

Hi this is Steve Nerlich from Cheap Astronomy [www.cheapastro.com](http://www.cheapastro.com) and this is *Light – and a bit of dark*.

This is the first of a series of two podcasts on light.

Light is pretty strange stuff, mind you so is gravity, in fact, so is empty space... but, never mind. Light, more correctly known as electromagnetic radiation, is famously weird in so far as it possesses both wave-like and particle-like properties – but even just its wave-like properties are weird enough – and that's what we are going to try and cover here.

So, your standard terrestrial waves – like a water wave or a sound wave are essentially energy that is propagated through a medium. But, again famously, electromagnetic radiation doesn't propagate through a medium – like the once proposed and now debunked luminiferous ether. Instead, electromagnetic radiation self-propagates.

So, what does that mean? The standard explanation is that an electromagnetic wave is what results from the simultaneous oscillations of electric and magnetic fields.

The idea of a field is a common one in physics – where something, let's say a point particle is the origin of a force which acts at a distance – although the strength of that force declines in accordance with the inverse square principle – something first proposed by Newton to describe a gravity field.

Such a charged particle might be an electron, a proton or some other ionised nucleus, or a larger object, being a compound of atoms, which might carry a nett positive or nett negative charge due to its atoms having lost or gained a numbers of electrons.

We tend to say that an electron exerts a tiny magnetic field due to its spin, while it exerts an electric field due to its motion – although arguably these are just two ways of exerting an electromagnetic field. A seeming inert material, like a lump of iron, can become magnetic if the spin of its electrons are roughly aligned so that they act in coordinated fashion rather than all the little fields cancelling each other out the way they do in a material where the electron spins aren't aligned.

Now, if you run that magnet along a conductive wire you create a moving current of electrons – giving you electricity and an electric field around that wire. You can also send a current of electrons through a coiled wire which aligns the spins of those moving electrons and you get an electromagnet.

Of course when you run a current through a wire, the wire starts to radiate heat - which is electromagnetic radiation. Indeed, run it through a wire filament in a light globe and it radiates visible light. Electromagnets will tend to radiate heat for the same reason, but this doesn't really happen with a permanent magnet. You can place a permanent magnet on or near a surface without heating it at all – even though the magnet may be exerting quite a strong magnetic field on and through that surface.

Again it's a bit like gravity. For example, here we are in the solar system tightly bound within the Sun's gravity field – but we won't experience any noticeable gravity waves unless some

giant hand comes along and shakes the Sun back and forth. If that happened a wave would propagate through the gravitational field – at the speed of light – and the Earth would feel a noticeable wobble about eight minutes later as those waves passed by.

Electrons in motion through a wire generate electromagnetic waves as a matter of course, but if you want a magnet to generate noticeable waves you're going to need to jiggle it.

Taking this analogy one step further we can say that something with the quality of mass generates a gravitational field, in the same way that something with the quality of charge generates an electric or a magnetic field. If you want to create waves you need to jiggle those somethings.

From all this, you can probably see why Einstein was apparently obsessed with finding an underlying sameness between gravity and electromagnetism through his proposed unified field theory. These days not many theorists are still pursuing that line given that it all seemed to come to nothing for Einstein, but who knows.

The self-propagating nature of light relates to the inter-relationship between electric and magnetic fields. James Clark Maxwell developed a set of equations – which represented a unified field theory for electricity and magnetism – and most people would consider Maxwell an Einstein of his day.

Maxwell showed that if you jiggle a magnetic field you create an electric field and if you jiggle an electric field you create a magnetic field. Thus it's possible to establish a kind of self-perpetuating bouncing vibration within a sort of three-dimensional electromagnetic field – which is usually conceptually pictured as two planar fields, one electric – one magnetic, orientated perpendicular to each other in a way that can support a self-perpetuating, bouncing vibration which is essentially a wave that moves perpendicular to both the electric and the magnetic field – which we can just think of as a wave that moves forward in time and hence also moves forward in space. Cool, huh?

It's in this way that electromagnetic radiation can be seen to be able to move forwards through a three dimensional vacuum across huge distances from whatever jiggling event may have initiated it – without ever needing an external medium.

From his equations and using some data gathered from various electric and magnetic gizmos – like induction coils – Maxwell was able to determine that the velocity of propagation of his transverse, bouncing electromagnetic vibrations were about 300,000 kilometres a second. And he found this out at about the same time that other people were estimating an almost identical figure for the speed of light. As Maxwell stated "The coincidence is not merely numerical".

So really the reason the universe is full of light is that there are an awful lot of charged particles jiggling about. If you could instantaneously cease the movement of all these charged particles in the universe – well, this would be equivalent to dropping the universe's intrinsic temperature to zero Kelvin, since if there's no heat, there's no movement – and needless to say there will be no electromagnetic radiation.

Well, at least that's how it will work for conventional energy. As much as anyone is willing to speculate, dark energy doesn't have electromagnetic properties. The standard statement is that dark energy is not known to interact through any of the four known forces, excepting gravity. So, from an Einstein-ian point of view, this would mean it doesn't interact with matter but just effects the curvature of space-time – and in a seemingly opposite way to how gravity does. That is, pushing space-time outwards – rather than pulling it inwards.

And could there be such a thing as dark energy waves? Is there a something, with the quality of something that generates some kind of field – and might produce dark waves if you jiggled that first something... (*crickets*).

And what about dark matter? Well, jiggle it and apparently you do get gravity waves – and apparently you don't get electromagnetic waves – because it's dark. Does this mean it doesn't have the quality of charge. Absolutely (well, I think).

Thanks for listening. This is Steve Nerlich from Cheap Astronomy, [www.cheapastro.com](http://www.cheapastro.com). Cheap Astronomy offers an educational website – trying to shine a light on the dark matters of this universe, except that doesn't seem to do anything. No ads, no profit, just good science. Bye.