Hi this is Steve Nerlich from Cheap Astronomy www.cheapastro.com and this is *The universe's phone number.*

The fine structure constant, or alpha as it is commonly known, indicates the strength of electromagnetic force. For example, electrons associated with an atomic nucleus can absorb a photon and jump up to a higher energy shell. Or, alternatively, electrons can drop to a lower energy shell by emitting a photon.

By knowing the value of alpha, the fine structure constant, we can predict exactly what photon energy level will make an electron, in a particular energy shell, jumps to a higher energy shell - and we can also predict what energy a photon will have, when it is emitted as an electron drops to a lower energy shell.

If alpha was not a constant we would not be able to make these predictions. Alpha defines exactly what energy level is required to partially dissociate the attraction that exists between the positively charged nucleus and the negatively charged electron. Consequently, it has a deep association with quantum mechanics, since there is a rigidly defined amount of energy, a quantum, that will cause an electron to make a 'quantum leap' to another energy shell. And alpha also has a deep association with the principles of electromagnetic radiation since alpha determines the energy level, and hence the wavelength, of a photon that is emitted when an electron drops to a lower energy shell.

Its name, the fine structure constant, comes from astronomy. When you do a spectroscopic analysis of starlight there's a whole bunch of different elements and isotopes involved in producing and transmitting that light. So, when you spectroscopically analyse the light from a star, you find lots of emission and absorption lines all the way along the different wavelengths of the full light spectrum that the star radiates. The position and distribution of these lines allows you to accurately determine the chemical composition of the star. Indeed, you can also determine the chemical composition of any gas clouds that might lie between a light source, like a star or a quasar, and Earth.

And the spectroscopic data we receive on Earth looks like a fine, comb-like structure of interspersed light and dark lines. Fine comb-like structure... fine structure. Get it?

So, alpha, the fine structure constant, is what governs the complex interplay between matter - at least matter that isn't dark matter - and electromagnetic radiation, that is, light.

But this is where it gets a bit spooky. It turns out that you can calculate alpha by taking the square of an electron's charge and dividing it by the product of the speed of light, c, and Planck's constant, h, and then multiplying the whole thing by 2 times Pi. So alpha seems connected with most of the key features of modern science and mathematics - since you calculate using terms drawn from sub-atomic particle physics, Einstein's relativity, quantum mechanics and that old stalwart of pure mathematics, Pi.

And it works out that if you mush all these things together - e, c, h and k, all their units of measurement - distance, time, charge and energy - all cancel each other out and you just get a dimensionless number with no units of measurement remaining. So the number you get represents a relationship rather than a measurement. And we call this relationship alpha, which, as we have previously explained, is the fine structure constant. Richard Feynman -

who was a kickass physicist of the late twentieth century, called alpha a 'magic number' and 'one of the greatest damn mysteries in physics'.

You might start to see the mysterious side of alpha, if we consider a situation which has nothing much to do the spectroscopic analysis of starlight. If you position two hypothetical particles, each having just a Planck mass and an electron charge, it works out that the ratio of their electrostatic repulsive force to their gravitational attractive force is alpha - and it's always alpha regardless of the distance between those two particles.

So alpha seems to interconnect quantum physics, electromagnetism and gravity. It's as though alpha offers us a hint that there really could be a Theory Of Everything, that might unify relativity and quantum physics into a theory of quantum gravity - an outcome that theorists have now been fruitlessly pursuing for decades.

But, on the other hand, all this hubbub about alpha could just be put down to a mundane trick of mathematics. For example, if I boil one saucepan of water in three minutes and then boil another saucepan of water at twice the heat setting and I find that it boils in nearly half the time, I am not driven to formulate a theory of temporal thermodynamics. The fact that water boils more quickly if you apply more heat to it is just the way that things work.

And this might be a better way to think about alpha - it's just the way that things work. This is not to understate its significance - it is true that almost everything that happens in the universe does seem to be inter-connected by this one number - which for the record is about 7.3 times ten to the minus 3 or to put it another way, about one over 137 and a bit.

Potentially, if you could transmit the number alpha to the denizen of a parallel universe and explain that it is *our* fine structure constant, they might be able to immediately see how our universe works. And if they sent us their fine structure constant, we might immediately see how their universe works.

At least, that's how it should be if our fine structure constant really is a constant. There was a bit of a kerfuffle back in 2010 when the value of the fine structure constant was measured as being different in different parts of the universe.

Remember that the constant underlies the reason why star light has spectroscopic light and dark lines - so to confirm the constant really is constant all you have to do is compare spectroscopic analyses of stars in different parts of the sky. The light and dark bands correspond to the presence of specific elements and isotopes - so those bands should be identically distributed regardless of the source.

Well, it turns out that comparing spectroscopic bands from stars in the northern sky, measured from the Keck telescopes in Hawaii, gives slightly different results to observations made in the southern sky, measured from the Very Large Telescope in Chile. And remember also, that with astronomy, the further out you look, the further back in time you look. The data gathered suggested that the fine structure constant was once slightly smaller in the northern hemisphere and was once slightly larger in the southern hemisphere. So it seemed as though alpha just has a particular value for us, right here and right now.

But... as with many announcements of findings that threaten to overturn the very foundations of modern physics, it's best to review this information with your skeptical goggles on. The finding has not been widely accepted - after all, two different telescopes delivering two slightly different values could be more about the telescopes than about reality. The analysis also depends on a statistical inference based on a number of assumptions - and there's always error bars involved when you try to do this. So, on balance, it's probably a bit premature to throw the text books away.

We still have good grounds to think that the fine structure constant is genuinely constant. And the universe would make a bit more sense if it is constant, than if it isn't. Indeed its constancy, and its fundamental interconnection with all things, does hint at a deeper puzzle that we are yet to solve.

Thanks for listening. This is Steve Nerlich from Cheap Astronomy www.cheapastro.com. Cheap Astronomy offers an educational website where the structure is constantly fine. No ads, no profit, just good science. Bye.