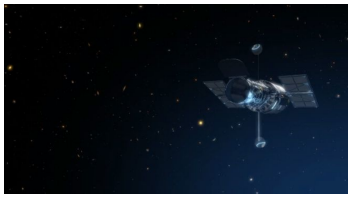
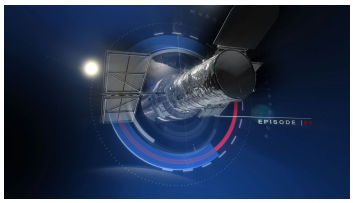
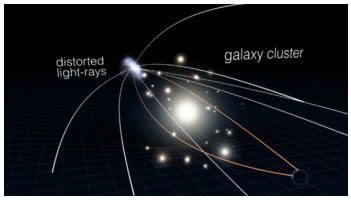
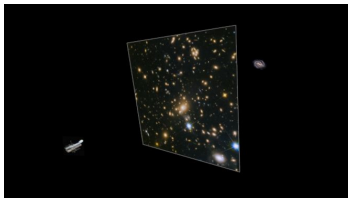
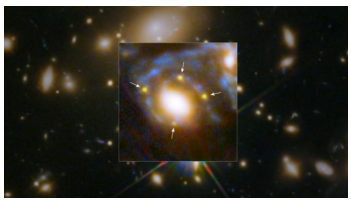
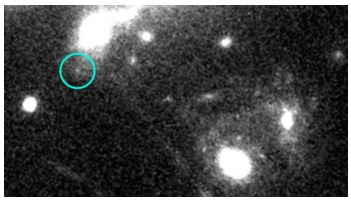
ESO, Karl-Schwarzschild-Str.2
D-85748 Garching bei München,
Germany
Telephone: +49 (0)89 3200 6855
Telefax: +49 (0)89 3200 6480
hubble@eso.org

www.spacetelescope.org

Keywords: Gravitational Lensing, Frontier Fields

Hubblecast Episode 90: The Final Frontier	**Visual notes**
00:00 [Narrator] 1. Over the last 25 years, the NASA/ESA Hubble Space Telescope has revealed the distant Universe with ever-increasing depth through the Deep and Ultra Deep fields. Hubble has embarked on an ambitious new programme to push even further towards the Universe's furthest frontiers.	 
00:24 2. Intro	
00:40 [Dr J.] 3. Hello, and welcome to another episode of the Hubblecast! In 2013, Hubble began a campaign to capture very deep images of some of the most massive structures in the Universe — galaxy clusters.	

The Frontier Fields campaign is using six of these giants to peer into the farthest reaches of the Universe. The enormous amount of mass in a galaxy cluster means that it bends the space around it and acts like a gigantic magnifying glass. This process is known as gravitational lensing and it allows astronomers to study objects behind the cluster in the very distant Universe that would normally be too faint to see even for Hubble.	 
01:28 [Narrator] 4. Abell 2744. One of the first and most captivating targets of the Frontier Fields campaign. Like all large galaxy clusters, Abell 2744's mammoth mass is warping the space around it and magnifying the light from distant galaxies behind it. This produces weird and wonderful arrangements of warped light in the form of arcs and distorted shapes. Magnified by Abell 2744, some of the most distant galaxies ever found became visible. These galaxies are so distant that the light Hubble has captured from them was emitted when the Universe was just 500 million years old. These distant galaxies — some of the first to form in the Universe — offer astronomers a glimpse of the conditions in the early Universe.	  
02:36 [Narrator] 5. One of the most distant clusters studied is MACS J1149.5+2223 — so distant that it takes the light five billion years to reach us! Using this cluster Hubble has captured a rare event for the first time: the gravitationally lensed image of a supernova, arranged four times in a galaxy in the cluster. The light from the dying star, was magnified by the mass of the cluster. And as it is perfectly aligned with one of the galaxies in	 

the cluster, its light has been split into four images.	
03:24 [Dr. J] 6. By studying gravitational lensing, astronomers are able to map out the total amount of matter in galaxy clusters. Now, this mapping is a very valuable tool in the search for one of the most elusive components of the Universe — dark matter. If the galaxy cluster contained only the matter that we can see directly, it would never have the gravitational power to distort the light as we observe it. So there must be additional dark matter present, and gravitational lensing tells us how this dark matter is distributed within the cluster. In the case of MACSJ1149, our understanding of the distribution of dark matter is in fact so good that it allowed us to predict the appearance of a fifth image of the lensed supernova in December 2015, and, lo and behold, this appearance has in fact been observed as predicted.	  
04:26 [Narrator] 7. As well as observing the clusters, Hubble puts its multiple cameras to use during the cluster observations by also observing six parallel fields — regions near the galaxy clusters. While these adjacent images cannot be used for gravitational lensing, Hubble uses them to perform deep-field observations and therefore to give astronomers an even larger window on the early Universe.	 
04:56 [Dr. J] 8. So far, Hubble has completed the observations for three of the six Frontier Fields clusters and their parallel fields. These data are already teaching us a lot about the very early Universe and they are paving the way for the James Webb Space Telescope in its quest for the very first generation of galaxies. This is Dr J, signing off for the Hubblecast. Once again, nature	

has surprised us beyond our wildest imagination.	

Ends 06:23