Hi this is Steve Nerlich from Cheap Astronomy www.cheapastro.com and this is *Wavelengths – more than meets the eye*.

This is the first of a two part podcast series on astronomy across the electromagnetic spectrum.

Electromagnetic radiation, which we colloquially refer to as light, is essentially radiating energy and comes in a variety of energy levels. So for example, short wavelength gamma rays are high energy and long wavelength radio waves are low energy. However, energy level is a separate issue to radiation intensity. So, for example being struck by one stray gamma ray photon would be largely unnoticeable, while standing in the path of an intense burst of gamma rays will certainly kill you - by blasting all your atoms into their sub-atomic components.

Short wavelengths like gamma rays are called ionising radiation – because their wavelength is so short the radiation can interact directly with the sub-structure of atoms, generally by knocking electrons of atomic nuclei – which turns those nuclei into ions.

Longer wavelength radiation is less able to interact with matter at a subatomic level – and instead tends to makes whole atoms and molecules kind of wobble – which at a material level is what makes a material hot. Such heating can change the phase of materials from solid to liquid to gas without ionising its atoms.

Nonetheless, the specific effect of non-ionising wavelengths on different materials depends upon each material's reflection, absorption and transmission properties. So for example, when we use our eyes - which are attuned to a narrow band of electromagnetic radiation we call optical light, different surfaces appear to have different colours depending upon what optical wavelengths are reflected, rather than absorbed by those surfaces. So, for example, the leaves of plants absorb most optical light for use in photosynthesis, except for a narrow band of green light - which is reflected and makes the leaves look green.

Some materials may be transparent, meaning they allow the transmission of radiation - but usually are transparent only to particular wavelengths and such materials may still reflect or absorb other wavelengths. So for example, liquid water is almost transparent to optical light - but put a glass of water in a microwave oven and the water quickly heats up - because it absorbs the energy of the microwave radiation rather than letting it pass through.

But from there, radio wavelengths longer than microwave become increasingly less able to be absorbed by average-sized objects. For example, wavelengths beyond 10 metres are unable to interact or be absorbed by your body say – since your body is smaller than 10 metres. Extremely long radio wavelengths might pass by the Earth without interacting with the planet.

All that said though, in reality it is rare that anything radiates energy at just one specific wavelength. For example, stars generally emit radiation at all wavelengths - so get too close to one and you will die by being ionised, blinded and overheated all at the same time.

But of course at a safe distance, these stars can be studied across all wavelengths. Stars will generally have peak intensities in different parts of the electromagnetic spectrum – and given our natural prejudice for optical light, we like to arrange stars into stellar spectral classes according to which colour they peak in, in optical light. So we arrange stars from big blue ones to white stars to Sun-like yellow stars all the way down to little red dwarfs.

Planets may only reflect light – and hence do so in accordance with their light absorbing properties – so Mars reflects predominantly red light in optical wavelengths, while planet Earth is blue and there's nothing I can... sorry.

Additionally, some planets may have intrinsic radiation – for example by radiating heat in infra-red even when their visible face is not lit by their star. Planets with magnetic fields may have even more intense intrinsic radiation – although planetary magnetism may only be able to generate radio waves.

High energy radiation like x-rays and gamma rays can arise from magnetic effects generated by extremely compact objects like neutron stars and black holes - which generate huge amounts of energy as they crush matter together within a rapidly spinning accretion disk.

Black holes that do this might be stellar-sized or supermassive – the most distant and easily detectable sources of the supermassive type being quasars which are galaxies far, far away – seen as they were long, long ago.

And this brings us to another wavelength issue in astronomy – that of red-shift. While the principles we've covered so far work for radiation generated by close or by distant objects, the radiation of objects distant from us is red-shifted by the expansion of the universe – meaning that it literally is stretched into longer wavelengths. So even though up close a quasar might have been blasting out gamma rays – when seen at a great distance, this radiation is red-shifted into the radio wavelengths.

And then – to really get the whole context of wavelengths in astronomy - you also need to consider the history of astronomy – which has been almost entirely ground-based for most of its 400 year history. So, at least historically, what we have been able to observe of the universe has been largely limited to the parts of the electromagnetic spectrum that could make it through the Earth's atmosphere.

In broad terms, any ionising radiation (which is anything more energetic than ultraviolet, and includes x and gamma rays) – just bounces off the atmosphere, although atmospheric atoms do get ionised in the process. Of course, intensity is also an issue here. So, for example if an intense gamma ray burst was directed at Earth, rather than bouncing off, it may just blow the whole atmosphere away.

Then, for non-ionising wavelengths, those between ultraviolet and blue don't bounce off, but are still scattered by the atmosphere – so initially the light bounces around in the upper atmosphere, before most of it eventually gets through. This is why the daytime sky is blue – with blue light seeming to be coming from all directions – although really all of it is just coming straight from the Sun.

Beyond optical light, infra-red wavelengths start getting partially blocked by the atmosphere – mainly due to water vapour, although there is a little window of semi-transparency in the sub-millimetre wavelengths. From there, light is completely blocked again until you get into the longer wavelength radio spectrum, where the atmosphere is almost transparent to wavelengths, all the way from about 10 cm to about 10 m.

It's also worth noting that as well as influencing astronomy, the atmosphere has influenced the evolution of visual systems on Earth since life's choices have been limited to wavelengths that can make it through the atmosphere, being radio, sub-millimetre or optical, along with a bit fringe ultraviolet and infrared. Optical light is clearly the most versatile wavelength for life to use, since its very short wavelength means it can provide information about fine detail when it is reflected off something – whereas if you could only see in 10 cm radio light, you might not be able to easily distinguish an object smaller than 10 cm because it would not reflect or absorb that wavelength.

This size issue is why you can pretty much build a radio telescope out of a wire fence and even for high efficiency radio telescopes, you still only need a metallic parabolic dish. As far as centimetre to metre wavelength radio waves are concerned, a roughly flat metallic surface is a perfect mirror. However, an optical telescope requires a very finely-precisioned mirror surface to accurately reflect nanometre wavelength optical light without distortion.

And more on all that next week.

Thanks for listening. This is Steve Nerlich from Cheap Astronomy, www.cheapastro.com. Cheap Astronomy offers an educational website where we never get too intense. No ads, no profit, just good science. Bye.