U3A-GROUP ASTRONOMY **(24-3-2006)**

'Big Bang'etc. + future of the Universe

All stars and galaxies seem to move away, visible as a *red shift* in the spectra ('Doppler effect') – discovered by Edwin Hubble in 1929. They do not move away from a central point (which does not exist), but the distances between all objects become larger as a result of the Universe's expansion. Before this discovery most astronomers believed in the *Eternal Universe*: the Universe had always existed as it is today.
Logical conclusion of the expansion model: in the past the Universe must have been much smaller and denser and possibly it started from nothing at all → *Big Bang* theory. First ideas by Belgian priest / astronomer Georges Lemaître (1927), ignored by most astronomers who accepted the expansion but believed that at the same time enough new stars and galaxies were formed to keep the Universe as it has always been: *Steady State Model.*
Some scientists nevertheless went on to develop the *Big Bang* (BB) model: before the BB there was no time, no space, no matter – nothing! – but then, about 14/15 billion years ago, an enormous explosion ('inflation') took place, with temperatures of billions of degrees. Most matter was formed in the first milli-second. After about 0.5 minute hydrogen and helium were formed in an incredibly dense 'soup'. After about 350,000 years of expansion the Universe started to become transparent and to radiate waves.
Around 1940 it was predicted that this radiation - a sort of echo of the BB – would still be observable. In 1964 two American astronomers discovered this *Cosmic Microwave Background radiation* (CMB). Then it was argued that minuscule variations in wavelengths of the CMB-radiation should exist in order to explain the formation of the first stars/galaxies. These variations were discovered by a special NASA-spacecraft in 1992:
BB-theory (more or less) generally accepted!
But we still do not know – and probably never will – what triggered the BB and what happened in the first 1/100,000th of a second.

And many things that happened afterwards are likewise difficult to understand or to explain:

1. in order to keep the Universe together, a certain minimal density of matter is required: the *critical density* (CD). The density of all observable (more than 'visible') matter is only c. 5% of this CD. So there must be much more matter, not observable but causing evident gravitational effects. This is called *Dark matter*.
2. in the 1990's it was discovered that the expansion of the Universe is not slowing down, but speeding up! Explained by assuming a force that caused the Universe to expand since the BB, but which was overpowered by strong gravitational forces in the dense Universe during the first c. 50% of its existence. Then, when the density of the Universe dropped below a certain critical level, this mysterious force got the upper hand, causing the expansion to accelerate. This force is called *Dark energy*.

Neither *Dark matter*, nor *Dark energy* are fully understood → much work still to be done!
The results of this work also influences ideas about the future of the Universe. There are various options, mainly depending on the future role of the dark energy (DE):

- if *DE* is constant, expansion will continue for ever, resulting in a cold and dark Universe: the '*Big Freeze'*.
- if *DE* ultimately decreases, expansion will end, and the Universe will either remain as it is, or it may collapse under its own gravitational force: the '*Big Crunch*' – perhaps followed by a new Big Bang?