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Hubblecast Episode 39: GOODS		
00:00 [Visuals start] [Narrator — Megan Watzke] Today's telescopes study the sky across the electromagnetic spectrum. Each part of the spectrum tells us different things about the Universe, giving us more pieces of the cosmic jigsaw puzzle. The most powerful telescopes on the ground and in space have joined forces over the last decade in a unique observing campaign, known as GOODS, which reaches across the spectrum and deep back into cosmic time.		
00:28 Hubblecast intro This is the Hubblecast. News and images from the NASA/ESA Hubble Space Telescope, travelling through time and space with our host Dr J, aka Dr Joe Liske.		
00:57 [Dr J] Hello and welcome to this very special "multicast". We'll be exploring a unique collaboration between some of the world's most powerful telescopes both on the ground and in space. Now, to do this, we've set up a similar collaboration between the ESOcast, the Hubblecast, the Spitzer Space Telescope's "Hidden Universe" and the Chandra X-Ray Observatory's "Beautiful Universe".		

01:20 [Megan Watzke] I'm Megan Watzke for the Beautiful Universe from the Chandra X-ray Center		
01.25 [Robert Hurt] And I'm Dr Robert Hurt for Hidden Universe from NASA Spitzer Science Center		
01:31 [Dr J] It's the combination of deep observations from many different telescopes that makes this project so important.		
01:39 [Dr J as narrator] The longer a telescope spends looking at a target, the more sensitive the observations become, and the deeper we can look into space. But to get the full picture of what's happening in the Universe, astronomers also need observations at a range of different wavelengths, requiring different telescopes. These are the key ideas behind the Great Observatories Origins Deep Survey, or GOODS for short.		
02:04 [Megan Watzke] The GOODS project unites the world's most advanced observatories, these include ESO's Very Large Telescope, the NASA/ESA Hubble Space Telescope, the Spitzer Space Telescope, the Chandra X-ray Observatory and many more, each making extremely deep observations of the distant Universe, across the electromagnetic spectrum. By combining their powers and observing the same piece of the sky, the GOODS observatories are giving us a unique view of the formation and evolution of galaxies across cosmic time, and mapping the history of the expansion of the		

Universe.		
02:52 [Dr J] Now, this is not the first time that telescopes have been used to give us extremely deep views of the cosmos. For example, the Hubble Deep Field is a very deep image of a small piece of sky in the northern constellation of Ursa Major. This revealed thousands of distant galaxies despite the fact that the whole field is actually only a tiny speck of the sky, about the size of a grain of sand held at arm's length.		
03:19 [Narrator — Megan Watzke] Now, with GOODS, many different observatories have brought their powers to bear on two larger targets, one centred on the original Hubble Deep Field in the northern sky, and one centred on a different deep target, the Chandra Deep Field South, in the southern sky. The main GOODS fields are each 30 times larger than the Hubble Deep Field, and additional observations cover an area the size of the full Moon.		
03:49 [Dr J] These areas of the sky were already some of the most extensively explored, and so the combination of existing archival data and many new, dedicated observations gives us an unprecedented view of of the history of galaxies.		
04:14 [Narrator — Megan Watzke] At ESO's Very Large Telescope on Cerro Paranal, the 8.2-metre diameter giants were used for a total of almost 100 nights of dedicated observations. The telescopes made images of the region both in near-infrared light, and on the boundary between visible light and ultraviolet light. At these short wavelengths, only telescopes on exceptional sites such as the VLT's Cerro Paranal have a chance to observe through the Earth's atmosphere.		

04:46 [Dr J] The NASA/ESA Hubble Space Telescope observed the GOODS regions at optical and near-infrared wavelengths, to detect distant star-forming galaxies among other things. Now, Hubble spent a total of 5 days observing the fields, spread over five repeat visits. Each of these was separated from the previous one by about 45 days. Now, by spreading out the observations like this, Hubble was able to watch for new supernovae appearing over the months, providing key information for studying the expansion and acceleration of the Universe due to the mysterious dark energy. [Robert Hurt on virtual screen] But it wasn't just Hubble making space-based observations for GOODS…		
05:26 [Robert Hurt] NASA's Spitzer Space Telescope imaged the GOODS regions in near- and mid-infrared light for 5 days, at wavelengths up to 30 times longer than the Hubble observations. These longer wavelengths are important for revealing distant galaxies whose light may be obscured by cosmic dust, or stretched by the expansion of the Universe, making them invisible to Hubble. For these distant galaxies, the Spitzer images also tell astronomers about their age and their total mass of stars — complementary information to the data from Hubble. Now, let's move from the infrared to much shorter wavelengths…		
06:06 [Megan Watzke] Also in orbit, the Chandra X-Ray Observatory had already observed the GOODS field in many long observations taken over the course of a year. The Chandra images are the deepest X-ray images ever taken, and detected more than 200 hundred X-ray sources believed to be supermassive black holes in the centres of young galaxies. The X-rays are produced by extremely hot interstellar gases falling into the black holes.		
06:37 [Narrator — Dr J] These multiwavelength observations identified tens of thousands of galaxies. To get a full understanding of the history and development of galaxies over the vast stretch of the Universe's history, we need to be able to pin down their distances more precisely, to fix them in cosmic time.		

As these galaxies are so far away, the light waves we see from them started their journey up to about 13 billion years ago, and because the Universe has been expanding since the Big Bang, back then the Universe was less than one seventh of its current size.		
07:11 [Megan Watzke] During the billions of years of the light's journey, its wavelength has been stretched as the fabric of space has expanded. This effect is known as "redshift" because, for example, light that was originally blue or ultraviolet in colour is shifted to longer, redder wavelengths.		
07:32 [Dr J] Back on the ground, astronomers used spectrographs on ESO's Very Large Telescope to capture the spectra of galaxies, spreading out their light like the colours of a rainbow. Now, the spectra allow astronomers to measure the redshifts of the galaxies, and hence, their distances. An extensive campaign produced redshifts for almost 3000 galaxies in the GOODS fields. Now, with this knowledge, we can place the galaxies at distances along a vast cone of space, stretching out from our own vantage point like a searchlight beam into the cosmos. We can take an amazing journey through kind of a tunnel towards the edge of the Universe. In some places, the galaxies cluster together, forming structures which are up to tens of millions of light years in scale.		
08:20 [Robert Hurt] Thanks to GOODS and other surveys of the same region, these areas of the sky are uniquely well studied with high resolution, deep observations across a wide wavelength range, plus there is more to come. For example, the Atacama Pathfinder Experiment telescope, or APEX, has spent a total of 300 hours — nearly two full weeks — imaging the region at submillimetre wavelengths, from its high site on the 5000-m altitude plateau of Chajnantor in the Chilean Andes.		

09:00 [Narrator — Dr J] Observations at these wavelengths are ideal for finding the redshifted light of distant dusty galaxies in the very early Universe. Because of the longer wavelength of its submillimetre light, the APEX image is not as sharp as the visible light and infrared images. However, thanks to the deep Spitzer images, as well as images made at radio wavelengths, we can match up and identify the objects found by APEX with galaxies seen at other wavelengths. The submillimetre light glow reveals that hundreds of stars are being formed per year in these galaxies. In the next couple of years, ALMA, the Atacama Large Millimeter/submillimeter Array, currently under construction on the same plateau as APEX, will begin its first science observations. Also observing at submillimetre wavelengths, it will have much greater sensitivity than APEX, and resolution even better than Hubble. ALMA will revolutionise our understanding of the early Universe by revealing many more distant, dust-obscured galaxies that cannot be seen at all by visible light and infrared telescopes.		
10:11 [Dr J] These projects are an excellent example of how great observatories are joining together, across the electromagnetic spectrum, to give us a more complete view of galaxies over the history of the Universe. Already, astronomers have written over 400 papers based on these data, with even more in the pipeline! And on top of that, the observations of the GOODS fields will continue in the future. These patches of the sky will be prime targets for the next generation of telescopes both on the ground and in space, and astronomers around the world use these data to learn new things about the Universe from them for many years to come. Saying goodbye to our friends at the other observatories, this is Dr J signing off for the ESOcast and the Hubblecast…		

10:54 [Robert Hurt] This is DrRobert Hurt signing off for the Hidden Universe and the Spitzer Science Center, reminding you there's a hidden Universe just waiting to be discovered.		
11:02 [Megan Watzke] And this is Megan Watzke signing off for the Chandra X-ray Observatory and the Beautiful Universe.		
11:08 [Dr J] Join me again next time for another cosmic adventure, which I'm sure will surprise us beyond our wildest imagination.		
11:18		Ads: This was a multicast from: • ESOcast [logo] • Hubblecast [logo] • Hidden Universe [logo] • Beautiful Universe [logo]
11:23 [Outro]		Hubblecast is produced by ESA/Hubble at the European Southern Observatory in Germany. The Hubble mission is a project of international cooperation between NASA and the European Space Agency.
12:07 END		