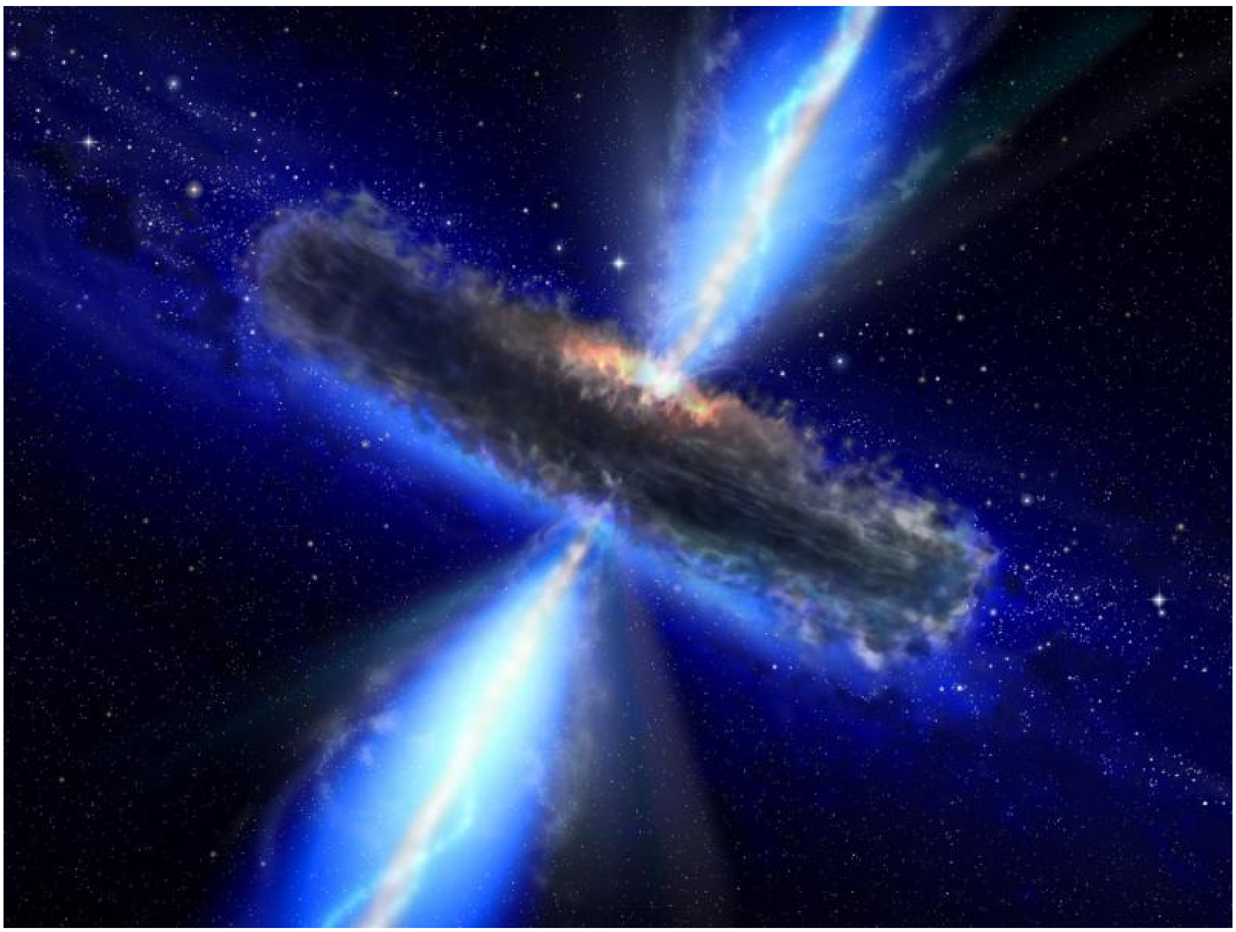
Mapping super massive black holes in the distant universe

May 19 2017, by Glenn Harris



The supermassive black hole at the centre of a distant galaxy is surrounded by a dusty torus of material falling in. Tremendous amounts of light is given off making quasars significantly brighter than typical galaxies, and distant quasars can therefore be used to map the distant universe. Credit: Hubble telescope websit

Astronomers have constructed the first map of the universe based on the positions of supermassive black holes, which reveals the large-scale structure of the universe.

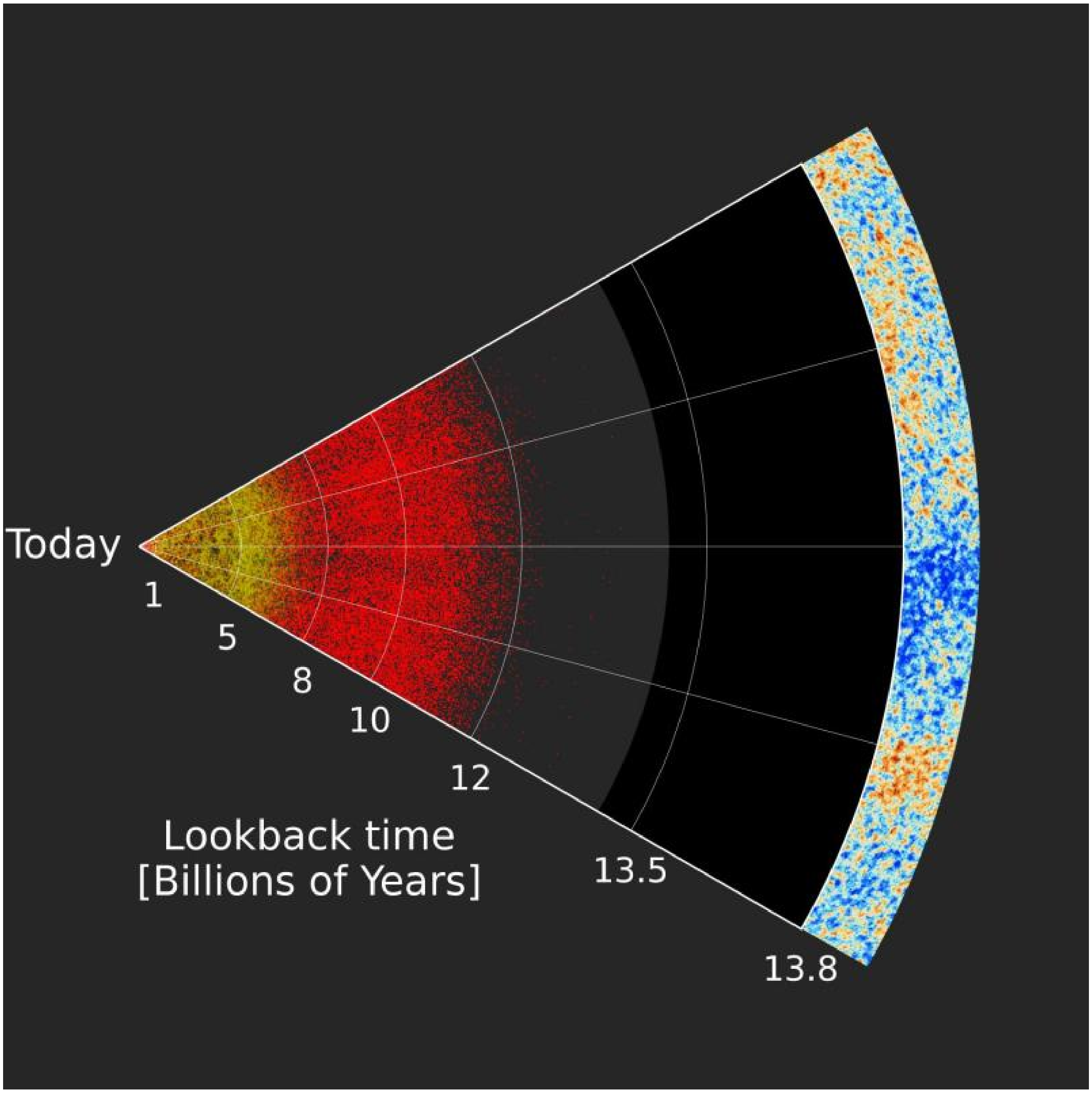
The map precisely measures the expansion history of the universe back to when the universe was less than three billion years old. It will help improve our understanding of 'Dark Energy', the unknown process that is causing the universe's expansion to speed up.

The map was created by scientists from the Sloan Digital Sky Survey (SDSS), an international collaboration including astronomers from the University of Portsmouth.

As part of the SDSS Extended Baryon Oscillation Spectroscopic Survey (eBOSS), scientists measured the positions of quasars - extremely bright discs of matter swirling around supermassive black holes at the centres of distant galaxies. The light reaching us from these objects left at a time when the universe was between three and seven billion years old, long before the Earth even existed.

The map findings confirm the standard model of cosmology that researchers have built over the last 20 years. In this model, the universe follows the predictions of Einstein's General Theory of Relativity but includes components that, while we can measure their effects, we do not understand what is causing them.

Along with the ordinary matter that makes up stars and galaxies, Dark Energy is the dominant component at the present time, and it has special properties that mean that it causes the expansion of the universe to speed up.



Largest-ever three-dimensional map of the universe. Earth is at the left, and distances to galaxies and quasars are labelled by the lookback time to the objects (lookback time means how long the light from an object has been travelling to reach us here on Earth). The locations of quasars (galaxies with supermassive black holes) are shown by the red dots, and nearer galaxies mapped by SDSS are also shown (yellow). The right hand edge of the map is the limit of the observable universe, from which we see the Cosmic Microwave Background (CMB) - the light “left over” from the Big Bang. Fluctuations in the CMB as observed by the recent ESA Planck satellite mission are shown. The bulk of the empty space in between the quasars and the edge of the observable universe are from the “dark ages”, prior to the formation of most stars, galaxies, or quasars. Credit: Anand Raichoor and the SDSS Collaboration

Will Percival, Professor of Cosmology at the University of Portsmouth, who is the eBOSS survey scientist said: "Even though we understand how gravity works, we still do not understand everything - there is still the question of what exactly Dark Energy is. We would like to understand Dark Energy further. Not with alternative facts, but with the scientific truth, and surveys such as eBOSS are helping us to build up our understanding of the universe."

To make the map, scientists used the Sloan telescope to observe more than 147,000 quasars. These observations gave the team the quasars' distances, which they used to create a three-dimensional map of where the quasars are.

But to use the map to understand the expansion history of the universe, astronomers had to go a step further and measure the imprint of sound waves, known as baryon acoustic oscillations (BAOs), travelling in the early universe. These sound waves travelled when the universe was much hotter and denser than the universe we see today. When the universe was 380,000 years old, conditions changed suddenly and the sound waves became 'frozen' in place. These frozen waves are left imprinted in the three-dimensional structure of the universe we see today.

Using the new map, the observed size of the BAO can be used as a 'standard ruler' to measure distances in our universe. "You have metres for small units of length, kilometres or miles for distances between cities, and we have the BAO for distances between galaxies and quasars in cosmology," explained Pauline Zarrouk, a PhD student at the

Irfu/CEA, University Paris-Saclay, who measured the distribution of the observed size of the BAO.

The current results cover a range of times where they have never been observed before, measuring the conditions when the universe was only three to seven billion years old, more than two billion years before the Earth formed.

The eBOSS experiment continues using the Sloan Telescope, at Apache Point Observatory in New Mexico, USA, observing more quasars and nearer galaxies, increasing the size of the map produced. After it is complete, a new generation of sky surveys will begin, including the Dark Energy Spectroscopic Instrument (DESI) and the European Space Agency Euclid satellite mission. These will increase the fidelity of the maps by a factor of ten compared with eBOSS, revealing the universe and Dark Energy in unprecedented detail.

More information: "The Clustering of the SDSS-IV Extended Baryon Oscillation Spectroscopic Survey DR14 Quasar Sample: First Measurement of Baryon Acoustic Oscillations Between Redshift 0.8 and 2.2," Metin Ata et al., 2017, submitted to *Monthly Notices of the Royal Astronomical Society* arxiv.org/abs/1705.06373

Provided by Sloan Digital Sky Survey

Citation: Mapping super massive black holes in the distant universe (2017, May 19) retrieved 23 April 2024 from https://phys.org/news/2017-05-super-massive-black-holes-distant.html