OUR UNIVERSE

Part 4

In this final part, I first talk about sizes and distances within the Universe, the relationship between space and time, and then go back to the wave particle nature of things and the uncertainty that I previously discussed. This leads on to how events appear to be determined by our observation! And then I talk a little about the anthropic principle, involving ourselves in determining the current, past and future states of everything, or determining nothing at all if the past and future are predetermined anyway, as the case may be.

The Sun is 1,400,000 km across and at our orbit distance of 140,000,000 km it subtends about half a degree. Light from it takes nearly eight minutes to reach us, and about thirty hours to cross the whole solar system. The next star is 4.2 light years away (its light takes 4.2 years to get here, at 300,000 km/sec). If our Sun were placed thirty light years away from us, it would only just be visible to the human eye, while most of the stars that we see in the sky are between 100 and 10000 light years away.

Super luminous stars are many times the mass of the Sun and can be up to 100 times brighter. As a class, they are only a few per cent in number compared to the rest of the 100,000 million stars that make up our Milky Way galaxy. The very luminous stars have lives of just a few hundred million years, as they burn through their energy at an enormous rate (compared to the Sun, with a life of about 10 billion years). Stars much smaller (and so dimmer) than the Sun, form the majority class of stars. They are much cooler and thus redder than the Sun, and are so dim that we can't see them visually at all. The most massive of stars have diameters similar to that of the size of the Earth's orbit around the Sun, or even more. They will end their lives in core collapse, as previously described, while the outer layers bounce off it into space as a supernova; recycling the synthesised heavier elements to mix with the interstellar hydrogen to eventually become new generation stars.

The core collapse leads to electron degeneracy, where all atoms share electrons between them, each on a different energy level in close proximity. Some stars finish at that point, as white dwarfs, about the size of the Earth. In extreme cases further collapse occurs as protons are stripped of charge to form close packed neutrons. Such stars, maintaining their original angular momentum, become very fast spinning neutron stars, only a few kilometres across. The most massive of such stars can't even maintain that state and become black holes, as they shrink further and their gravity becomes so strong that not even light can escape their surface.

Stars are mostly formed in the spiral arms of our galaxy from the collapse of interstellar clouds of hydrogen. Stars orbit the centre of our Milky Way galaxy, just like planets orbiting the Sun, and the Sun is 30,000 light years from the centre of the galaxy. The galaxy is about 100,000 light years in diameter.   In common with other galaxies, there is a black hole at the centre, amounting to hundreds of thousands of solar masses, but it is benign and invisible and only affects stars orbiting around it in its immediate vicinity. The rest of the stars in the galaxy orbit around the stars closer than they are to the centre, forming a disk about 10,000 light years thick at the centre, while the rest that are not in the disk are in randomly orientated orbits, forming a large halo of higher speed stars.

Not all galaxies are spirals. Many galaxies are elliptical, of which some are very large compared to our own, while some are much smaller. They orbit each other in clusters, gradually coalescing on each near encounter. The clusters of galaxies tend to form chains through the Universe. Smaller galaxies are disrupted and consumed by larger ones, over billions of years. The stars never hit each other, as there is so much space between them.

As we look out at night we are looking back in time, because the light further away takes longer to get to us. Our nearest neighbour spiral galaxy is the Andromeda galaxy M31 at 2.2 million light years distance; it is easily visible through binoculars on a clear night and as a fuzzy patch to the naked eye. It is heading towards us and will eventually combine with the Milky Way.

Ordinary matter only amounts to about 4 per cent of the total mass of the Universe. The remaining 96%, so-called dark matter and dark energy, is a mystery and subject to speculation for now. It influences everything gravitationally and yet had no part in the nucleosynthesis that created hydrogen and helium in the beginning. The current average (ordinary) matter density of the Universe is a few hydrogen atoms per cubic metre.

As I described in an earlier part, the structure of the Universe has gone through many different phases in the early stages, each one with a hierarchy of particles created at their corresponding mass energy. But they were very short lived, breaking up into more fundamental ones as the available free radiative background and collision energy dropped as the temperature cooled because of the increasing volume space from expansion.

Each phase change reduces the symmetry, just like water, which has perfect symmetry in all directions, but on cooling into ice crystals it has only the symmetry axes of the crystals, at the same temperature, giving off energy to do so (the same amount of energy required to melt the ice at 0° C in the reverse process). In the Universe this release of energy from loss of degrees of symmetry at each change of phase, creates new sets of particles!

We are just in one such phase, albeit long-lasting. It is one that began when the Universe became transparent and started to form stars, a process which is now ending. The protons and neutrons of the elements of matter, made of quark triplets, will eventually break down into doublets of mesons forming a meson gas. That will probably be the fate of the Universe, assuming its infinite expansion.

When we look out at the stars at night and marvel at it all, we are looking back in time. The further we look back, the more the wavelengths of light get stretched due to the Universe's expansion, and eventually into microwave wavelengths as seen with detectors on telescopes orbiting the Earth above the atmosphere, which would otherwise block out the radiation. We then see back to the first point that the Universe became transparent (after 300,000 years of its 13.8 billion years of existence), and can map the fluctuations of the original quantum vacuum that caused it all, imprinted into the background, that led to the formation of stars and galaxies.

Now a little more about the relationship between space and time. I have already covered the case of gravity and mass distorting space and time equally (known as general relativity). Here I consider the relationship between space and time in the absence of any such distorting gravitational field (special relativity). The speed of light is simply its distance travelled divided by the time taken to do so, and is a constant of nature (300,000 km/sec); it is always seen to have the same value, whatever the speed of the source or the speed of the observer. If we travel at speed in a given direction, then something coming towards us at speed is seen to be at a closing speed of the sum of the speeds. But when travelling at a reasonable fraction of the speed of light, the result is always slightly less, because the closing speed can never be seen to exceed that of light. Instead, if we apply energy to increase the speed of any mass, it is split between increasing its speed and increasing its apparent mass. Thus accelerated particles seem to get heavier instead of gaining so much speed, and so never get to the speed of light.

Spatial distances appear to contract when seen at high speed in the direction of travel, but so must time differences also, as distance divided by time must always give the same value of the speed of light. We don't experience such high speeds in daily life, but it does have observable consequences. For example, the metal gold is the colour that it is because the nucleus is so heavy that the electrons are travelling at relativistic speeds compared with most other metals, and causing a shift of their energy levels. In another example, high energy collisions from particles shot out of exploding stars that hit the top of the Earth's atmosphere create high mass versions of electrons (muons) from the impact energy; they would normally decay in a time less than it takes them to reach the Earth's surface. But in fact they don't as they appear to decay more slowly, caused by their high-speed .

I am now going to build up to the finale which should be when all is revealed! First we have to go back to the very small scales of quantum physics . I have already described in a previous part why the uncertainty of measurement is fundamental. In measuring the energy of a state of a particle, we do so over a given time, but the time itself has an uncertainty; the smaller the measurement time, the less certain we are about the energy, and vice versa. The same applies to position and momentum. The basic uncertainties of each quantity when multiplied together are always a multiple of Planck's constant and never zero. So neither of the quantities can be zero either.

I now take this one stage further. This equally applies to the vacuum in the absence of any particle. So the energy of the vacuum is always a nonzero value, constantly fluctuating, corresponding to virtual particles. It is a mirror virtual cauldron of the particle zoo of reality! I have said this before and, indeed, what follows, but it really needs emphasising.

Any amount of energy can be borrowed from the vacuum as long as it is paid back from any real energy source available within the allowed uncertainty time. That is how the Universe started, borrowed for a moment before it had to be paid back. The process of particle creation is going on around us all the time; but without a source of energy they don't materialise permanently.

Even black holes suffer from this. Particle pair production out of the vacuum on the edge of a black hole (the event horizon) could lead to one particle falling into the hole and the other one escaping, so preventing them from ever combining and cancelling out. The black hole has to give up the energy to maintain the two and in doing so evaporates slowly. This is an example of the general principle of quantum tunnelling through an energy barrier, a process I mentioned in the first part as responsible for the energy released in the Sun.

We are now ready to understand how we are influenced by the Universe and how we influence it!

Now here is perhaps the most amazing thing I have described so far. Particles are speculated as in all possible states at any one moment! That is until they are observed. The very action of observation involves interaction to produce the information we seek, and so disturbs the multiple states to produce just one state, i.e. the observed state, the one created by the act of observation!

If we create a photon twin pair (also true for matter particles, where it's called an entangled state) and send them round a pair of alternative routes in a laboratory optical system and combine them at the end, we get wavelike interference as they both behave as waves, so not revealing which took which route. It is as if both took both routes. If we try to determine which one took which route, then magically the interference stops and we get just particle hits. That is because we have influenced the result to make it so. If we double blind test both routes not knowing which is which, then the interference reappears. Even light photons illuminating two adjacent slits in otherwise darkness have the same consequence. Nature does not tell us which photon goes through which slit: they effectively both take both, and in combination we get interference. In particle behaviour nature refuses to be tricked into revealing which route any one particle took by taking all possible routes at once, until Man determines a state (route) by observation.

If we only have one photon in the path at any one time, we will get a series of hits at the detector; but over time a pattern builds up as if they had all been interfering with each other all along, whereas, as we know, there was never more than one in the system at any one time. It is as if nature knows what happened before and what will happen later! It even happens with entangled pairs of matter particles over huge distances, that is twin particles in two different states. If we try to identify the state of one, then the other one behaves to be in the other immediately, but not until the first one is observed.

We are the Observer, and it is our observation that fixes states from all other possibilities. This is no more than a restatement of what I have already implicated. The various balances of forces leading to fine tuning of physical and chemical processes, including the incredibly fine tuning that in massive stars creates the carbon from which we are made, may seem extraordinary and unlikely. All the constants of nature have very precise values for no obvious reason, and if any one of those was slightly different, then stars would never have been created and so we would not have evolved to argue the case. This is the weak Anthropic principle. It requires all cosmological models of evolution including values of physical constants, to produce conditions for man to exist as the Observer. It is often cited as the case for the existence of God otherwise it is impossibly unlikely chance. Well that is up to you, but in my opinion that is NOT SO AT ALL! But yes, I do agree that chance has nothing to do with it!

When we look back through the route in space and time that caused our existence, right back to the beginning, there is only one probable path: the one that the Universe came along! It is WE who determined it. This is the strong Anthropic principle! If we extrapolate from this quantum behaviour to the macroscopic world, then without our observation, the Universe does not exist! QED.

So the question is: do we have control of our future or not? The beautiful ambiguity is that it can be read either way.

So now for the answer to ‘ Life, the Universe, and Everything ’ ! Or is it? Either we have set our history and can determine our future and so have determinacy over everything. Or the alternative case is that the future, just like the past, is already written, and so we have no control of anything.

We can make deductions and draw conclusions, but we just go through the motions and never make decisions at all in reality!

For me, I prefer the former and think it is all in our minds; we interpret what we make of it to suit our model to live with it in our glorious Universe of our making.

It's up to YOU!: a good point at which to end!

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