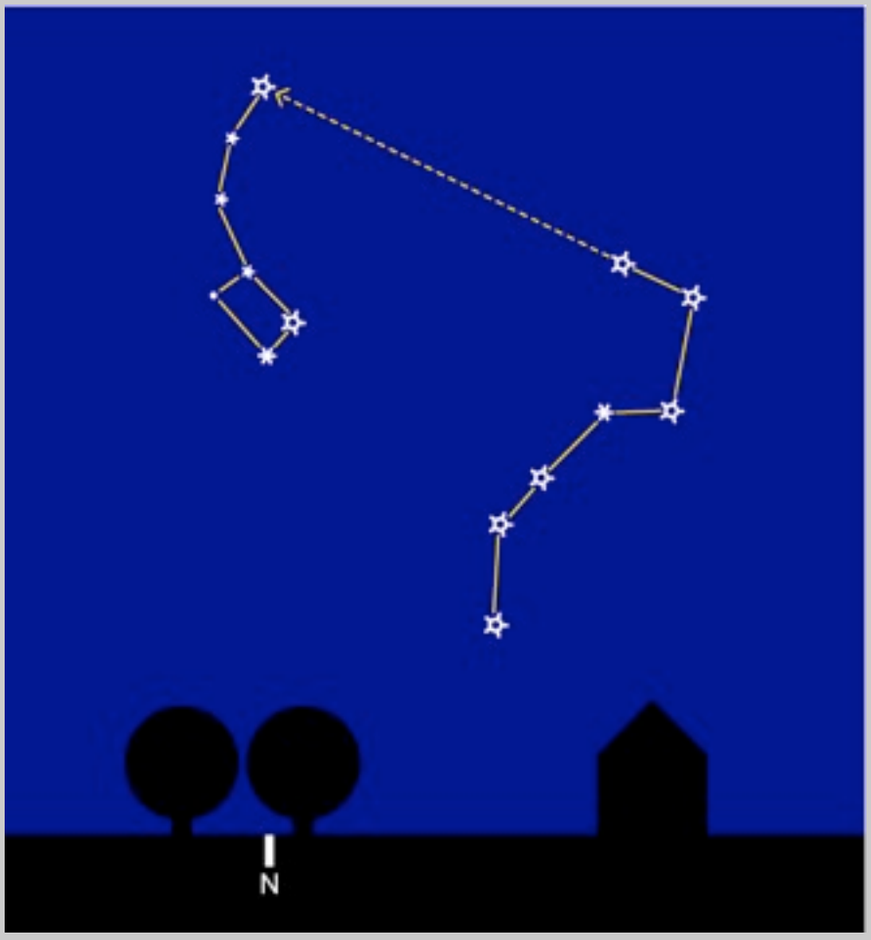
So, we set out to design an astronomy service for people with a casual interest in astronomy, who are unlikely to plan their astronomical viewings but will instead:

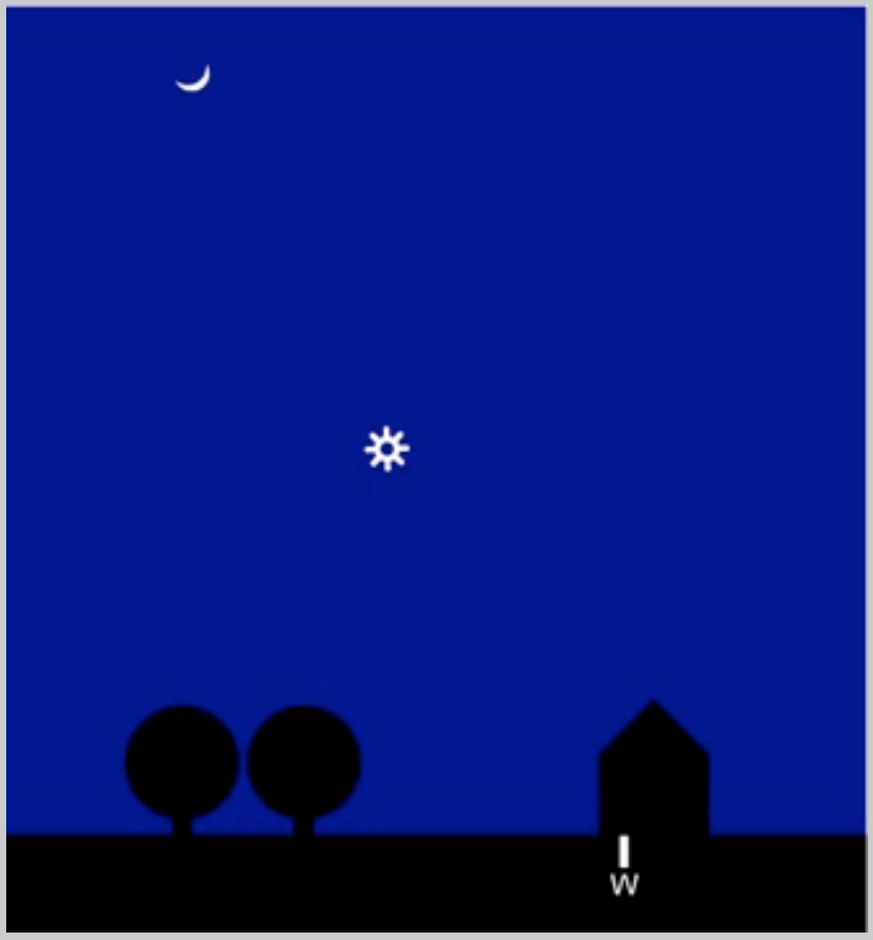
- make serendipitous observations and afterwards wonder what they saw
- find themselves out on a clear night, with low light pollution, and wonder what they should look for ('first date scenario')
- only want to be told when there's something major to see, e.g. a Total Lunar Eclipse
– only want to be told when it's equinox, solstice, they should change their clocks, observe Ramadan (new moon), etc



- A limited, prioritised list of 3-5 things to look for in the sky for each night of the year, with simple instructions for finding them
- Simplified view of the sky
- Fuzzier coordinates, so people aren't overwhelmed by precision
- Mobile: calendar view or text alert for each of the year's big 10 astronomical events

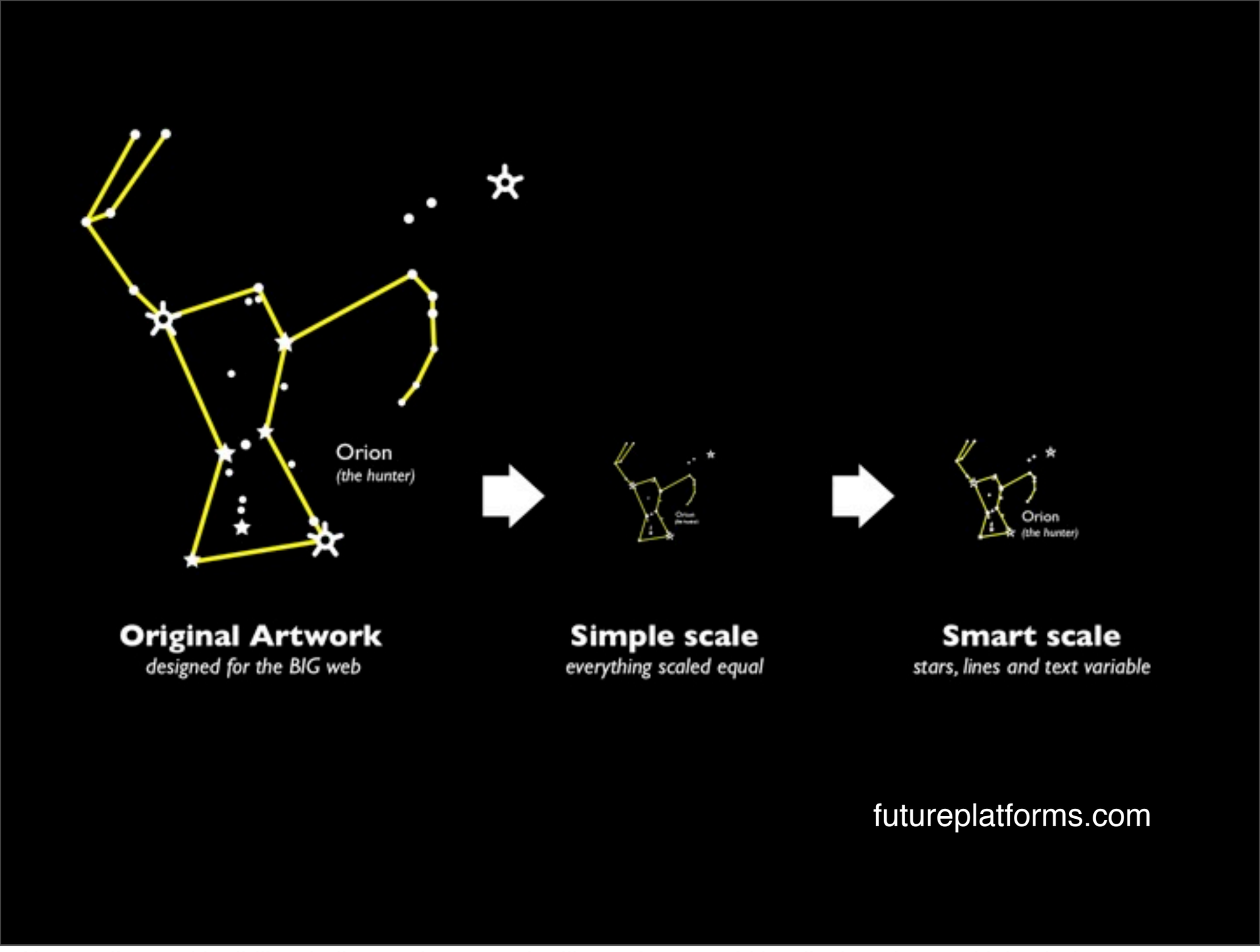
(There's also a public API and web feeds in various formats.)



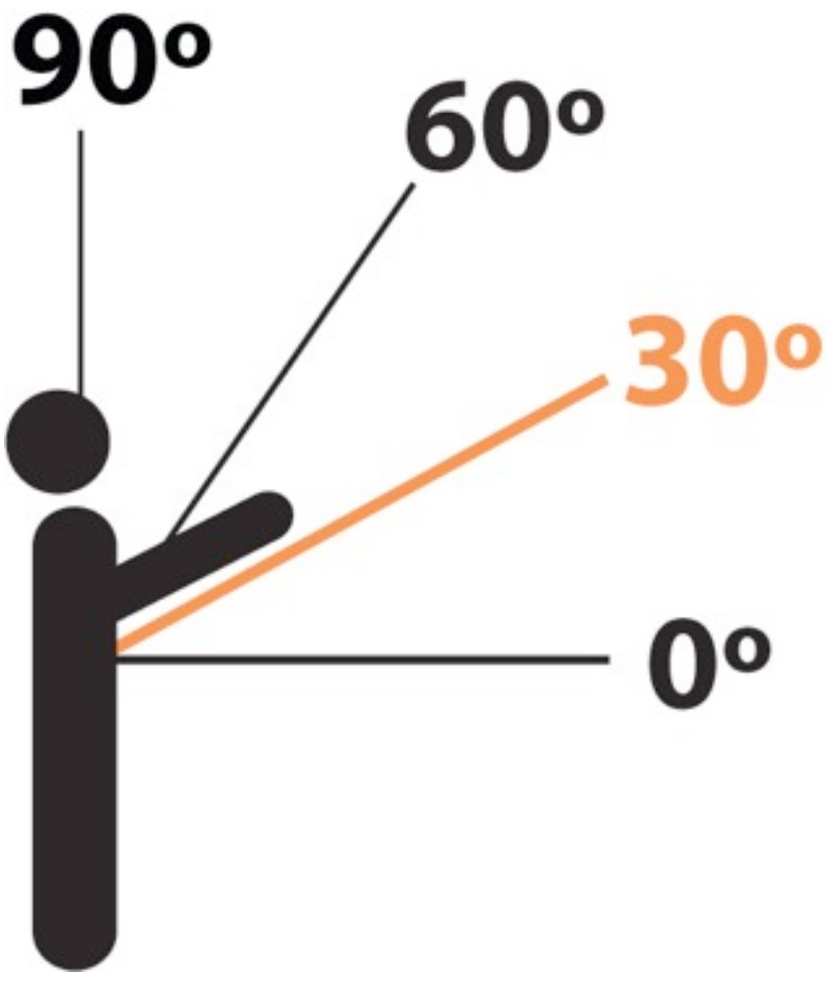


anthonyburrill.com

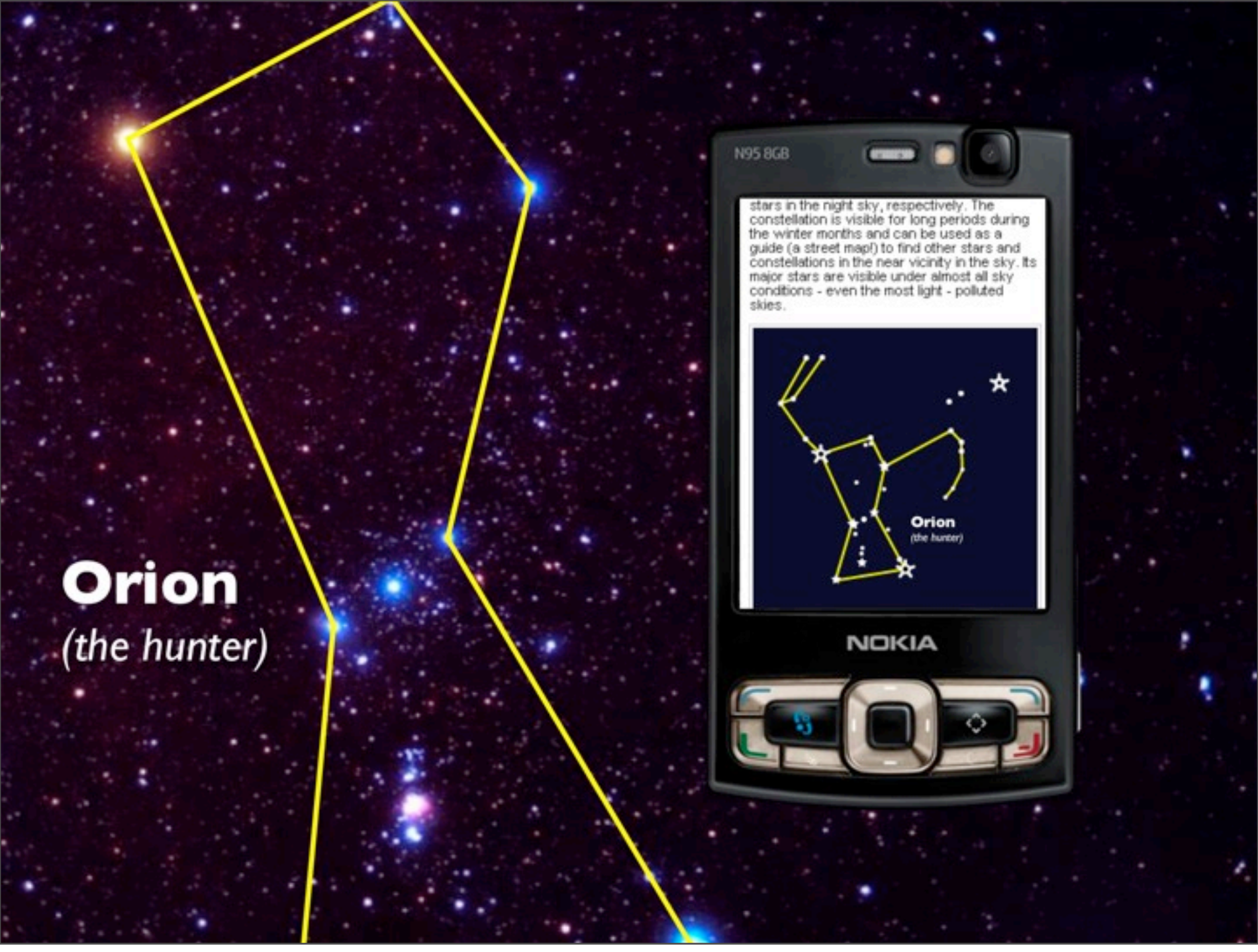
Design challenges: To represent constellations and other heavenly bodies on a small screen.
For that, we worked with Anthony Burrill, a London-based illustrator with a deliberately naive style, to produce Rey-inspired illustrations.

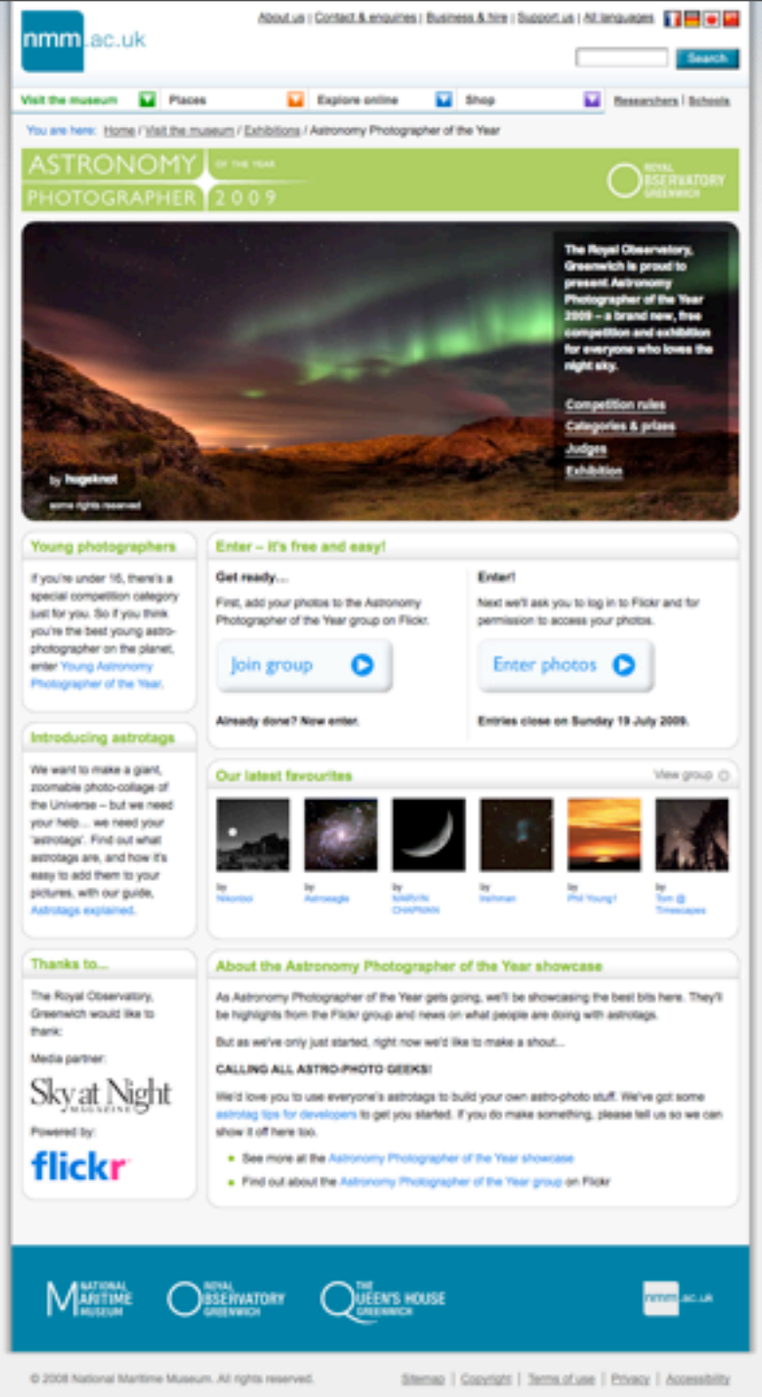


Also scaling and legibility challenges because the illustrations would be displayed on multiple platforms and devices (lines, shapes and text).
To solve that we worked with Future Platforms, the leading mobile developer in the UK, who did some innovative rescaling work.

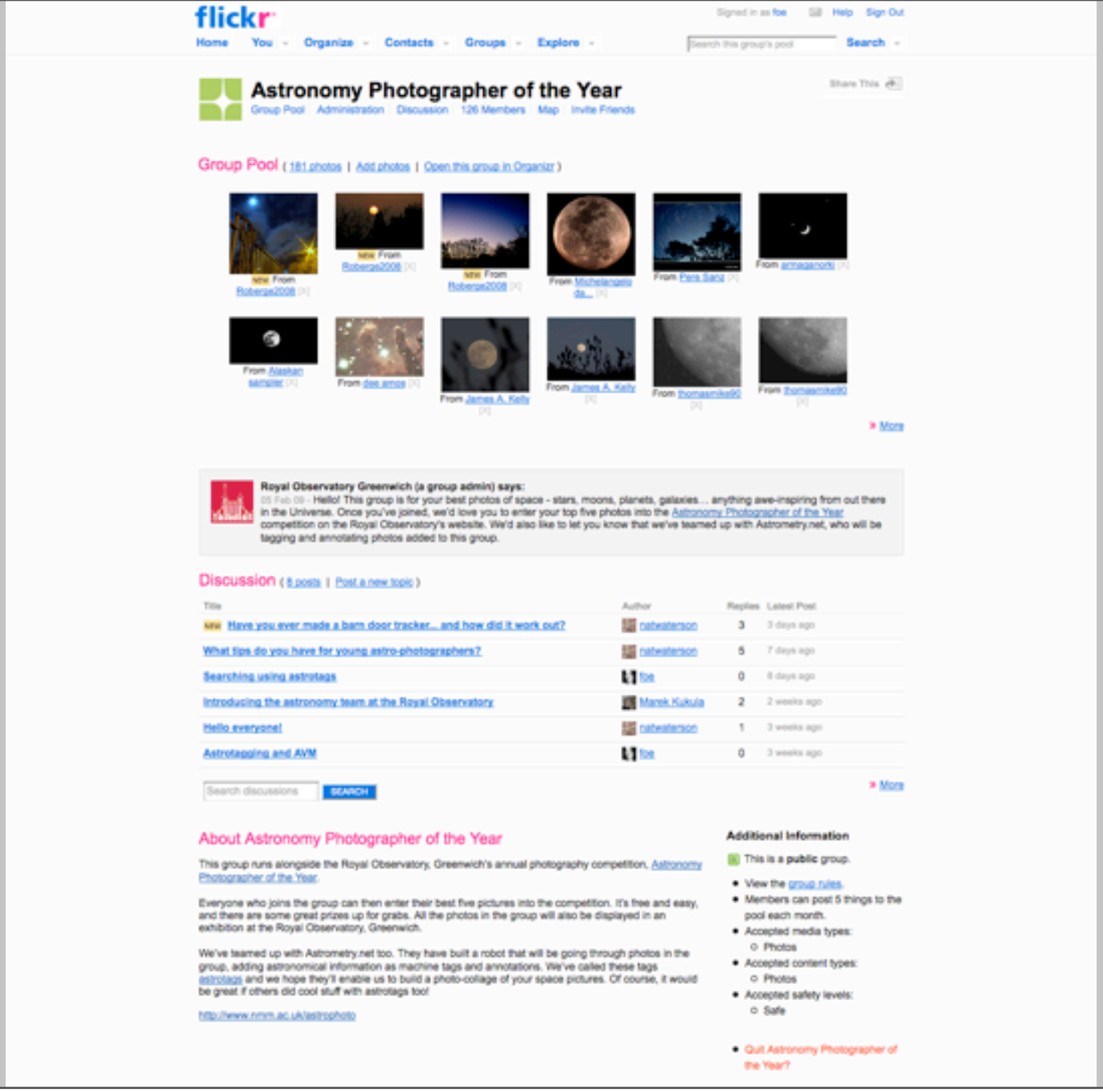


Second big design challenge: user orientation. Typically represented as precise altitude and azimuth. We wanted something more fuzzy and human scale. So we tell you a general direction and an approximate altitude only. And it turns out that you can actually use your body to find the altitude.


Orion
(the hunter)
N95 8GB
stars in the night sky, respectively. The constellation is visible for long periods during the winter months and can be used as a guide (a street map!) to find other stars and constellations in the near vicinity in the sky. Its major stars are visible under almost all sky conditions - even the most light - polluted skies.
Orion
(the hunter)
NOKIA



OK, project number 2… A new annual competition and exhibition for astronomy photographers.



Digital outreach on Flickr**:** From the beginning, we knew that we could extend the exhibition experience– and broaden participation – by using Flickr to collect entries. Our own website uses the Flickr API to pull though pictures as part of the entry process. Participants can add more photos than they want to enter in the competition – or choose not to enter at all. And our Group will stay open from year to year, so come 2009's competition closing date we don't have to say goodbye to a bunch of people we've just said hello to.

Talk to the judges and our astronomers on Flickr. Participants can talk to the Royal Observatory's astronomers and judges – and among themselves – on Flickr, making the group an online community of practice for amateur astronomers and astrophotography enthusiasts. Marek Kukula, our Public Astronomer and a judge on the competition, is participating.

We also have an astronomy podcast, which gets real voices 'on the line' via a Skype answering service. We take the best recorded questions, convert them to mp3 and assemble them into a monthly podcast, transcribed by CastingWords.com.

And here’s a selection of some of the beautiful images shared so far...

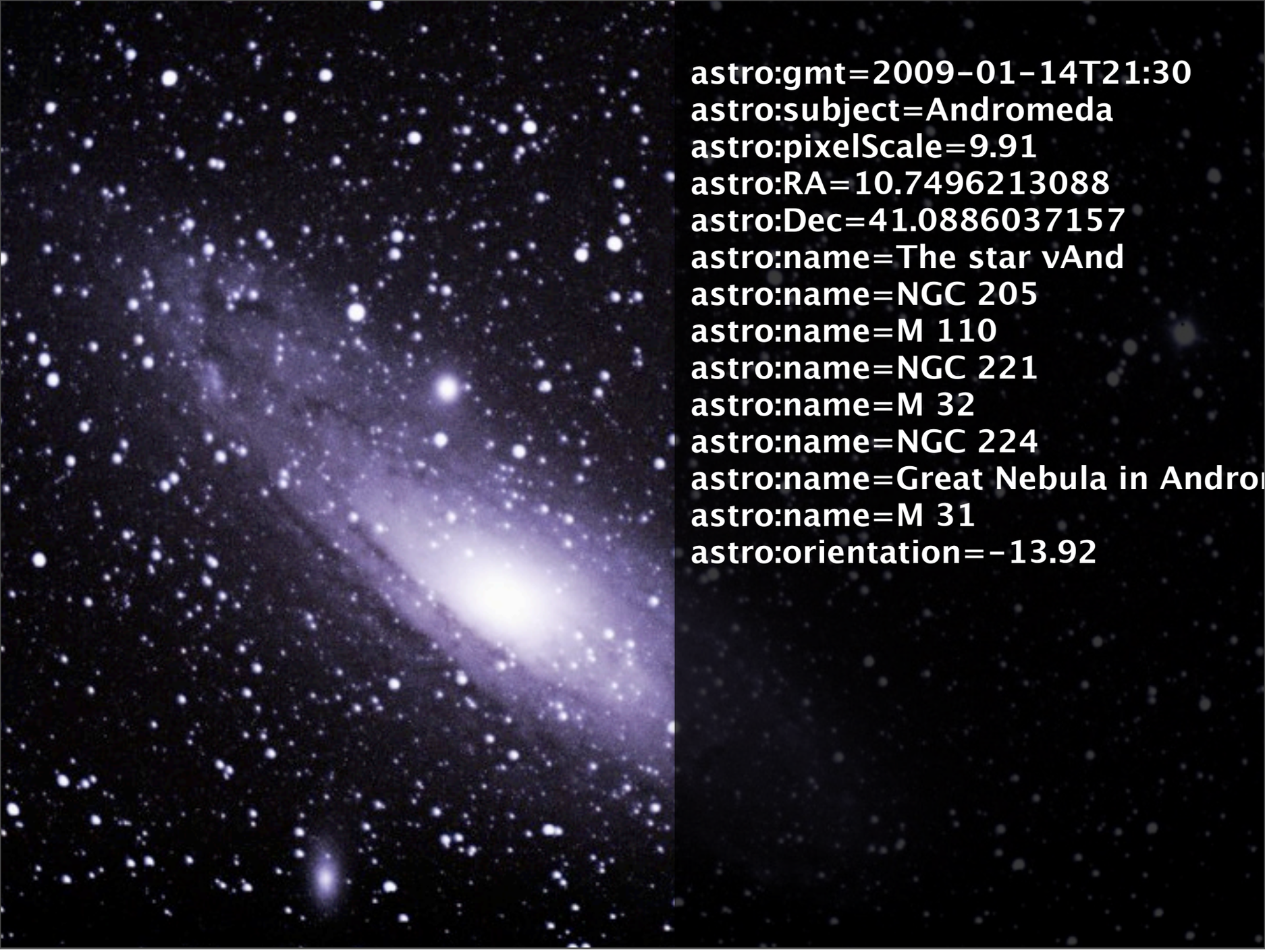
http://www.flickr.com/photos/zamb0ni/2914278402

http://www.flickr.com/photos/fivedollarones/3037932855/

http://www.flickr.com/photos/peasap/1797667874/

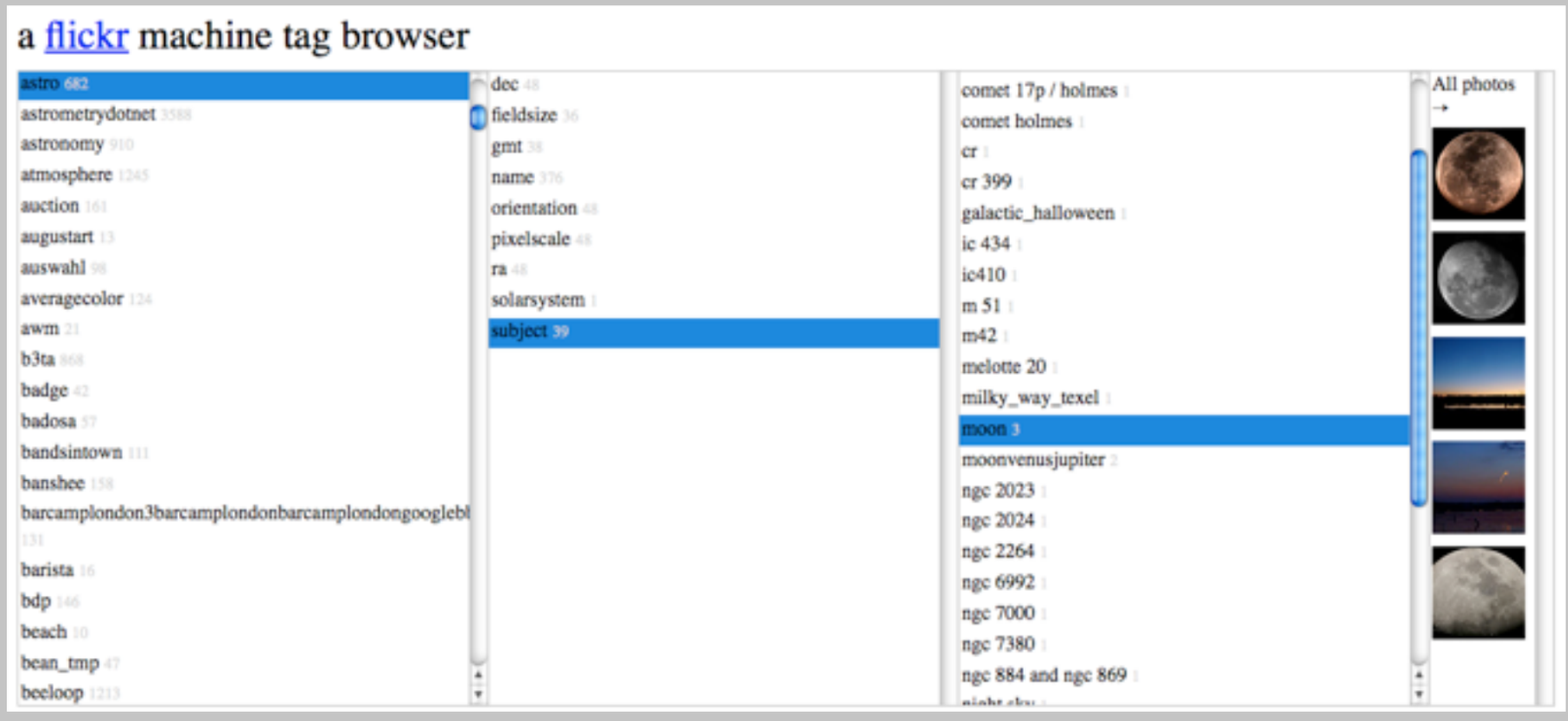
http://www.flickr.com/photos/icelandaurora/2944475248

OK, so that's all very lovely but where's the science bit?
Selecting Flickr as our platform immediately got us to ask, what would be the space equivalent of geotagging?
Answer: astrotagging! Astrotags are a new way to label your photos of space – they describe what your photo is of, and where in space that is.



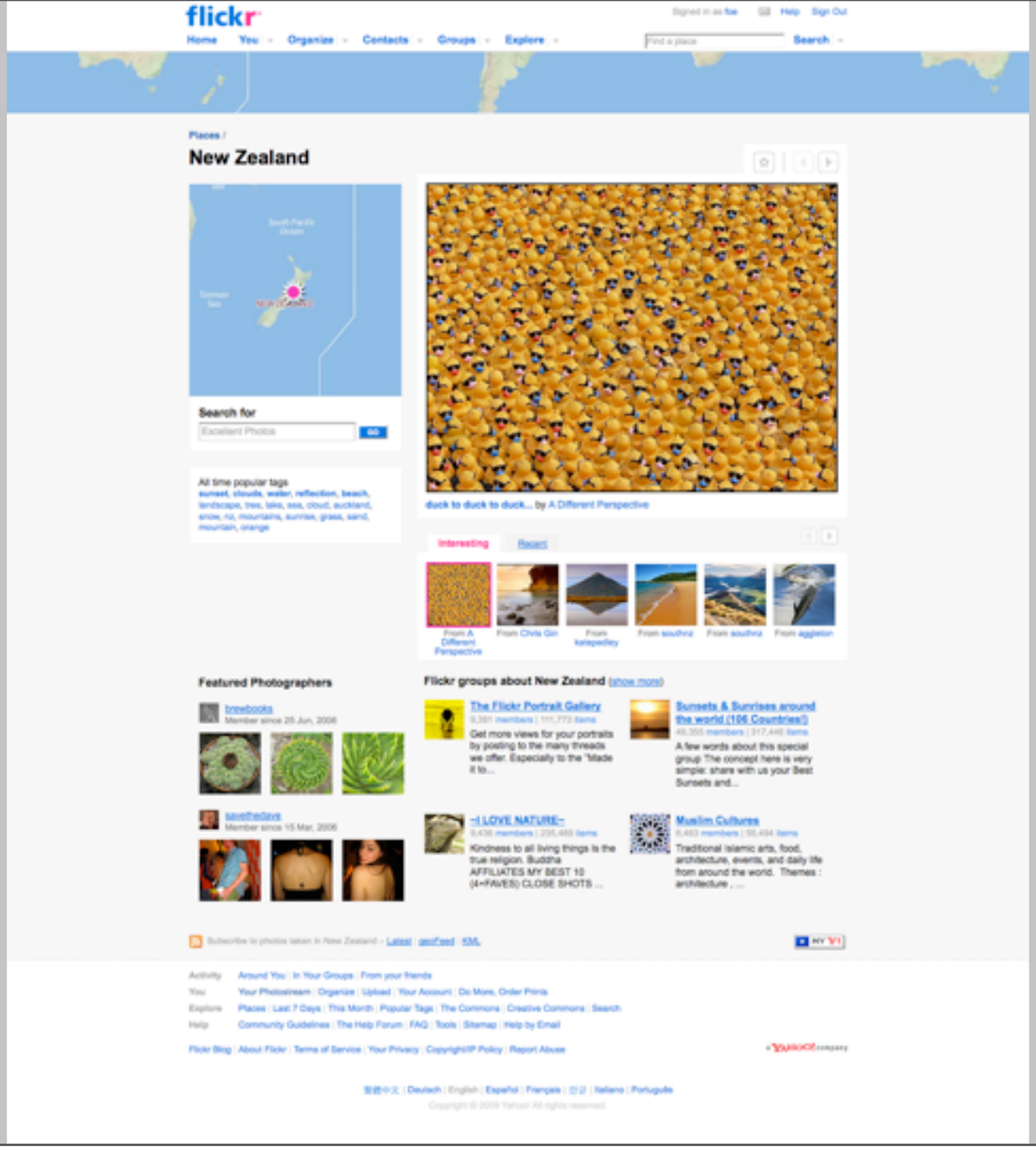
Machine tags on Flickr are tags that use a special syntax to define extra information about a tag. Machine tags have a namespace, a predicate and a value. Where geotagging uses the geo: namespace, astrotagging uses machine tags in the astro: namespace.

- **astro:gmt** describes the exact date and time your photo was taken, in Greenwich Mean Time (of course)
- **astro:subject** describes the main astronomical subject of your photo, using its English name or letter and number combination
- **astro:pixelScale** describes how much of space each pixel in your photo shows
- **astro:RA** measures the right ascension of the centre of your photo. Right ascension (RA) is the space equivalent of Earth's longitude
- **astro:Dec** is the declination of the centre of your photo. Declination is the space equivalent of Earth's latitude, that is, how far north or south something is.
- **astro:name** simply names each of the objects found in your photo
- **astro:orientation** describes which way up your picture is



http://husk.org/code/machine-tag-browser.html

Using this machine tag browser, built by Paul Mison using the Flickr API, you can see some of the subjects shared so far.

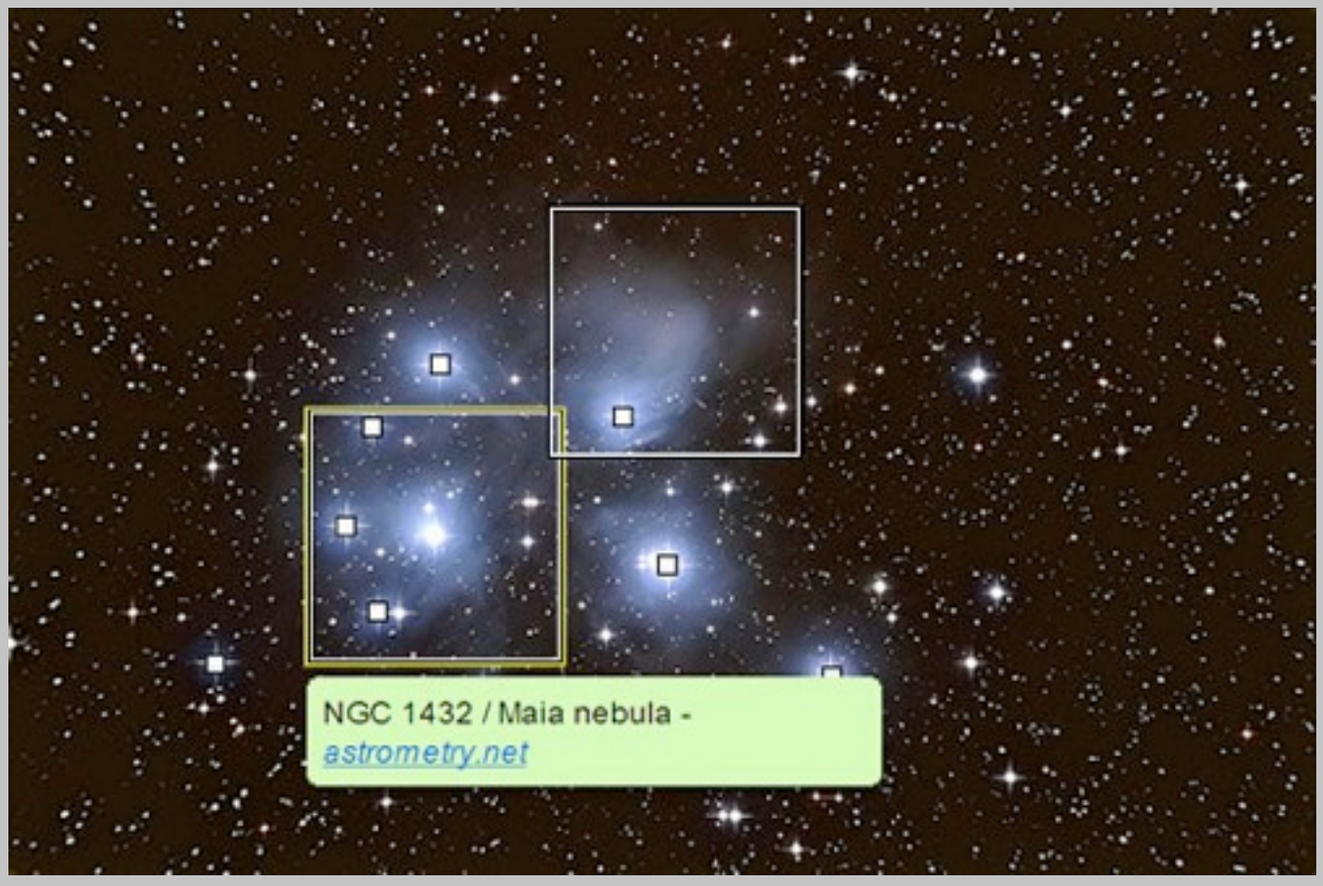


We're hoping that astrotagging will become an accepted and widely-used standard for describing astrophotography
We're aiming to montage pictures together and create a zoom function for display in the exhibition opening in September 2009, but will be excited to see what others come up with.
What are some of the things that astrotags enable?
–Map our photos and group them by proximity to each other, just as we already do with geocoded photos of places on the Earth.
–Knowing the position, extent and orientation of a picture, we can overlay and mosaic photos of the same region of the sky.

Furuhjelm and Franck, Helsinki Observatory, 1911
Carte du Ciel project

And there’s a really nice historic precedent for our involvement in this. The ROG's historic South Wing – where the Astronomy Photographer of the Year exhibition will be held – was built for astro-photographic work, under the guidance of Astronomer Royal Sir William Christie. Christie transformed the role of the Observatory through a project called Carte du Ciel, which brought together observatories from around the world to produce a photographic map of the entire sky. To us, Astronomy Photographer of the Year has those same aspirations and enables us to make meaningful connections between our history and contemporary science.

But – as you might have already been thinking – working out where you are in space is much trickier than putting a pin in a map – the added dimensions of depth and movement mean it's not immediately user-friendly. Would anyone really go to the trouble of figuring out and tagging all of that information? Eventually, we came up with a ‘some-human, some-robot’ approach.



http://www.flickr.com/photos/johnny9s/2897062004

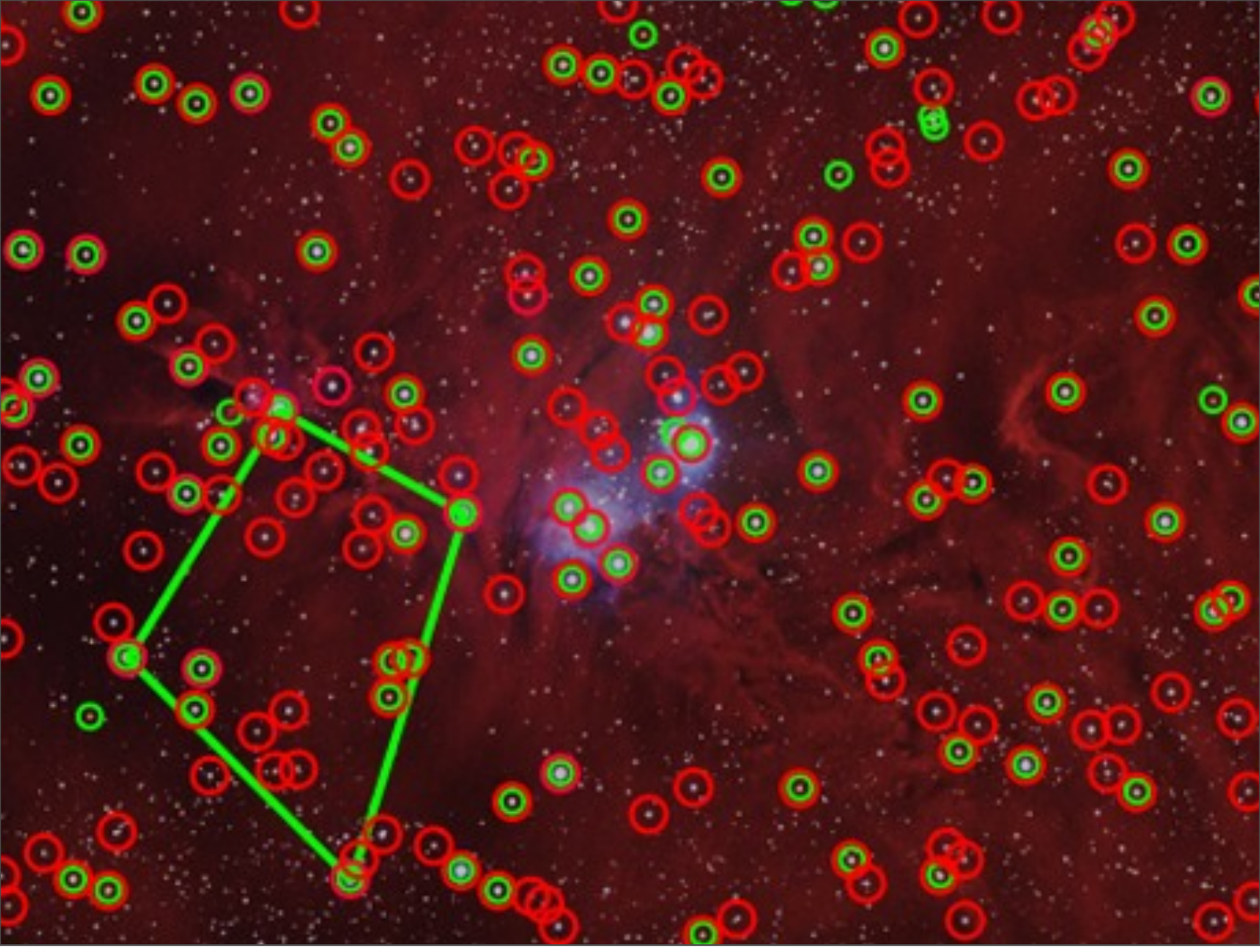
We worked with the scientists at Astrometry.net, who built us a robot to go through all pictures shared in our group. The robot identifies the objects in the picture – and the space equivalents of latitude, longitude, scale and photo orientation – using the geometry of the stars. It then automatically adds this info to pictures as notes and machine tags.

The robot is built on top of Astrometry.net's blind astrometry solver - called 'blind' because all it needs is a photo to work out where the telescope or camera was pointing and which stars the image shows. Stargazers do a similar thing when they look up at the night sky and orientate themselves using constellations. But the robot can also recognise tiny images that cover one ten-millionth of the sky, containing no stars visible to the unaided human eye.

How does it work?

−The robot starts with a large catalogue of star positions

− Next, it uses this catalogue to find a large number of ‘skymarks’ in each photo. Each skymark is composed of four stars, and it describes their relative positions



What happens when you submit a photo

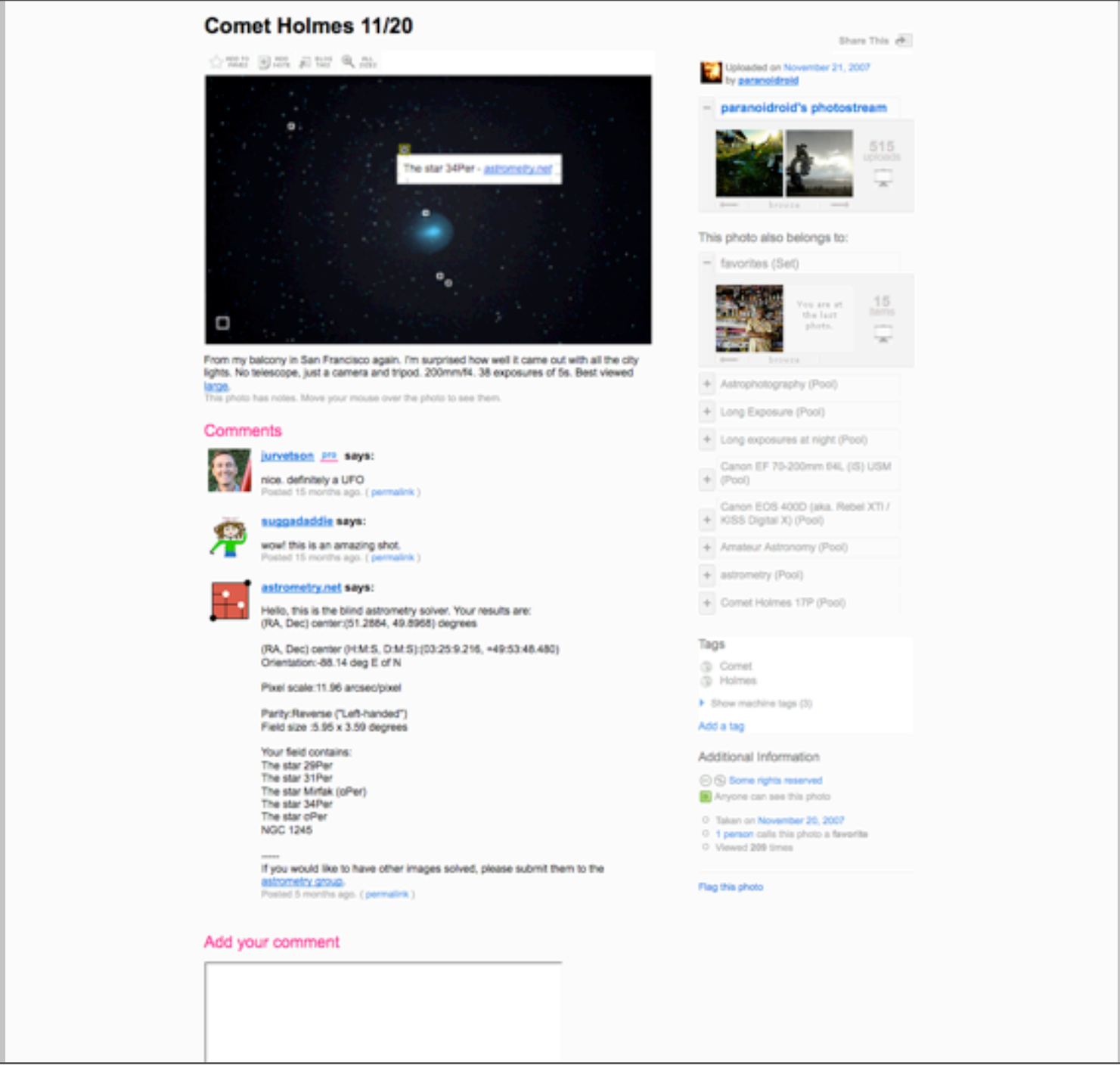
- First, the robot runs some image processing steps to find stars.
- Next, it starts looking for sets of four stars in your photo. For each set of four stars, it checks for a match in the skymarks index.
- Often, one skymark can be mistaken for another. So when the robot finds a skymark that seems to match, it does some cross-checking. If the skymark really is a match, it asks, ‘where else would I expect to see stars in this image?’ If many of the predicted stars really are there, then the match must be correct and the image is solved.

So, in this image…

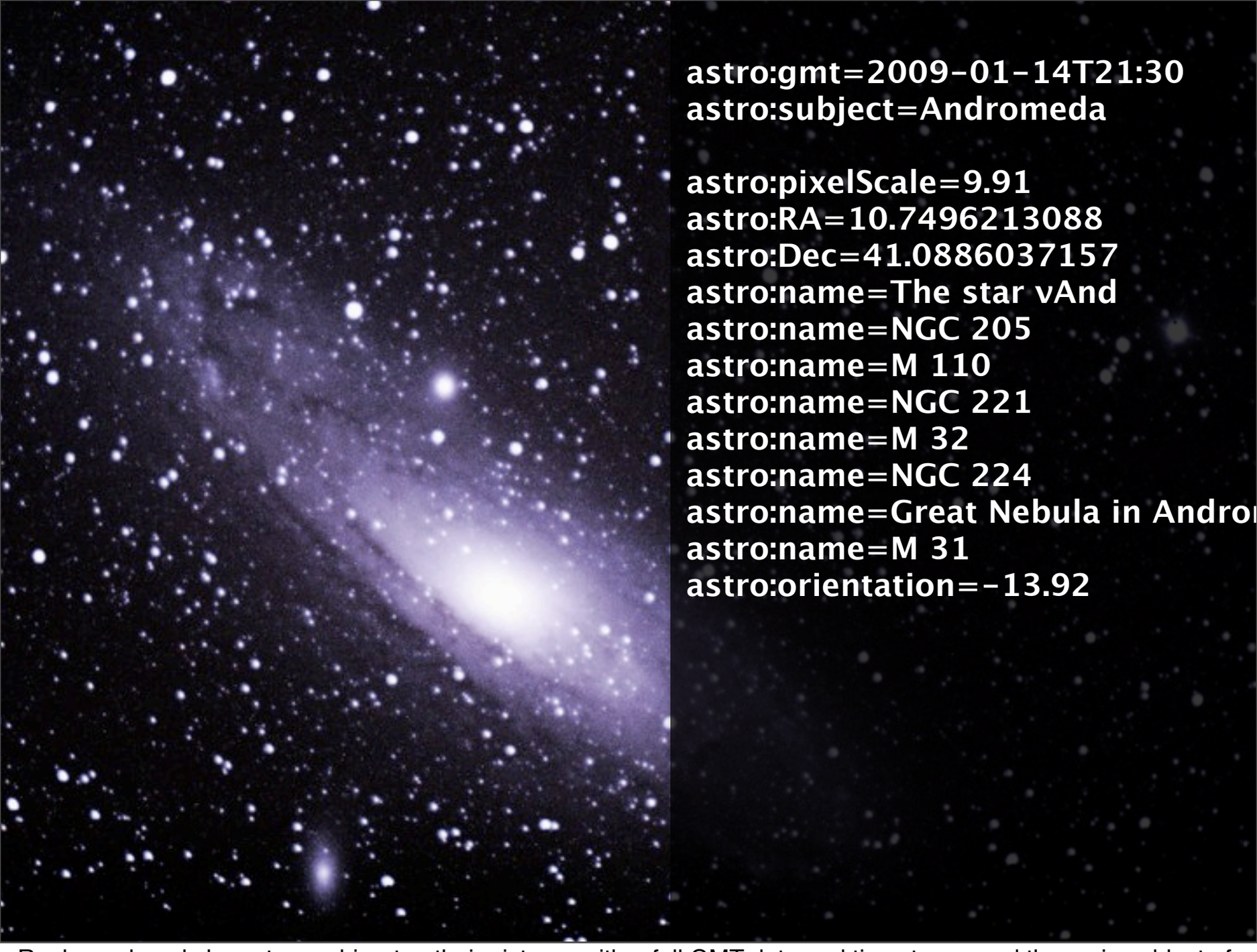
The red circles are around stars the robot has found in the photo. The green circles are the positions of stars in the index. The green lines join together four stars that make up a skymark. Lots of red and green circles overlap, so this must be a correct match.

Now that the photo has been correctly identified, the robot can label and tag objects in it. As the robot works through more photos it's building up a bigger and better log of skymarks.

But, clever as it is, there are some things the ‘bot can’t do – like pick up moving things such as planets and comets.



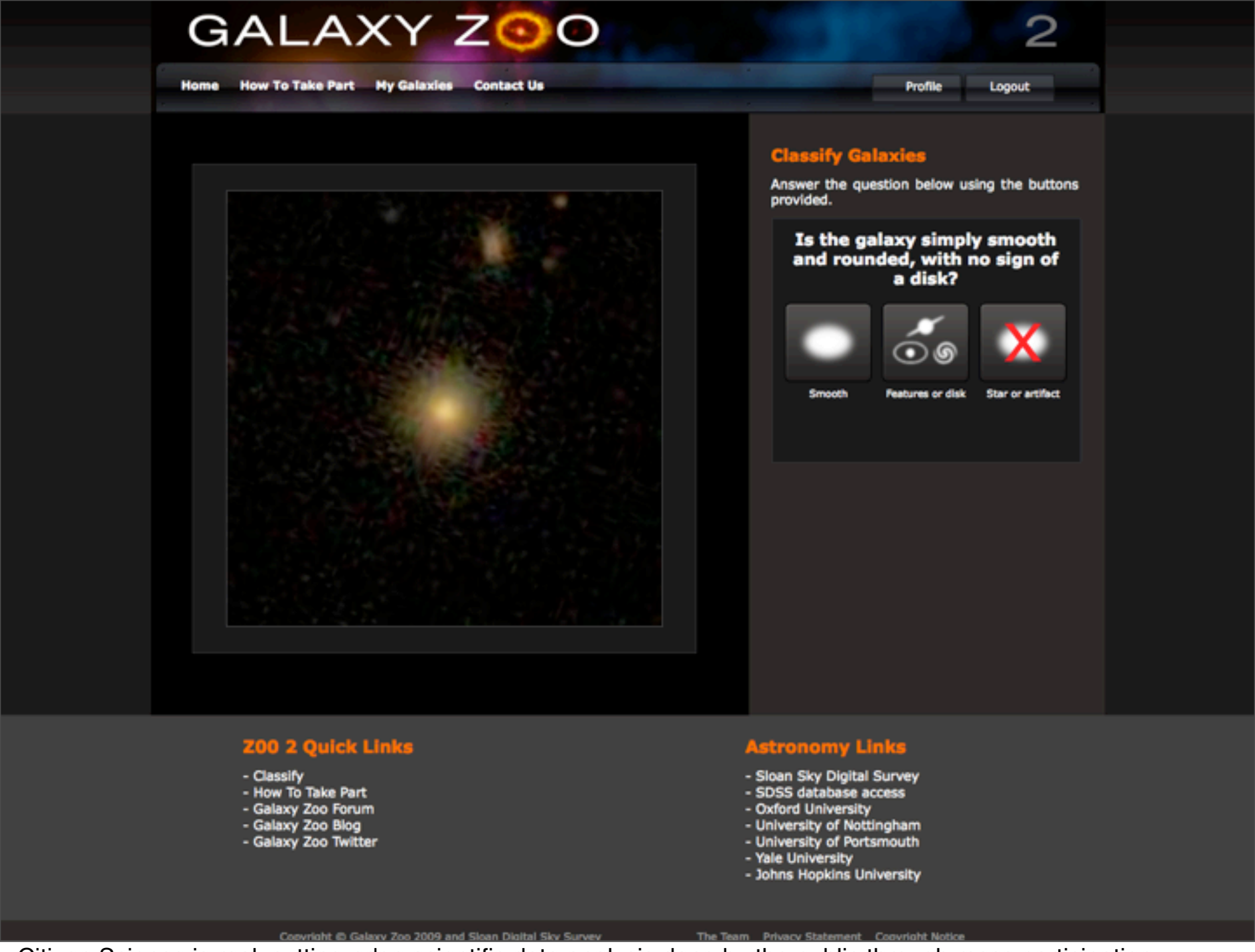
E.g. Astrometry bot doesn't see Comet Holmes in this photo, even though it's the main subject and clearly remarkable to the human eye. Eventually, we came up with a 'some-human, some-robot' approach.



Real people only have to machine-tag their pictures with a full GMT date and timestamp, and the main subject of their photo. And if someone has a great photo but they don't know what it depicts, they can post to the Flickr Group and our astronomers will help them.

So, what this illustrates is that there are some things that people are really good at, problems that need human intervention to solve. To quote my husband paraphrasing Charlie Stross: ‘This is a really hard problem. We’re going to need some amateurs.’

Mary Ellen French began work at the Observatory in 1930 as a computer, alongside 4 other ‘lady computers’ as they were termed. As a computer she had to make routine calculations on the observations made by the astronomers. She is photographed here using a solar micrometer to measure the exact position of sunspots on a glass plate of the Sun that the astronomers had produced.



Citizen Science is real, cutting-edge scientific data analysis done by the public through mass participation, usually online.

In other words it's…

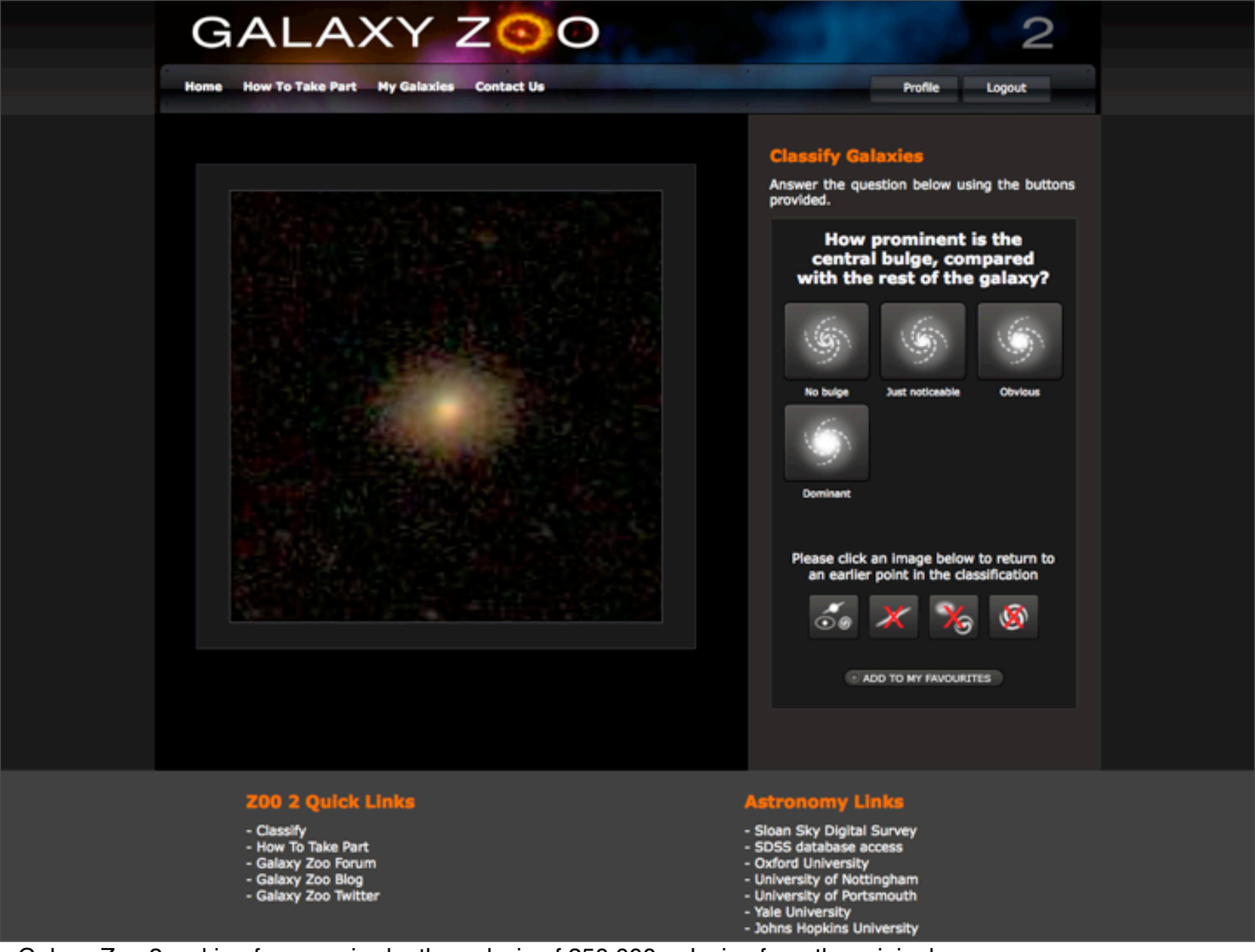
–huge data sets that are…

–too big to be analysed by scientists alone, but that…

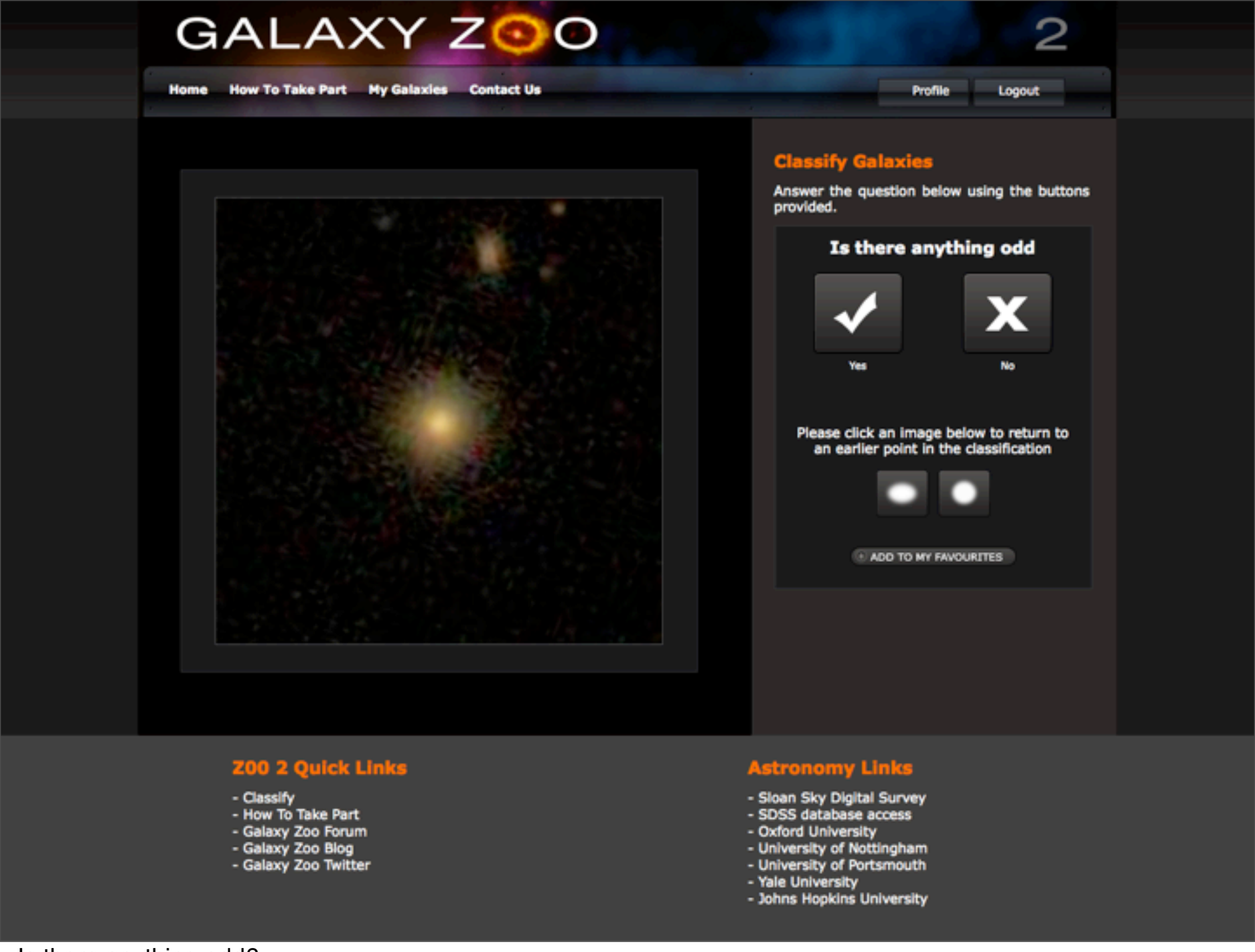
–aren't easy for computers to tackle, so need…

–many human eyes

Best example is Galaxy Zoo, 10 million classifications, http://www.galaxyzoo.org/



Galaxy Zoo 2: asking for more in-depth analysis of 250,000 galaxies from the original survey.



Is there anything odd?

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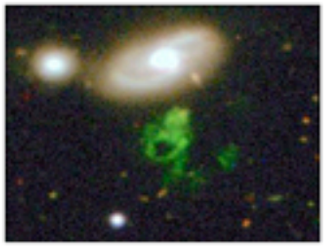
Teacher finds new cosmic object

By Paul Rincon
Science reporter, BBC News

A new class of cosmic object has been found by a Dutch schoolteacher, through a project which allows the public to take part in astronomy research online.



The object is lit up by a long-dead quasar

Hanny Van Arkel, 25, came across the strange gaseous blob while using the Galaxy Zoo website to help classify galaxies in telescope images.

Astronomers subsequently confirmed that the object was one-of-a-kind.

The work has been submitted to the journal Monthly Notices of the Royal Astronomical Society.

The object quickly became known as "Hanny's Voorwerp" - Voorwerp being the Dutch word for "object".

Researchers think this green blob got its energy from light emitted by a quasar (a powerful radiation source powered by a supermassive black hole) that has since gone dim.

> **"The Voorwerp is a massive 'light echo' produced as the light strikes the gas"**
>
> Dr Chris Lintott, University of Oxford

They think the quasar was hosted in a nearby spiral galaxy called IC 2497. It was so bright that, if the quasar was still active, it would be visible from Earth with binoculars.

However, because of the distance between the galaxy and the Voorwerp, light from the quasar would have taken tens of thousands of years to reach the gaseous blob.

This is why the Voorwerp is still bright despite the quasar having now shut off.

"The quasar itself is no longer visible to us, but its light continues to travel through space and the Voorwerp is a massive 'light echo' produced as the light strikes the gas," Dr Chris Lintott, from Oxford

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The online volunteers who take part in Citizen Science projects don't just contribute to science, they ake new discoveries possible.
Without them, some data sets would simply be too vast to ever analyse in-depth.

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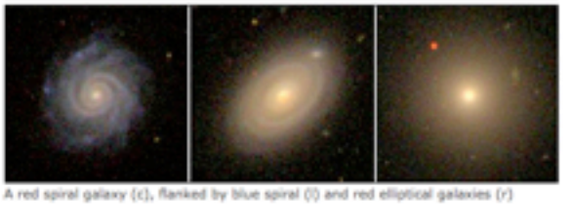
Galaxy 'missing link' uncovered

By Jason Palmer
Science and technology reporter, BBC News



A red spiral galaxy (c), flanked by blue spiral (l) and red elliptical galaxies (r)

Astronomers have identified a type of galaxy that represents a "missing link" in our understanding of the Universe.

Spiral and elliptical galaxies used to be known exclusively as "blue" and "red", respectively.

But two studies, published in a Royal Astronomical Society journal, show that one in five galaxies is a red spiral.

It is now thought the red spirals occur when spiral galaxies grow old without any violent collisions, such as with other galaxies.

Astronomers have seen that, in dense regions of space where there is a high concentration of galaxies, there are many old, "red and dead" galaxies which are elliptical or spherical in shape.

These galaxies are presumed to have formed rapidly, early in the history of the Universe. The red light we now see from them is that of their twilight years, showing that new star formation has long since stopped.

Elsewhere, comparatively young spiral galaxies still promote star formation, whose emitted light tends towards the blue.

But the new findings demonstrate the existence of red spirals, the first evidence that there are galaxies whose star formation ceased in the last few billion years - relatively recently when one considers the entire history of the Universe.

Pictures' worth

"There have been hints that red spirals that would exist in clusters and groups of galaxies before and people had seen handfuls of objects, but never enough to say that they are a major player in the galaxy population," said co-author Steven Bamford of the University of Nottingham.

Dr Bamford used data from the Galaxy Zoo project, which has seen some 170,000 members of the public help classify galaxies imaged with the Sloan Digital Sky Survey.

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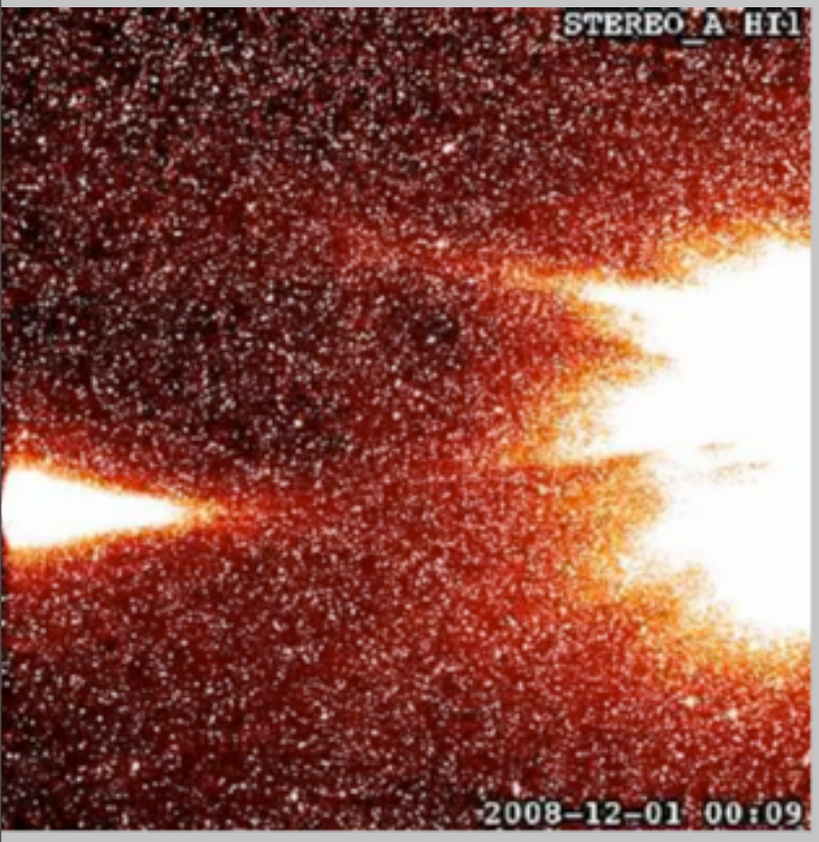
Galaxy Zoo volunteers are credited in peer-reviewed science research – and sometimes initiating their own original research.



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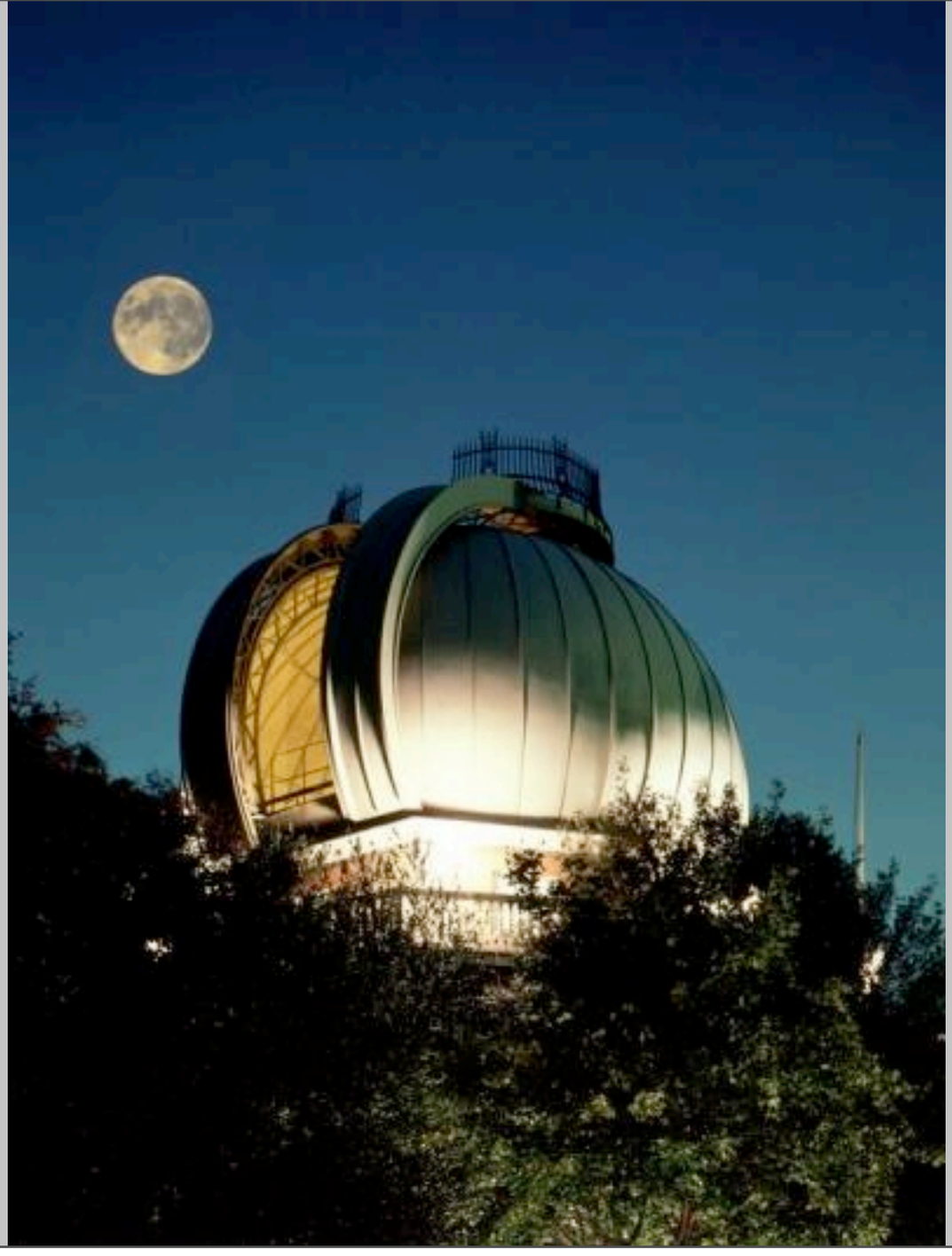
It will enable the Royal Observatory Greenwich to once again be at the forefront of scientific research, generating media interest by making the science headlines.



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