Question 1:

Dear Cheap Astronomy – Why do spiral galaxies have bulges?

Firstly, it probably has nothing to do with the super-massive black holes. Not all spiral galaxies have bulges, but it's looking likely, from observations to date, that all spiral galaxies have supermassive black holes. As we've discussed in earlier podcasts (see episode 99), it may be that the first proto-galaxies formed around black holes, which were probably stellar-sized black holes to begin with – but, as the proto-galaxy grew by consuming nearby star clusters and later dwarf galaxies, the black hole within it also grew through gobbling up anything that chanced nearby until it grew to a supermassive size in parallel with its proto-galaxy growing to a galactic size.

Now, any object that's captured by a growing galaxy's gravity is first drawn into a downward spiralling orbit before it finally merges with the growing galaxy and adds its momentum to that galaxy. With a steady consumption of such objects spiralling in, conservation of momentum means the galaxy as a whole begins to spin - and that spinning then spreads the mass of the galaxy out into a disk shape – just like pizza dough when it's spun up in mid-air.

As we've also discussed in earlier podcasts (like episode 109), a galaxy is way too big for its central mass to exert any meaningful gravitational influence on its outer parts. Instead the whole galaxy holds together in a disk because its inner parts are inter-connected to its outer parts by all the intervening gas and dust that the galaxy has accumulated over time. And as the galaxy spins, density waves form where circling gas and dust are caught up in traffic jams – and those traffic jams become bright star-forming regions – which is what produces the appearance of spiral arms. In this way, much of the intervening gas and dust is either consumed in star formation or it gets shifted outwards by centrifugal forces.

So, the central areas of the galaxy will become bereft of gas and dust until all that's left there are ageing stars. With no intervening gas and dust left to constrain them within a flat, spinning disk, the occasional gravitational interaction between those old stars begins to bump them out of alignment. Eventually, you end up with a large population of ageing stars whose orbits go all over the place – forming a rough blob of stars, that's rounded in the middle, but flattens out towards the persisting disk of the galaxy where intervening gas and dust is still keeping everything spinning together like pizza dough.

However, all that is what is known as a classical explanation. The prevailing modern view of galaxy structure is that dark matter plays a key role in holding a large galaxy together. It's speculated about 90% of the Milky Way's mass is dark matter – which is generally hypothesised to be distributed in a halo around the galaxy. We need to include dark matter in our understanding of galaxies to explain why the outer parts of galaxies move at similar angular velocities to the inner parts.

Some theorists propose the dark matter halo is evenly distributed around a large galaxy, while others argue that it's more-likely to be clumped, or cusped, towards the galaxy's centre. Since, dark matter is utterly invisible we can only infer its distribution by looking at the distribution and velocities of visible matter – and all the data we've collected so far does not unequivocally support one model over the other. In any case, neither the even-spread, nor the clumpy-cusped model help to explain why many large spiral galaxies have bulges in the

middle, So, the classical explanation that we gave you, about gas and dust dispersal, still seems the best way to explain bulges.

Indeed, for the most part, the role that dark matter plays in the shape and the evolution of galaxies is… well, dark.

Question 2:

Dear Cheap Astronomy – Is there a galactic internet?

Given the Universe's speed limit, the speed of light, it doesn't seem likely that members of an advanced alien race are going to spend years, decades or centuries sitting in a cabin watching DVDS, just so they can come and visit us. Crossing vast interstellar voids for the sake of a handshake or to strut up and down in front of some poor unsuspecting soul and make beep-beep noises just isn't worth the time, the effort, the cost or the risk.

After all, since we can readily exchange information at the speed of light, what's the point of physically travelling vast distances at less than the speed of light for a face-to-face meeting? Whatever inhabited exoplanet you visit, it's unlikely the atmosphere, the gravity or the radiation will be compatible, so it's not likely you'll be able to have a relaxing chat with your new alien buddies over coffee. And if your new alien buddies are a hundred light years away and if, in your more-than one-hundred years of travel time, they a) develop a xenophobic dislike of visiting aliens and b) develop better tech than anything you've got on board – you might end up regretting your decision to go and visit then.

So, if there are advanced alien civilisations out there, it's likely they've thought this through already – and decided that the best way to meet new aliens is online. Any race that has begun to actively colonise nearby star systems will surely establish a communications network across those colonies. And as those colonies begat more colonies, that communications network would be even further extended.

Over such a light-year-spanning network, real time communication would no longer be feasible. At best, you could upload an interesting piece of data with the faint hope that your grandchildren might receive a response from a distant correspondent.

How such an established network might come to cross species barriers is a matter of speculation. But it's not hard to imagine a distant colony encountering a similarly-interconnected alien civilisation and both agreeing there was value in extending their respective reaches by inter-connecting their respective networks. And perhaps such cross-fertilisation steps have already happened several times over.

If such a galactic inter-species internet really is out there, we can expect that the common basis of any encoded messages will be mathematics, as well as physics. Any alien civilisations that have mastered both space travel and interstellar communications would have a common understanding of electromagnetic propagation, gravity and mass, relativistic distance and time and the periodic table of elements – which is organised using internally-consistent and universally measurable characteristics – so the periodic table might be the Rosetta stone that allows us to translate alien communications into something we can comprehend.

Because electromagnetic radiation quickly attenuates over distance – the galactic internet would probably rely on tightly-beamed transmissions between nodes rather than indiscriminate 360 degree broadcasting. If we're lucky a node might be nearby – say, within a hundred light years, anyway But, before we can start receiving and translating any messages from it, we are going to need to log on.

Some kind of log on process will have been established to avoid the network picking up and transmitting random noise – since, our Universe is full of random electromagnetic random noise. To initiate a log on we'd need to be transmitting something that indicated we are intelligent and have something useful to contribute. This is why we should probably desist from the indiscriminate broadcasting of parochial and incomprehensible material like I Love Lucy episodes, Beatles songs or Twitter messages. If we want 'in' to the galactic intelligence club – it's time we started broadcasting some more intelligent content that has some chance of initiating a response.