Dear Cheap Astronomy - Episode 001

Question 1:

Dear Cheap Astronomy - If photons move at the ultimate speed of the universe c in a vacuum - how come they slow down in a medium, like air or water?

Well, firstly you could argue that they're not the same photons - since photons carrying radiation energy through water are being constantly absorbed and re-emitted as they encounter particles along the route they travel. They lose energy each time until eventually they are not re-emitted (which is why the bottom of the ocean is pitch black).

You can also see a similar effect of air on light around sunset when the slightly thicker amount of atmosphere you observe the Sun begins limiting what light can penetrate it to longer wavelength, low energy, red light.

The effect of air is less dramatic than water because it's less dense - and it works out that the measured speed of light in air is faster than it is in water. And the speed of light in glass - a dense solid, is slower than it is in water.

This is all quite different from sound - which also travels as a wave but whose existence is entirely dependent on the medium that carries it. Sound actually moves faster in the denser medium of water than it does in air - about 4 times faster. Indeed, sound moves about 20 times faster in a really dense medium - like a resonant length of steel.

I hope that answers your question - and here's another interesting fact to finish up on. Since light does move slower than the ultimate speed of the universe c - when light moves through a medium like water - you can get what's called Cherenkov radiation.

Cherenkov radiation is usually seen in nuclear reactors - where high energy particles (like an electron) are emitted by the reactor and move through the reactor's surrounding water coolant faster than the speed at which light can move through that water (but not of course faster than light can move through a vacuum).

These very fast high energy particles moving through water act just like a supersonic jet plane - which moves through air faster than sound can move through air and so creates a sonic boom.

A high energy particle emitted by a nuclear reactor excites atoms along its path through the water coolant making those atoms emit photons (that is light waves). But these light waves move a bit slower than the high energy particle can - so that the light waves get all bunched up together and create an eerie blue glow, as though the water itself is glowing... which it kind of is.

So this Cherenkov radiation is essentially a 'light boom' (equivalent to the sonic boom produced by a supersonic jet moving through air). Awesome.

Question 2:

Dear Cheap Astronomy - What is the difference between weight and mass?

Well, mass is an intrinsic property of matter - while weight is an emergent phenomena of whatever gravitational context you happen to be in. So fly to the Moon and your mass doesn't change, but you will find that you weigh one sixth of what you do on Earth at sea level.

To measure your weight you can stand on a set of scales which are then pushed downwards by your natural tendency to accelerate towards the centre of whatever massive object you happen to be standing upon. So, you will generate a bigger push on scales on Earth than you will be able to generate on scales on the Moon - for reasons that are largely irrelevant to your intrinsic mass. Everything accelerates at the same rate in the same gravity field.

But it's also the case that the scales are less affected (pushed down) by a feather than by a hammer, whether those scales are on the Earth or on the Moon. This *is* because of mass. Mass represents inertia - which is a reflection of what force (measured in Newtons) is required to shift a particular mass through the syrupy-resistant Higgs field.

You need more force to shift a hammer than you do a feather - presumably because the more massive hammer has more Higgs bosons than the feather does. So the scales, which have their own inertia, are more resistant to a push from a feather than to a push from a hammer - whether you are on the Earth or on the Moon.

And here's the really cool thing. We flew to the Moon to do an experiment that involved dropping a feather and a hammer from the same height above the Moon's surface. There is a You-Tube video is of Commander Dave Scott from the Apollo 15 mission doing this very experiment and the audio sounds like this:
http://video.google.com/videoplay?docid=6926891572259784994#.

The hammer versus feather effect is immediately apparent on the Moon due to the Moon's lack of an atmosphere that might otherwise slow up a feather's fall in the way that it does on Earth. Despite their significant Higgs-boson-related intrinsic mass differences, the feather and the hammer both fall with the same gravitational acceleration and hence they hit the ground at the same time. But if you weigh the feather and the hammer on a set of scales on the Moon - the hammer will weigh more than the feather - indeed they will both weigh a sixth of what they weigh on Earth at sea level.

That's the difference between weight and mass.