Cheap Trek Episode 4 (a cheap attempt at mimicking the legendary *Physics of Star Trek*).

Dear Cheap Astronomy – Please tell us about subspace communications.

If we suspend disbelief and accept that star ships on Star Trek can cross light year distances over the course of a single episode, we also need to consider how such fast-moving ships are able to stay in touch with the rest of Star Fleet. After all, if the ships are going faster than the speed of light, how is it that a radio signal can still reach them? And how come there's no time lag between the sending and receiving of a message? In the real world, we had the 1.5 second time delay between Houston and the lunar astronauts and for the recent New Horizons Pluto mission there was more than four hours delay. If we ever get a mission to the Alpha Centauri system, the nearest star system to us, it will be a more than a four year delay. This is clearly a problem for TV shows that have hour-length episodes.

Of course, the answer is subspace communications. Apparently, sending messages through subspace allows anyone with the right equipment to receive your signal as though you were in the next room. Not only does the communication arrive instantaneously, it arrives unattenuated – that is, its signal strength is unaffected by the vast distances lying between sender and receiver. Nor is the signal affected by the speed at which the receiver is moving away from the source, which should normally exert a Doppler effect on the transmission.

Ursula K Le Guin is generally credited as the first fiction author to deal with the problem of how we might communicate meaningfully over light year distances, in her 1966 novel *Rocannon's World*, which was coincidentally the same year that Star Trek first aired. Le Guin proposed a device called an ansible, capable of supporting instantaneous two way communication between a sender and receiver, without the lag time imposed by the speed of light.

Isaac Asimov had preceded Le Guin with his mention of hyperspace relay technology in the 1950's Foundation trilogy, but Asimov mostly left it to the reader to deduce why such technology might be necessary, while Le Guin actually discussed the physics of it – well, at least some of the physics.

Neither Le Guin nor Asimov made any mention of subspace, which is a term commonly-employed in extra-dimensional geometries – which are sometimes grouped together under the term Hilbert space. Hilbert space encompasses any spaces that extend beyond standard three dimensional Euclidian space. So, the term subspace really just means a subset of the entirety of Hilbert space. This means that subspace is a *generic* term. If you ask a mathematician to describe subspace, you will get a quizzical look – before being asked which particular subspace are you talking about?

The term hyperspace is rarely by anyone in science these days, perhaps because it has become so entrenched in science fiction – albeit more in the Star Wars than the Star Trek universe. In the real world, about the only place you might still hear the term 'hyper' being used is in the field of imaginary geometries, called topology. For example, while a conventional three dimensional cube has six square faces, the eight faces of an imaginary hypercube are themselves three-dimensional cubes – see for example Salvador Dali's surrealist painting *Corpus hypercubus*.

So, as is often the case, science fiction appears to have grabbed a sciencey-sounding term and applied it in ways that it was not really intended for. In the Star Trek Universe, subspace is an imaginary place into which spacecraft can enter and later exit, without all that tedious muckingabout in space-time. And, apparently, subspace is also where two-way faster-then-light communications become possible.

Exiting and later re-entering space-time for the purposes of faster-than-light travel requires mechanisms that we have no real understanding of at the moment. Our best guess is that exiting space-time would require the generation of colossal amounts of energy, meaning your spacecraft would probably be destroyed long before it went anywhere.

However, the transmission of *information* through some kind of subspace, does pose a few less problems than the transmission of a massive object. That said, we still have no idea how to access such a subspace – nor do we have any idea how information might be propagated through it or later retrieved from it.

But consider this, if subspace communication really is possible, it might explain the total absence of alien communications detected so far, despite all our searching for extra-terrestrial intelligence. We could just be looking in the wrong place.

Dear Cheap Astronomy – So, what about the Holodeck.

A holodeck, in the way it is portrayed in *Star Trek- the Next Generation*, is about as likely as warp drive, which is to say not very likely at all. Star Trek writers are seemingly obsessed with the idea of transforming energy into *something equivalent* to matter – for example, those objects that exist only on a holodeck. Indeed Star Trek writers are also seemingly obsessed with the idea of transforming energy into *actual* matter – in the case of replicators and transporters.

As the show itself has sometimes acknowledged, what distinguishes a holodeck object from a replicated object and a replicated object from a transported object is not always clear. For example, on the holodeck it is apparently possible to 'remove the safeties' so that holodeck-created bullets can kill you – although in another set of episodes it was made clear that holodeck objects could never leave (or be transported from) the holodeck itself. Nonetheless, elsewhere in a starship a cup of hot tea can be created from seeming-nothingness on demand.

In the real world, it is true that energy and matter are somewhat interchangeable. E really does equal MC squared – and that relationship does quantify the way in which electromagnetic radiation can be generated from matter. For an obvious example, just look at the Sun – well OK, please don't look at the Sun, it's bad for you – but you get the idea. The mass that's lost in fusing hydrogen into helium becomes all those hot and bright photons that rain down upon us every day.

However, the reverse process of generating matter from electromagnetic radiation is not so straight-forward. For example, nuclear fission is not really the opposite of nuclear fusion, since it also involves mass being converted into energy, as large nuclei decay into smaller nuclei.

It's true that during the first nanoseconds of the Big Bang, the contents of the Universe was all energy and no matter, but that was mostly because of the density involved. In a thimble-sized Universe, there were still mass-carrying quarks and force-carrying bosons. But all those particles were so closely intermingled that their material differences were largely irrelevant. It was only after universal expansion and cooling that the differences between the force-carrying particles and the mass-carrying particles began to mean something.

In the Universe today, there are a few places where we can still see energy converting into mass. Those places are called particle accelerators. In a particle accelerator, particles are accelerated up towards the speed of light and then made to collide. In those collisions, the kinetic energy of the fast-moving particles creates a multitude of new massive particles, the cumulative mass of which well exceeds the initial mass of the two accelerated particles. However, those particles are a mix of particles and *anti*-particles and, in a few nanoseconds, nearly all of them are annihilated into heat and some random neutrinos.

So, in a nutshell, creating organised matter from energy is probably a breach of the second law of thermodynamics, the one about entropy. This means a Star Trek replicator looks highly dubious, unless the underlying mechanism is really just a 3D printer that organises tiny mass-carrying particles into stable macro-scale objects.

Of course, the Holodeck could just be a clever combination of holograms and force fields, which are made to give the *appearance* of matter. But, as we dealt with in an earlier episode on Star Trek shields, force fields don’t work very well outside science fiction. You can have magnetic fields, but they will only deflect charged particles.

In the case of the Holodeck, it would be vastly easier and vastly more effective to just create the Matrix. In the Matrix, people’s brains get jacked into a computer interface capable of mimicking all the neuronal and synaptic activity involved in people seeing, hearing and feeling – as well as tasting and smelling – a completely artificial world. In the Holodeck, it was never clear whether you could actually taste and smell things – and if you could, you would then have a job on your hands explaining *why* you could.

Of course, it was never really clear why you wouldn’t keep running into one of the walls of the Holodeck either – but then most of us figured *that* out in about ten seconds of being introduced to the concept. Hey, it’s Star Trek.