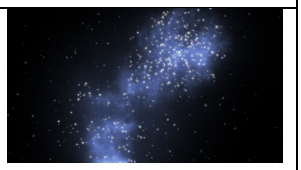
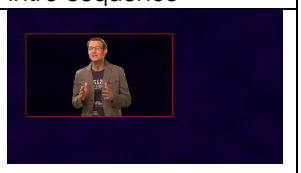
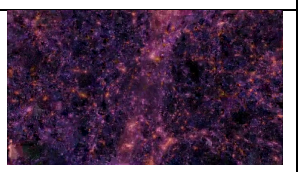
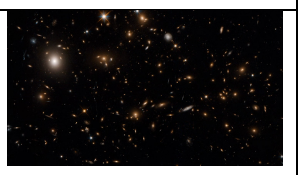
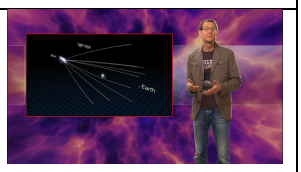
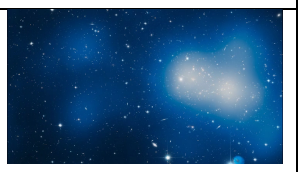
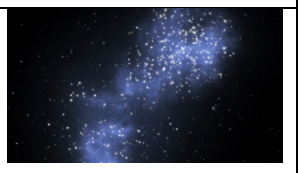
ESO, Karl-Schwarzschild-Str.2
D-85748 Garching bei München,
Germany
Telephone: +49 (0)89 3200 6855
Telefax: +49 (0)89 3200 6480
hubble@eso.org

www.spacetelescope.org

Hubblecast Episode 58: Caught in the cosmic web		
00:00 [Narrator] Astronomers have mapped a giant structure made of dark matter. It extends almost 60 million light-years out from a huge galaxy cluster, and is our best glimpse so far of the scaffolding that gives the Universe its large-scale structure.		
		Intro sequence
00:50 [Dr J] Hello and welcome to the Hubblecast. In its very early years, the Universe was extremely smooth and uniform. There were no stars and no galaxies, and all of the matter was distributed throughout the Universe very, very evenly. Almost perfectly so. But not quite. Even back then there were tiny variations in the density from place to place. And over time, these tiny fluctuations grew and condensed into a web-like pattern that pervades and gives structure to the Universe of today. Formed of vast filaments and sheets of dark matter, this structure is known to astronomers as the cosmic web. Now the trouble is, because it's made of dark matter, you can't actually see it when you look up into the sky. You can model it using computer simulations, but until very recently it had only ever been observed indirectly.		
02:02 [Narrator] Scientists know that less than a quarter of the matter in the Universe is actually visible, in the form of stars, nebulae, gas and so on. The majority is dark matter, which cannot be seen directly. Astronomers have had compelling evidence for the cosmic web for years, thanks to galaxies clustering along it. But directly observing the dark-matter web itself has been far more difficult.		

02:35 [Dr J] In fact, the very first successful observations of a filament of the web were only made earlier this year. Now, a team of scientists has used Hubble to take this a step further, making detailed observations of a dark matter filament, measuring its length, shape and density.		
02:55 [Narrator] Finding one of these filaments is no easy task. First, you need to look where you are likely to find one. Theories say galaxy clusters form where filaments of the cosmic web meet, with the filaments gradually funnelling galaxies and dark matter into the clusters. So the team focused Hubble on the galaxy cluster MACS J0717, which is known to still be growing.		
03:26 [Dr J] And then you need Albert Einstein. As predicted by the theory of general relativity, a beam of light is bent as it passes near an object with a large mass. So although you can't directly see a dark matter filament, its mass should nevertheless bend the light coming from galaxies behind it, subtly distorting their shapes.		
03:53 [Narrator] Next, you have to combine Einstein and Hubble. The space telescope can make very detailed observations of galaxy clusters, perfect for spotting these tiny distortions. And if you map them all out, the hidden filament of dark matter is revealed.		
04:19 [Dr J] And then finally, you take this two dimensional map and you extend it into three dimensions. The astronomers used data from the Keck-II and Subaru telescopes in Hawaii, among others, to measure distances to the galaxies within the filament mapped by Hubble, and to trace their motions. They used this to make the first ever three-dimensional reconstruction of a filament and of how it is funnelling matter into a massive cluster of galaxies.		
04:51 [Narrator] The filament extends across at least 60 million light-years of space. From our perspective, we see it gently curving towards us, then continuing almost along our line of sight, before it plunges into the back of the galaxy cluster. Measurements of hundreds of galaxies within the filament show them moving along the filament and into cluster MACS J0717.		

05:22 [Dr J] Observing and reconstructing the cosmic web is quite a big deal, because it tells us about the underlying structure of the cosmos. Now in the future we'll be seeing more research like this. The NASA/ESA/CSA James Webb Space Telescope, scheduled to be launched later this decade, will be an excellent tool for studying the cosmic web, because of its greatly improved sensitivity compared to Hubble. This is Dr J signing off for the Hubblecast. Once again, nature has surprised us beyond our wildest imagination.