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On 11/5 NASA launched the shuttle *Atlantis* for the final service mission to the *Hubble Space Telescope* – originally planned for 10/10/2008.
Three days later (14/5) ESA launched a mighty *Ariane 5* rocket with the space telescopes *Planck* and *Herschel* – originally planned for 16/4.
And in addition to these two big projects, a *Soyuz* spacecraft brought three astronauts to the ISS on 27/5, bringing the number of people working there 'permanently' (up to 6 months) from 3 to 6.

Hubble

A final service mission should have been launched around 10/10 last year. But on 27/9 a critical equipment failure happened aboard the HST and as a result the mission had to be postponed for several months. On Monday 11th May, the shuttle *Atlantis* finally went on its way to *Hubble,* with seven astronauts on board, 4 of them 'space walkers'. When *Atlantis* reached *Hubble* after a voyage of some 832,000 miles, the telescope was grabbed by the shuttle's robotic arm and brought into the shuttle's cargo bay. Then the actual work could begin: 5 space walks, during which the following work was carried out:

New instruments or replacement of failing instruments

- a new computer
- a new $132 mln camera
- a new $ 88 mln spectrograph for UV radiation
- 6 gyroscopes (that stabilise instruments onboard)
- 6 fresh batteries

Repairs

- a camera which failed in 2007
- a spectrograph which failed in 2004
- new insulation cover

The result is an essentially new telescope, much better than it was before. It should be able to work for an additional 5-10 years. This was definitely the last service mission, as within five years from now the new and much larger James Webb Space Telescope should be operational.
But for the years to come there remain a large number of things which Hubble can do with its excellent instruments high above Earth's atmosphere.

Planck and Herschel

These two important space telescopes, named after 18th century astronomer William Herschel and 19th century German scientist Max Planck, were launched with one huge Ariane-5 rocket from the ESA space centre in French Guyana on the 14th of May. They are no 'normal' telescopes, as they do *not* – as Hubble does – observe mostly visual light from distant stars and galaxies. They both receive invisible long wavelength radiation: radio waves for *Planck* and infrared waves for *Herschel*.
What are they supposed to discover?
Planck will measure radio waves of the *Cosmic Microwave Background Radiation.* Tiny variations in the temperature of this radiation are responsible for the first formation of stars and galaxies, just 400,000 years after the Big Bang.
Herschel will study the earliest stages of stars and galaxies by measuring infrared radiation, using the largest telescope ever launched thus far: its mirror measures 3.5 m (*Hubble*: 2.4 m). It will receive infrared radiation with a large spectral range, which enables it to register the very faint radiation of very old stars and galaxies – as old as just a few billions of years after the BB - which until now remained obscured by thick clouds of dust.

These two telescopes, neither of which registers visible light from the Universe, bring us to the topic of *Spectroscopy.*

Spectroscopy

Spectroscopy is an often overlooked tool in astronomy. Astronomers use it extensively, but it does not get much attention in popular publications, probably because it is not very spectacular at first sight.
It is, however, a very important way to find out things that would otherwise be impossible, for instance, what astronomical bodies are made of.
Sir Isaac Newton was, in 1665, the first person to produce an 'artificial rainbow' by letting sunlight pass through a prism and explaining what he saw. In 1800, William Herschel discovered infrared light when he measured the temperature of the different colours of sunlight when broken down by a prism, and also measured a rather high temperature *beyond* the visible red. This showed that there was a form of radiation which was invisible but the temperature of which could be registered. We now know this as infrared radiation.
Soon after that, ultraviolet radiation was also discovered.

So the electromagnetic spectre contains much more radiation than just the visible light. As a matter of fact, visible light forms only a very tiny part of the whole spectre. Beyond the 'blue' side of the visible light we find radiation with ever increasing energy (high temperatures) and shorter wavelengths: ultraviolet rays, X-rays and gamma rays. At the other – the 'red' – side there are forms of radiation with ever longer wavelengths and lower energy: infrared, radar waves and radio waves.

Visible light

Radio waves	Radar waves	Infrared	Ultraviolet	X-rays	Gamma rays
Longer waves, lower energy			Shorter waves, higher energy		

The Earth's atmosphere absorbs most of the high-energy radiation (ultraviolet etc.). This is good for life, but bad for people who want to study this radiation. Hence the importance of space-telescopes specially made for the study of these forms of radiation, such as *Chandra* (1999 – X-rays), *Spitzer* (2003 – Infrared, as most of the infrared radiation is also absorbed by the atmosphere), *Galex* (2003 – Ultraviolet) and *GLAST* (2008 – Gamma rays), plus, of course, *Planck* and *Herschel*.

In the course of the 19th century it was discovered that the spectra of light emitted by the Sun, stars and galaxies show a number of black lines at different wavelengths – so called *spectral lines* – and that these lines correspond with certain chemical elements. That meant the beginning of the science of *Astrophysics,* which made it possible to discover the chemical composition of heavenly objects.
Spectroscopy has – among other things – enabled us to obtain information about the atmosphere of exoplanets, for instance, the presence of water(vapour), and it has even been possible already to discover also CO, CO_2 and CH_4 (methane).
In 2013 a new space telescope for spectral research will be launched – the *James Webb* – which will do this work much better again (for instance at the planets which the *Kepler* telescope hopes to discover in the years to come).

But spectroscopy does not only measure the chemical composition of objects in the sky. With stars and galaxies moving away from us in the expansion of the Universe, the Doppler effect causes the black lines in the spectrum to shift. Very distant galaxies, moving away fast, have larger redshifts than objects nearer to us. This causes the spectral lines to shift within the spectre, and by measuring these redshifts (mainly of H and He), it is possible to calculate the speed of the object. And this again gives an indication of the distance it is away from us (the further a star or galaxy is away from us, the faster it moves). Spectral lines are further also influenced by the temperature and the gas pressure of the matter producing radiation.
So spectroscopy is really of great importance.