



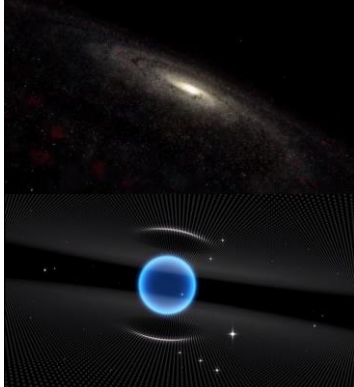




ESO, Karl-Schwarzschild-Str.2
D-85748 Garching bei München,
Germany
Telephone: +49 (0)89 3200 6855
Telefax: +49 (0)89 3200 6480
hubble@eso.org

www.spacetelescope.org

Hubblecast 70: Peering around cosmic corners	Visual notes
<p>00:00 [Narrator] 1. The Universe is vast and mysterious.</p> <p>To uncover its secrets we use telescopes like Hubble, but nature has some tricks of its own to help us on our way. Tricks of the light that mean we can see very faint and distant galaxies — galaxies we wouldn't be able to see otherwise.</p>	
<p>00:24 2. Intro</p>	
<p>00:52 [Dr. J] 3. Hi, and welcome to another episode of the Hubblecast!</p> <p>Hubble has produced some of the very deepest images of the Universe ever — but even these extraordinary images have their limitations.</p> <p>We know that there are galaxies that are simply too distant, and therefore too faint, to show up even in these extremely deep images. So what can we do? Well, we can either build a bigger telescope, or we can be clever and use one of nature's telescopes. I'm talking about a phenomenon called gravitational lensing.</p>	 
<p>01:28 [Narrator] 4. Take something like a galaxy. Full of stars, gas, dark matter, and dust, this galaxy's gravitational force is so enormous that it affects the region it sits in and distorts the very fabric of the surrounding space.</p> <p>It isn't only galaxies that do this. Any object that has mass distorts the space around it with its gravity, from large galaxy clusters down to individual stars.</p>	

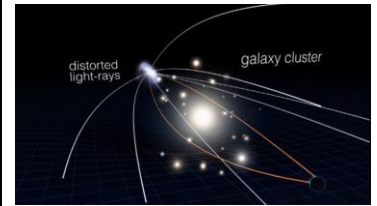
02:07

[Dr. J]

5. In space, light travels invariably along straight lines. But what is a straight line? Well, it is the shortest distance between two points. But in a curved space, the shortest distance between two points may not look particularly straight to us.

Now what that means is that when light passes very near by a massive object that curves the space around it, the light ray is bent.

As a result, this massive object, or rather the curved space around it produced by its gravity, acts like a lens; a gravitational lens that deflects light into our telescopes that would have otherwise never made it there.



02:53

[Narrator]

5. This deflection means that distant and faint objects can suddenly be seen peeking from around the edge of a nearer “lens” — although they may look quite different than expected.

We see distant galaxies that have been “lensed” as arcs on the sky around their lenses. For example, the arc around this galaxy cluster is not a photographic error, but a second more distant galaxy — deformed, but visible.

Or, if everything is *perfectly* aligned, we see a ring of light encircling the huge galaxy in the foreground. These perfect rings — known as Einstein rings — are so rare that only a few handfuls have ever been observed in visible light.

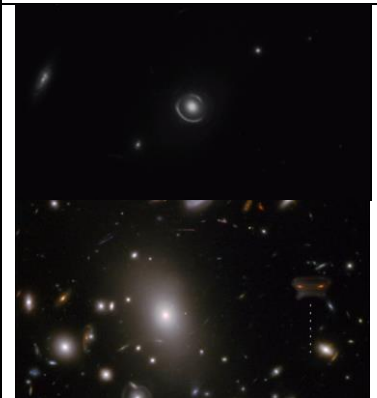


03:54

[Narrator]

6. A few years ago Hubble observed an even rarer cosmic coincidence — an incredible double ring, where Hubble can see the light from not one but two galaxies, perfectly aligned behind a closer galaxy.

Lensing can create weird and amusing shapes. Take Hubble’s image of galaxy cluster Abell 68. The central part of this image is distorted and stretched out into streaks by the cluster’s lensing effects, but visible in the top corner is a cosmic space invader! This deformed galaxy is actually visible twice, as its light is following two separate paths around a nearer elliptical galaxy before reaching us.



04:56

[Dr. J]

7. Now a gravitational lens not only distorts the images of background sources into funny shapes, but it actually makes them brighter. That means that, when using a gravitational lens, we can actually see fainter, and therefore more distant objects, than would otherwise be possible.

Also, the images are magnified, so that we can see more detail — just like when using an ordinary magnifying glass.

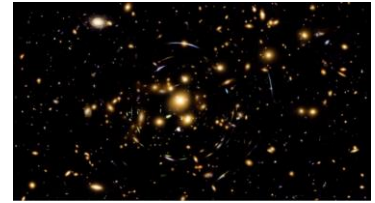
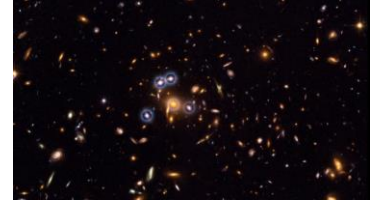


05:24

[Narrator]

8. This isn't the only intriguing effect that gravitational lensing can produce. Take these five quasars photographed by Hubble back in 2006. They all look very similar and close together... perhaps a little too similar. In fact, these are not quasar quintuplets, but a single quasar seen five separate times as its light is lensed by a huge cluster of galaxies lying in the foreground.

While bizarre, this multiple imaging can be very useful to astronomers, and allows us to figure out how light from the distant object has travelled to us. These weird cosmic doppelgängers can be used to explore both the characteristics of the gravitational lens, and the Universe itself – for example, how it is expanding.



06:22

[Dr. J]

9. Hubble's Frontier Fields observing campaign, which began in October 2013, will combine the magnifying power of gravitational lensing with the light-collecting power of Hubble to delve even deeper into the distant Universe — so watch this space!

This is Dr J, signing off for another episode of the Hubblecast. Once again, nature has surprised us beyond our wildest imagination.



End

06:48