Scientists have used a novel technique to probe the nature of dark energy some 10 billion years into the past. They hope it will bring them closer to an explanation for the strange force that appears to be driving the Universe apart at an accelerating rate.

The method relies on bright but distant objects known as quasars to map the spread of hydrogen gas clouds in space.

The 3D distribution of these clouds can be used as a tracer for the influence of dark energy through time.

A scholarly paper describing the approach has been submitted to the journal Astronomy & Astrophysics and posted on the arXiv.org preprint site.

It is authored by the BOSS (Baryon Oscillation Spectroscopic Survey) team, which uses the 2.5m Sloan Foundation Telescope in New Mexico, US, to make its observations of the sky.

The international group's new data is said to be a very neat fit with theory, confirming ideas that dark energy did not have a dominant role in the nascent Universe. Back then, gravity actually held sway, decelerating cosmic expansion. Only later did dark energy come to the fore.

"We know very little about dark energy but one of our ideas is that it is a property of space itself - when you have more space, you have more energy," explained Dr Matthew Pieri, a BOSS

team-member.

"So, dark energy is something that increases with time. As the Universe expands, it gives us more space and therefore more energy, and at some point dark energy takes over from gravity to end the deceleration and drive an acceleration," the Portsmouth University, UK, researcher told BBC News.

The discovery that everything in the cosmos is now moving apart at a faster and faster rate was one of the major breakthroughs of the 20th Century. But scientists have found themselves grasping for new physics to try to explain this extraordinary phenomenon.

A number of techniques are being deployed to try to get some insight. One concerns so-called baryon acoustic oscillations.

These refer to the pressure-driven waves that passed through the post-Big-Bang Universe and which subsequently became frozen into the distribution of matter once it had cooled to a sufficient level.

Today, those oscillations show themselves as a "preferred scale" in the spread of galaxies - a slight excess in the numbers of such objects with separations of 500 million light-years.

It is an observation that can be used as a kind of standard ruler to measure the geometry of the cosmos.
Survey schematic The BOSS team used 48,000 distant quasars to "back-light" and map the distribution of clouds of hydrogen gas in the early Universe

The BOSS team has already done this using a large volume of galaxies that stretch some six billion light-years from Earth. But at greater distances - and hence deeper in cosmic time - these standard galaxies are simply too faint for the Sloan telescope to see.

Instead, the BOSS team has used quasars (quasi-stellar radio sources) to help it map the cosmos.

Quasars are far flung galaxies where a massive central black hole is driving the emission of huge amounts of electromagnetic radiation. These are visible to Sloan.

As the quasars' light travels through space towards Earth, it passes through clouds of hydrogen gas.

Some of the light is absorbed in a very characteristic way, and the pattern of absorption betrays how the density of gas varies with distance along the line of sight to the telescope.

By observing almost 50,000 closely spaced quasars, the BOSS team has now been able to build a detailed 3D map of the distribution of hydrogen gas clouds reaching 11 billion light-years away, and recording an epoch just two billion years after the Big Bang itself.

"Each line of sight may have several hundred clouds, and so with 48,000 quasars we have many millions of these clouds," said Portsmouth colleague Prof Bob Nichol.

"Then what we do is take their 3D positions and we look at how they're clustered, and we say, 'is there a preferred scale in this clustering?'" And, lo and behold, there is, just as there is a preferred scale in the clustering of nearby galaxies."

The BOSS maps allow scientists to check the pace of expansion at different cosmological epochs, helping them to determine whether gravity and dark energy are behaving as theory predicts.

"What we're basically confirming is this nice roller-coaster analogy," said Dr Pieri. "From the Big Bang, the expansion of the Universe was decelerating, and then we crested the hill about seven billion years ago, and it was like something putting the foot on the pedal and the acceleration

occurred."

BOSS is so far only a third of the way through its work. The goal in the next few years is to map the locations of a million-and-a-half galaxies and more than 160,000 quasars.

History of the Universe
Before Nobel Prize-winning research in 1998, it was assumed gravity was slowing the post-Big Bang expansion of the Universe

Now scientists say the expansion - far from slowing - is accelerating, pushing galaxies apart at a faster and faster rate

The BOSS team has traced dark energy's part in the expansion over more than 10 billion years of cosmic history