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Cosmic microwave background

The discovery of the cosmic microwave background cemented the "Big Bang" theory. Originating in the heat of the very early universe, this "sea" of weak electromagnetic radiation is due to photons, which were released over thirteen billion (13×10^9) years ago.

In 1965, Arno Penzias and Robert Wilson discovered an unexpected, warm glow in the sky. Working on their microwave radio antenna in New Jersey, the Bell Laboratories physicists detected a faint signal from every direction. At first, they thought it was mundane — perhaps, due to pigeon droppings clogging their sensitive equipment.

After hearing a talk by Princeton theorist, Robert Dicke, they realised (realized?) they had discovered a phenomenon of huge significance. The bath of warmth that had been detected was not coming from the Earth; its origin was cosmic. They had discovered the predicted afterglow of the "Big Bang". Dicke, who had been involved with a similar radio antenna to look for the background radiation, was a little less than jubilant:

"Boys, we've been scooped," he quipped.

The C.M.B. makes the entire sky appear as a bath of warmth, with a temperature of about 3 degrees kelvin (equivalent to 3 degrees Celsius above absolute zero). Its characteristics are precisely predicted by the Physics of the "Big Bang". In its early stages, the Universe was hot. As it expanded, cooling occurred. Today it should be 2·73 K; and that is what Penzias and Wilson found.

The C.M.B. indicates that the sky emits microwaves in a frequency range which peaks around 160.2 GHz (160.2×10^9 Hz), with a wavelength of 1.9 mm = 1.9×10^{-3} m. In 1990, NASA's Cosmic Background Explorer (COBE) satellite showed that the C.M.B. is a perfect example of a black-body spectrum.

Careful measurements show that the sky is not the same temperature all over. The microwaves indicate that one hemisphere is warmer by 2.5 milli-kelvin, or about one part in a thousand ($\Delta T = 2.5 \times 10^{-3}$ kelvin). Discovered soon after the background radiation itself, this differential heat pattern is known as the "dipole", due to its two poles, hot and cold. This difference arises from the Doppler effect, due to the motion of the Earth: the Solar System is moving at 600 km s^{-1} (6×10^5 m s^{-1}) "relative" to the Universe.

At a level of about one part in a million, the sky is speckled with hot and cold spots. These so-called "ripples" are of great interest to astronomers, because they were created shortly after the "Big Bang", revealed as numerous patches, about the angular size of the full Moon. As the Universe cooled, the protons and electrons gradually moved more slowly, and after around 400 000 years, they were able to fuse, to form Hydrogen atoms. The nature of this cosmic "soup" changed from being ionised (ionized?) to electrically neutral.