Question 1:

Dear Cheap Astronomy – Oh mama 'Oumuamua

Yes, indeed. An object called C/2017 U1 was first observed in October 2017, where the C stands for comet – since it was coming through the inner solar system quite fast suggesting it was most likely a long-period comet. However, further observation could not detect the faintest sign of a coma – that is the outgassing of volatiles that is normally seen from a comet as it approaches the Sun. And since this object was already within 30 million kilometres of Earth, it was clearly not a comet – and so was reclassified A/2017 U1, where the A stands for asteroid.

But, as interest in A/2017 U1 grew and its orbital trajectory was more-accurately tracked, it became clear that this wasn't one of ours. Although the object's path had curved around as it passed near the Sun, its trajectory was clearly hyperbolic – that is, it was moving too fast for the Sun's gravity to have any hope of ever curving it around into a solar orbit. So, this was something that was just passing through.

Further confirmation of the object's interstellar origin arose from the fact that it had appeared from the direction of the solar apex. The solar apex is the direction in which the Sun is moving in the Milky Way galaxy. Well, at least there's a whole bunch of stuff that's moving in the Milky Way galaxy – at about 220 kilometres a second. But, within this general milieu, the Sun has its own proper motion –relative to that whole bunch of other stuff – a frame of reference that we call The Local Standard of Rest. So, while we do correctly say that the Sun is moving around the centre of the galaxy at 220 kilometres a second it also has a proper motion, against The Local Standard of Rest, of about 20 kilometres a second– and that proper motion, relative to the other stuff around it, is in the direction of the constellation of Hercules. So, we should expect that interstellar objects are going to appear from that direction – because the Sun is essentially overtaking them as it moves through the general milieu of everything else that's orbiting the galaxy.

Anyhow, once it has become clear that this was an interstellar asteroid, the International Astronomical Union, assigned it a new name of 1I/2017 U1 – where the I stands for interstellar and the 1 means it's the first we've ever seen. There's now an expectation that we could start picking up I objects on a regular basis – now that we know what we're looking for and as our technology for observing smallish objects continues to improve. Indeed, there could well come a time when we get nimble enough to intercept an I object with a probe and start a whole new science of interstellar geology.

Our distant observations of the rapidly moving 1I/2017 U1 has led to a good deal of speculation about it. Based on rapid changes in brightness it seems to be spinning once on its axis every 8 hours and may be 10 times as long as it is wide –about 400 metres long and only 40 metres wide. This all suggests it must also be structurally dense since its spin should have otherwise flung off bits of its extremities long ago. So it's probably rocky, if not metallic.

The origin of 1I/2017 U1 is also a matter of speculation, if not wild conjecture. Its dry asteroidal nature – that is, doesn't have a coma of evaporating volatiles, means it might have formed within the frost line of another star system. However, its bizarre shape is more suggestive of shrapnel – perhaps a chunk of something flung out from an explosive collision of two planetary-sized bodies – where it might actually be a remnant of one of those bodies' compressed inner structure.

That event, in a whole 'nother star system, may have happened millions or billions of years ago – which is why we're calling it 'Oumuamua , Hawaiian for advance scout from the distant past.

Question 2:

Dear Cheap Astronomy – How do we keep low Earth orbiting spacecraft, like the ISS, in orbit

The ISS, the International Space Station, is in low Earth orbit and the challenge with low Earth orbit is that you are almost in a vacuum, but not quite. So, while you will quickly die if you step outside the air lock, there are just enough scant air molecules outside to create drag and slowly rob your spacecraft of velocity. And, as your spacecraft loses orbital velocity, it also loses altitude and as a spacecraft loses altitude it encounters denser air, which will slow it down even more and so on and so forth until it burns up on re-entry. If left uncorrected the ISS' altitude would drop about two kilometres a month on average – and this is why the ISS' altitude is corrected every month on average.

Outside of Star Trek, the only technology available to keep kilogram-plus objects in low-earth orbit over long time periods are propellant-based rockets and thrusters. There's no official definitional division between what's a rocket and what's a thruster, but usually a rocket maintains a powerful blast over a long period , while a thruster just delivers an occasional puff of propellant – perhaps just enough to maintain a low-Earth orbit.

Rockets have traditionally relied on mixing liquid oxygen and kerosene mix liquid oxygen and liquid hydrogen. The liquid oxygen (or LOX) is there to ensure that combustion happens at a highly explosive rate without needing to depend upon external oxygen from the atmosphere, which is going to become depleted with altitude anyway.

But to have enough LOX concentrated for use in an effective rocket blast you have to store it in a liquid state. So, there are major engineering challenges involved in storing LOX (or liquid hydrogen) over long periods of time, because if the LOX doesn't stay cold, the fuel will start expanding back towards its gaseous state.

So, for this reason solid fuel rocketry has become more popular in recent decades. But, while solid rocket booster fuel can be stored for long periods of time, once ignited you can't regulate the reaction, it just burns and burns until it's all burnt up. So, solid rocket fuel is mostly only useful for launching something from Earth's surface up to orbit with a long, sustained burn. So, we only really use solid fuel in boosters which supplement liquid oxygen mixed fuel engines, because LOX engines can be regulated for more exacting orbital manoeuvring once the solid rocket boosters have got you up there.

But, none of this technology is really going to help if you want a thruster that just delivers little puffs of thrust every now and again. For that, there is another solution. Hypergolic fuels are stable liquids at room temperature, but mix them together and you get spontaneous combustion. Most hypergolic fuels are variants of hydrazine and an oxidiser, generally nitrogen tetroxide. So, a hypergolic engine has a very simple design. Basically a couple of valves to let the two fluids exit their tanks, helped by pressurised helium when they're in microgravity – so they then mix in the combustion chamber. Then the rapidly expanding gases of combustion rush out the engine nozzle and, in doing so, propel the spacecraft in the opposite direction.

Most spacecraft launched on deep space missions have hypergolic thrusters, since they are the most dependable solution for long term use. The ISS also has such thrusters in the Zvezda module of the Russian segment.

It turns out that about 7 metric tonnes of propellant is burnt each year to maintain the ISS' orbit and also its attitude – that is, keeping one side of the station always facing Earth – and also debris avoidance – that is, avoiding space junk. The Zvezda thrusters maybe used up to once a month for this purpose although to conserve on board fuel, visiting resupply vessels often use their thrusters to raise the ISS's orbit. And otherwise, the Zvezda's fuel tanks can be easily refilled by Russian Progress resupply ships. To make this easy, there are fuelling ports amongst the various docking connectors – and both the Zvezda thrusters and Progress thrusters use the same hypergolic fuel components - Unsymmetrical dimethyl hydrazine and nitrogen tetroxide, if you really want to know.