Published: 21 December 2000

Boost for Big Bang theory

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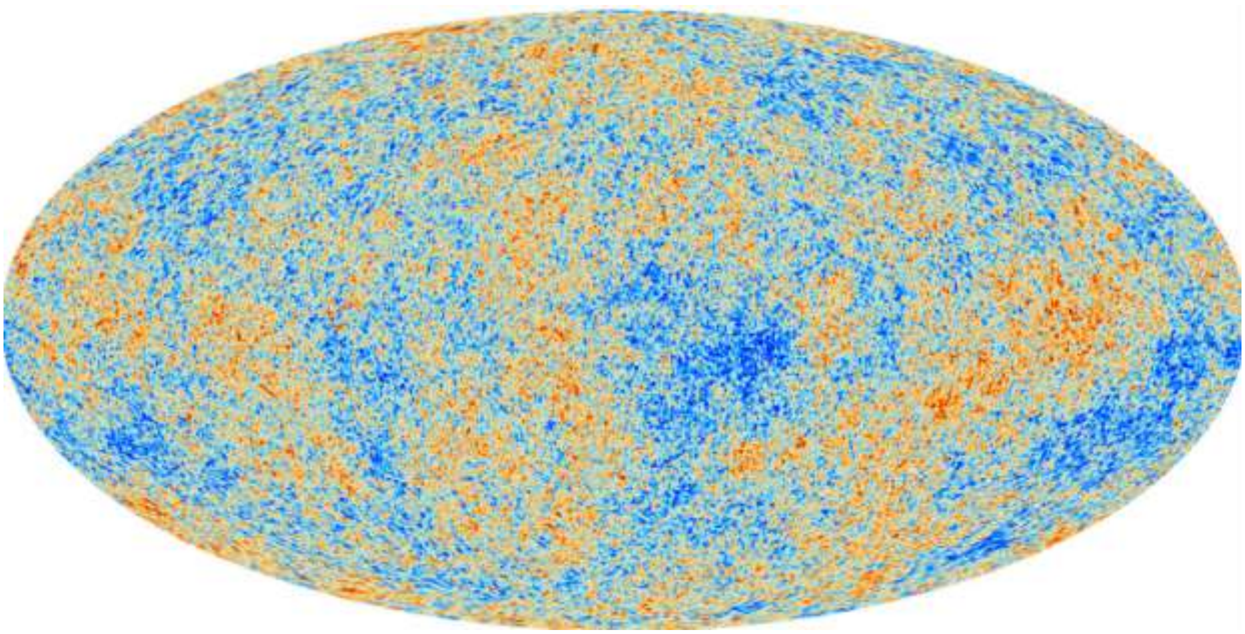
Astrophysicists have looked back 12 billion years to take the temperature of the infant Universe.



Map of CMBR for the nearby Universe [Image -- NASA].

The Universe is getting colder. It has been cooling down ever since the Big Bang, which is thought to have happened about 15 billion years ago. Astronomers Raghunathan Srianand of the Inter University Centre for Astronomy and Astrophysics in Pune, India, and colleagues have now taken the temperature of the Universe 12 billion years ago, when it was just one-fifth of its current age.

Their measurement, reported in *Nature*, helps to strengthen the prevailing view of the Big Bang, which predicts that the temperature of the Universe should decline steadily as it ages.

Big Bang theory links temperature to the 'redshift'. Distant galaxies are receding from our own, at speeds that increase with their distance. This recession stretches the wavelength of the light coming from the other galaxies, just as the pitch of a wailing ambulance siren changes as it approaches the onlooker. Thus, the light from distant galaxies is shifted towards the red (long-wavelength) end of the visible spectrum. So 'redshift' is a measure of how far away the galaxies are.

But the redshift also serves as a clock. The light from other galaxies takes longer to reach us the further away they are. So when we look at high-redshift galaxies, we are looking far back in time, seeing the Universe as it was billions of years ago. Telescopes that can see out to such vast distances are a window on events that happened long before the Earth formed.

If the Big Bang theory is right, the temperature of the Universe should increase in direct proportion to the redshift: the further back we look, the closer we are to the Big Bang and so the hotter the Universe should become. Srianand and colleagues now confirm this prediction, showing that at a redshift corresponding to a time about three billion years after the Big Bang, the temperature was between 6 and 14 degrees above absolute zero. Theory predicts a value of 9 degrees.

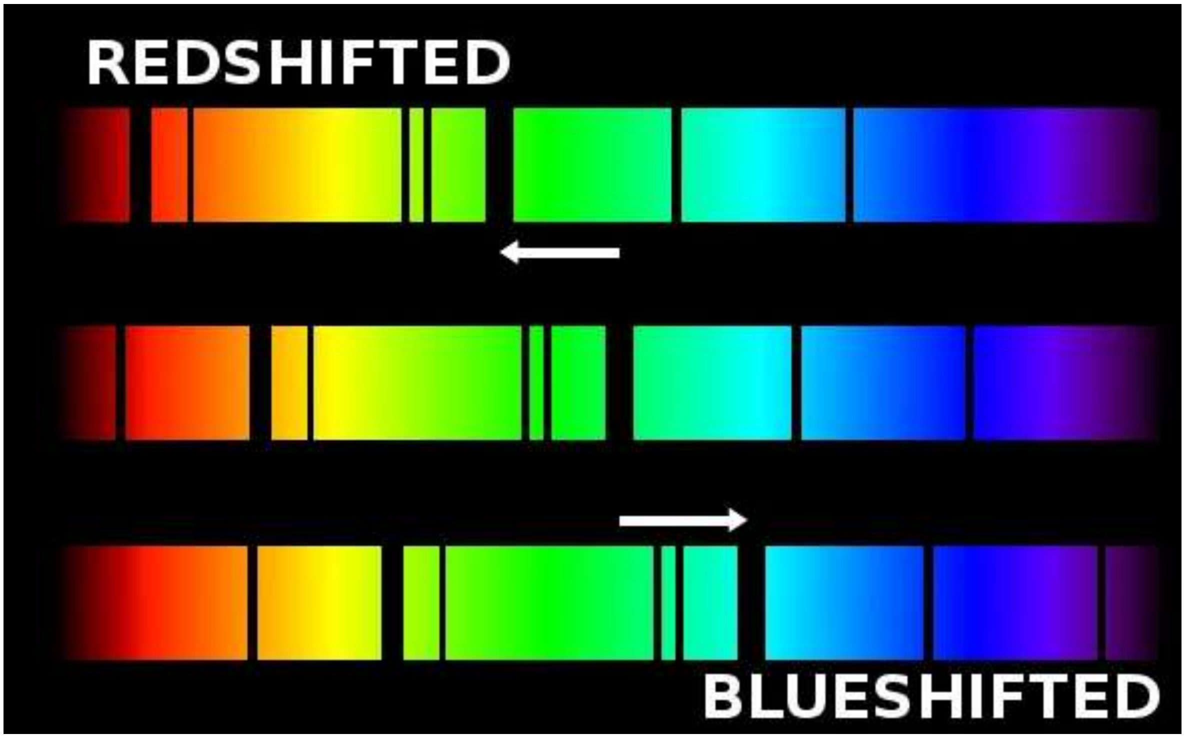


Figure 1 When an object moves away from us, the light is shifted to the red end of the spectrum, as its wavelengths get longer. Image Source: https://www.secretsofuniverse.in/wp-content/uploads/2020/04/redshift.png

But what exactly do we mean by the temperature of the Universe? In the first fractions of a second after the Big Bang, while the Universe was smaller than an atom, it was an unimaginable inferno billions of times hotter than the centre of the Sun.

But it grew quickly: in less than a second it was as big as our present-day Solar System. And as it expanded, it eventually grew clumpy, as matter condensed into stars and galaxies. Nonetheless, everything -- even empty space -- was still pervaded by a glow that testified to the fury of the Big Bang.

In 1964 two physicists, Arno Penzias and Robert Wilson, working at Bell Laboratories in New Jersey, discovered this glow by accident. They detected microwaves coming from all directions in the sky, indicating that the Universe was still about 2.73 degrees above absolute zero. This is called the 'cosmic microwave background radiation' (CMBR).

Srianand's team measured the CMBR for the very distant, older Universe by looking at how it affected the way in which molecules in high-redshift gas clouds absorbed visible and ultraviolet light. The background radiation heats up the molecules, causing them to jump between different energetically excited states and so altering the way they absorb light.

Earlier studies placed upper limits on the temperature of the CMBR at other redshifts, including even higher ones. But Srianand's group are the first to deduce both upper and lower bounds, and thus to make a meaningful comparison with the predictions of Big Bang theory.