Physics with Synno – Matter – Lesson 2

M.2 The Big Bang

The expanding Universe theory suggests that, at some time in the past, the Universe had no volume. The Big Bang model suggests that all matter and space was concentrated in zero volume, a singularity. At this time the Universe was at an infinitely high temperature, and had infinitely high density. Since then, the Universe has expanded and cooled to form galaxies and stars. Along with the decrease in temperature the associated radiation should also change, increasing in wavelength as the universe expands. The apparent temperature should have fallen from billions of degrees to a few degrees Kelvin.

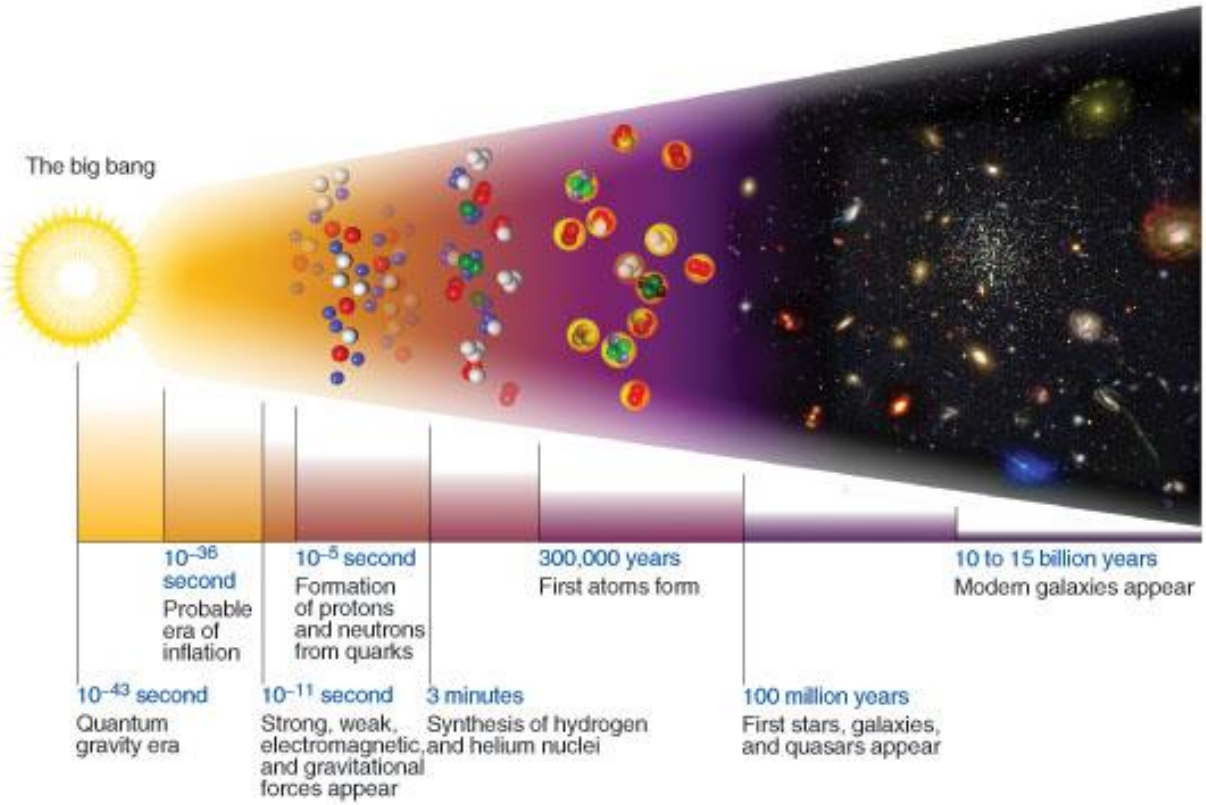
M.2.1 Microwave Background Radiation

Video: Cosmic Microwave Background Radiation

In 1964, Arno Penzias and Robert Wilson were experiencing difficulty with background noise in their radio telescope, which they could not eliminate. The intensity of this radiation did not vary with the time of day, the time of year or the direction. Eventually they became convinced that it was real and that it was coming from outside our Galaxy. They made precise measurements and found the radiation had a wavelength of $\lambda = 7.35\,cm$, which is in the microwave region of the electromagnetic spectrum. If we apply Wien's displacement law, this radiation corresponds to a black body temperature of 3 Kelvin (current measurements are 2.7 ± 0.1 K). Hence this radiation is referred to as the 3 K background radiation.

In 1948 George Gamow suggested that the early stages of the universe must have been very hot and therefore should contain large amounts of black-body radiation. In 1949 Ralf Hermann and Robert Herman pointed out that the expansion of the Universe would cause the wavelength of this radiation to be redshifted and thus lengthen. This suggests that the radiation's temperature would have decreased since the big bang.

Calculations suggested that the radiation would be in the radio-wave region of the electromagnetic spectrum. Penzias and Wilson's discovery was highly significant because it provides strong evidence in support of the Big Bang. No other theory on the creation of the universe can explain this background radiation.



In the first few seconds, elementary particles known as **Quarks** combined to form protons and neutrons. The protons and neutrons were forced close enough together to form hydrogen, Helium and Lithium nuclei. After the the temperature cooled below that required for fusion and no new nuclei were formed.

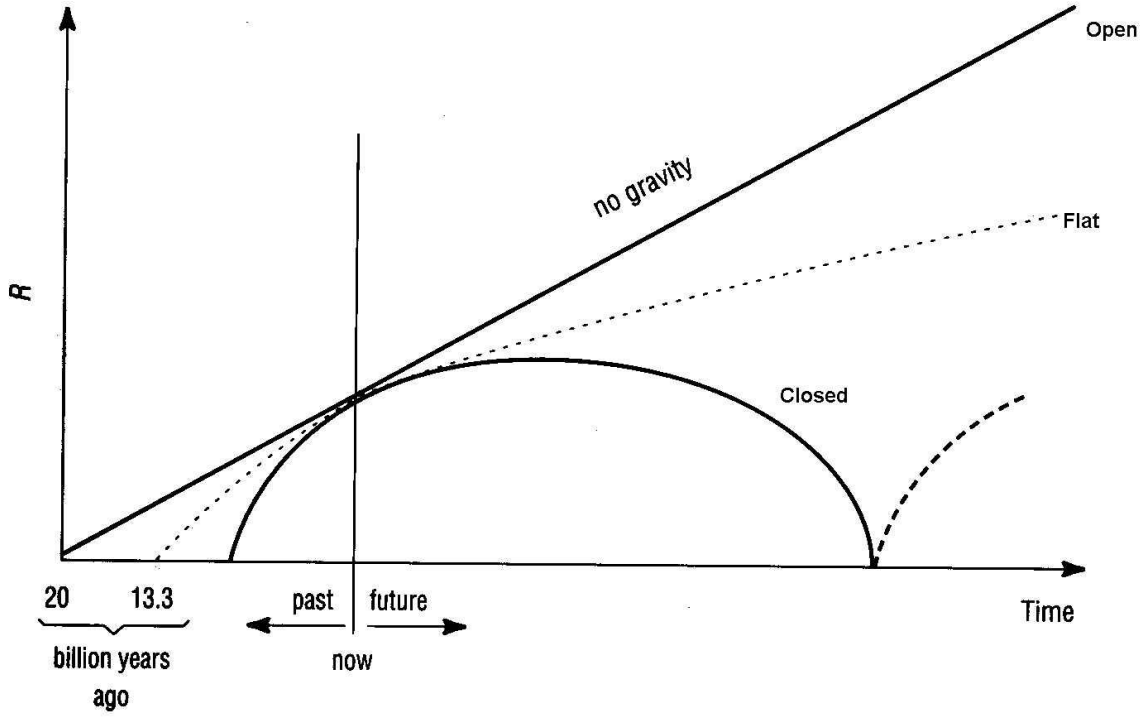
M.2.2 Future of the Universe

Will the Universe ever come to an end? Will it continue to expand forever, or will gravity pull it back on itself, so that it will end in a 'Big Crunch'?
The fate of the Universe depends on its mass. If there is sufficient matter in the Universe the gravitational attraction will be great enough to stop the expansion of the Universe and it will be pulled back on itself. If the Universe's mass is less, its gravity will be too weak, and its expansion may slow down but will never stop.
So there are three possible outcomes

1. The Universe is **closed** - its density is sufficiently high that its gravity is strong enough to pull everything back to a Big Crunch.

2. The Universe is **open** - its density is low, so that gravity is too weak to stop it expanding forever.

3. The Universe is **flat** - its density has the critical value, so that, in principle, it will only start to contract after infinite time.



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