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| **Hubblecast Episode 68: The Hubble time machine** | | Visual notes |
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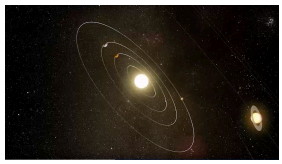
| 00:00<br>**[Narrator]**<br>1. Understanding the vast scale of the Universe is no mean feat. But Hubble has helped us to understand the skies around us: it has peered far away, to the very edges of the visible Universe, and taken snapshots of space as it appeared deep in the cosmic past, billions of years ago. | |  |
| 00:25<br>2. Intro | |  |
| 00:53<br>**[Dr. J - STUDIO 1]**<br>3. The Universe is a very big, and very old, place. The distance and timescales involved in astronomy are sometimes difficult to wrap your head around.<br><br>For example, we usually think of the Solar System as being a pretty big place; after all, it would take nearly 600 years to travel out to Neptune at the speed of an average passenger jet. But on a cosmic scale, the entire Solar System is just a tiny, tiny speck. | |  |
| 01:23<br>**[Narrator]**<br>4. As we can't travel to other galaxies or star systems and view them for ourselves, we rely on telescopes like Hubble.<br><br>One of the main scientific justifications for building Hubble was to measure the size and age of the Universe. This task has produced some of the telescope's most iconic images, taken as Hubble peered into the faraway Universe to see what galaxies looked like in the past. | |  |
| 01:56<br>**[Dr. J - STUDIO 2]**<br>5. So how is it possible that Hubble can look into the past?<br><br>Well, that's because, just like a spacecraft, light also travels at a finite speed. At 300,000 kilometres per second, this speed is very high, but it is still finite. That means that, in principle, everything we see is a thing of the past.<br><br>Now normally, in our everyday lives, it doesn't matter, because the distances are just too small. But when we look at the Moon, we see it as | |  |

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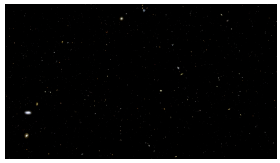
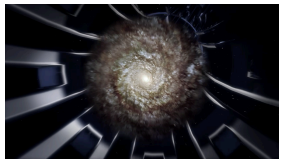
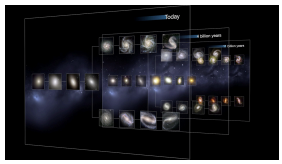
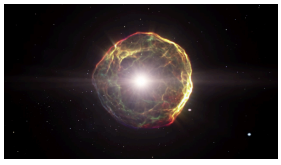
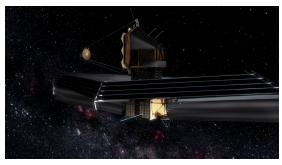
| it was about 1 second ago. The Sun we see as it was about 8 minutes ago. For the nearest star, it's about 4 years, and the edge of our galaxy we see as it was about 100,000 years ago. | | |
| 02:54<br>**[Narrator]**<br>6. As we look further, these thousands of years turn into millions, and even billions – right back to when the Universe was very young.<br><br>We see these galaxies as they were in the very distant past. Galaxies near to us are fully formed, seen as sleek spirals and smooth ellipticals. As we travel further back, we see toddlers that are rough around the edges, still in the middle of evolving into fully-grown galaxies. | |  |
| 03:30<br>**[Dr. J - STUDIO 3]**<br>7. Nowhere is this seen better than in the Hubble Deep Field images. To create these images Hubble gazed at the same patches of sky for very long periods of time, gathering enough light to see extremely faint and very far away objects.<br><br>These images show some of the most distant galaxies that have ever been observed, going back an incredible 13.2 billion years, to a time when the Universe was only about half a billion years old. | |  |
| 04:06<br>**[Narrator]**<br>8. This far back in time, our Milky Way may have just formed. However, the Earth only made an appearance just under 8.5 billion years later.<br><br>The entire history of the Earth has taken place over just a third of the Universe's lifetime – from the Earth's formation, to the emergence of dinosaurs, early life, and humans – to the present day, where astronomers use Hubble to view some of the Universe's earliest inhabitants and explore our origins. | |  |
| 04:43<br>**[Dr. J - STUDIO 4]**<br>9. So how do we know what these very distant galaxies look like today?<br><br>Well, we can't know for sure. We do know, however, that the Universe, on very large scales, pretty much looks the same everywhere. That means that today these very distant galaxies will look very similar to the galaxies we observe in our local patch of the Universe around us.<br><br>Vice versa, by looking at these distant galaxies we are also, in a way, observing our own past. | |  |
| 05:15<br>**[Narrator]**<br>10. Hubble is still searching the distant Universe for clues about how the Universe formed, and how it has evolved.<br><br>Several of Hubble's surveys, for example CANDELS, CLASH, and GOODS, are scanning for distant supernova explosions, objects that are good celestial distance markers. Observations of distant supernovae led to the discovery that the expansion of the Universe is accelerating, which earned three astronomers a Nobel Prize in Physics in 2011. | |  |
| 05:55<br>**[Dr. J - STUDIO 5]**<br>11. Using Hubble, we can observe the Universe as it once was — going back to a time before the Sun, and perhaps even the Milky Way, had even formed. Hubble's successor, the James Webb Space Telescope, due to be launched in 2018, will push this frontier even further, and will perhaps even allow us to observe the very first generation of galaxies to | |  |

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| have formed in the Universe.<br><br>This is Dr J, signing off for the Hubblecast. Once again, Nature has surprised us beyond our wildest imagination. | | |

End
06:32