Hi this is Steve Nerlich from Cheap Astronomy www.cheapastro.com and this is *Wavelengths – the long and the short of it.*

This the second of a series of two podcasts on astronomy across the electromagnetic spectrum.

In part 2 of this series, we'll quickly run through what astronomy can be done at all the different wavelengths that we covered in Part 1. So without further ado:

Gamma ray astronomy.

Wavelength – less than 0.01 nanometres.

Being high energy radiation, gamma rays arise from high energy collisions such as when cosmic rays collide with other particles. This tends to occur all across the sky giving us a diffuse gamma ray background. Main sequence stars don't have much gamma ray output – although energetic solar flares can be a local source of gamma rays. So if you had gamma ray vision you would just see a diffuse background glow, the occasional flash from the Sun, a funny bipolar glow from the centre of the Milky Way that we don't completely understand the cause of yet – and gamma ray bursts – about 4 per day on average, being brief, bright point sources of gamma ray light.

Gamma ray bursts are generally classified into long duration – which are usually supernovae and might last for a minute or more. And there are short duration bursts which last less than two seconds and might arise from the collision and merging of black holes or neutron stars.

Space-based gamma ray observatories include Swift and GLAST – with most of their attention devoted to gamma ray bursts.

Xray astronomy

Wavelength – 0.1 nanometre to 10 nanometres.

Main sequence stars routinely radiate small amounts of Xrays, so a faint glow from the Sun would be visible with imaginary Xray glasses. More distant stars would be generally dim – but some giant stars, like Eta Carinae for example, would be a bit brighter.

Very bright Xray objects include actively feeding black holes and neutron stars which generate high energy radiation from their accretion disks – and there will be Xray flashes from supernovae and Xray after glow from supernovae remnants. Gas clouds heated to high temperatures by supernovae and other energetic sources can also glow in Xray. All this results in a general soft Xray background, mainly generated from within the Milky Way, although distant galaxies with active galactic nuclei can also be hard Xray sources.

Space based Xray observatories include Chandra.

Ultraviolet astronomy

Wavelength – 10 to 320 nanometres

Hot stars over 10,000 Kelvin actually peak in ultraviolet wavelengths – so looking at the universe through UV goggles does start looking more like the optical universe we are familiar with. However, stars with temperatures over 10,000 Kelvin are generally massive stars over at least three solar masses.

Spectroscopy also becomes possible in UV with spectral lines visible for most common elements – which may have transition signatures, indicating the transition from different states of excitation due local temperature changes. So for example, you might try to assess the chemistry of the hot atmospheric clouds of Venus (which listener Alan is quite keen on).

Ground-based ultraviolet astronomy is possible – though extreme (that is, short wavelength) UV observations are only achievable above the atmosphere via space observatories such as Galex.

Optical astronomy

Wavelength – 320 nanometres to 750 nanometres.

So, now you can take your goggles off. Most stars peak in optical wavelengths – and their light gets reflected off planets – so optical is a highly useful wavelength spectrum for astronomy, quite apart from our natural prejudice for it, because we can see it.

To get a bit technical here - as well as direct observation, we can do photometry, being a measurement of the amount of light received from an object - which actually incorporates the transit method used to identify exoplanets; and we can do spectroscopy – where elements and compounds have characteristic absorbtion lines – meaning they block out part of the spectrum – or they might have characteristic emission spectra where (when heated) they glow at a particular wavelength. There's also polarimetry – looking at the way light is polarised, which might identify the magnetic orientation of a dust cloud for example.

In reality, these principles can be applied to wavelengths other than just optical, but I had to mention these techniques somewhere – and they were all invented for the field of optical astronomy – because for most of the history of astronomy, optical astronomy was all there was.

Ground-based optical telescopes are everywhere – there's even Sky Station 1, possibly the cheapest department store telescope in the Southern Hemisphere, in my study. The Hubble Space Telescope is the quintessential space-based optical observatory (although it does a bit of fringe UV and also infrared astronomy - speaking of which).

Infrared astronomy

Wavelength – 750 nanometres to 0.3 millimetres.

Stars do of course radiate infrared, but perhaps more importantly so do dust clouds that have been heated by nearby stars. So for example, although dust clouds may obscure stars in ultraviolet and optical wavelengths - radiant objects within or behind dust clouds can be indirectly observed by the way they light up the dust. Much of our growing understanding of the centre of the Milky Way, which is heavily obscured by dust, comes from infrared astronomy. Adjacent galaxies also glow prominently in infrared due to their dust content. And then, very distant galaxies might only be visible in infrared or longer wavelengths – due to redshift, resulting from the expansion of the universe.

Ground based infrared astronomy is possible though challenging, as the water vapour content of the atmosphere is partially opaque to infrared. The best sites are high altitude, low humidity spots like Mauna Kea observatory in Hawaii - or you can even do infrared astronomy from a plane, like the Sofia telescope.

Space-based infrared astronomy is also taking off (small astronomy joke there). For example, Spitzer and the planned James Webb Space Telescope.

Submillimetre astronomy

Wavelength – 0.3 to 1 millimetre.

Submillimetre is the wavelength of choice for observing star formation, normally hidden by dust clouds in stellar nurseries within the Milky Way. Also, in the context of red shift, submillimetre is just right to observe early galaxy formation in the first few billion years of the universe's history.

High and dry Mauna Kea in Hawaii is again a good site and hosts the 15 metre James Clerk Maxwell observatory. For space-based astronomy, there's the Herschel observatory, which is often considered an infrared telescope, but you can tell from its original launch name - the Far Infrared and Submillimetre Telescope (or FIRST) – that it actually bridges the whole infrared and submillimetre range.

Radio astronomy

Wavelength – 1 millimetre to a metre to 10 metres... and just keep going from there.

The radio spectrum incorporates microwave at its shorter end – all the way up to very long wavelength radio. As we touched on in part 1, radio telescopes tend to be large in scale to effectively capture such large wavelengths.

The largest steerable radio dish ever built, the 110 metre Greenbank telescope in West Virginia (mountain momma), still struggles to achieve the resolving power that is possible for an optical telescope. A one metre optical telescope mirror is around two million times the size of optical wavelengths that it collects. The Greenbank telescope is at best 100,000 and at worst only 100 times the size of the wavelengths it is designed to collect.

Nonetheless, ground-based radio astronomy has the huge advantage that our atmosphere is transparent to radio – which also means you can do radio astronomy both day and night. Radio astronomy first identified exotic objects like pulsars and quasars and blazars, which we later honed in on with other wavelengths to get a higher resolution view of those objects - but radio is how we found them.

And of course, radio remains the only wavelength available to detect the cosmic microwave background and potentially lots of other highly red-shifted information that may be out there. When we eventually build the Square Kilometre Array, we will have a radio collector at least 10,000 times better than anything we have now. With the SKA we might start getting closer to the kind of resolution that we enjoy in optical astronomy – which will give us a whole new level of detail on all that stuff that is so far, far away and long, long ago.

Thanks for listening. This is Steve Nerlich from Cheap Astronomy, www.cheapastro.com. Cheap Astronomy offers an educational website where we're resolved to deliver good science without ads or profit. Bye.