Hi this is Steve Nerlich from Cheap Astronomy www.cheapastro.com and this is *Arms around the galaxy.*

You are probably familiar with the story of Edwin Hubble who in the 1920s used the 100-inch Hooker telescope at Mt Wilson Observatory, then the biggest telescope in the world, to confirm that the universe was an awful lot bigger than many people thought at that time. I mean OK, the whole red shift business and the expansion of the universe was pretty nifty too, but the discovery that *the* galaxy was just *a* galaxy within a sea of other galaxies was kind of special. Apparently, it was all about finding Cepheid variables in nebulae - which were of course re-named galaxies – when the Cepheids, which are standard candles, made it clear just how far away those nebulae were.

Anyhow, having discovered other galaxies, Hubble then set about cataloguing them and came up with a basic taxonomy – which today we still call the Hubble sequence. Reading it from right to left tends to work better, with our current understanding of galaxy evolution. So you start with two types of spiral galaxies – either with or without a bar. The sub-classes of spirals progress from ones with a bright central bulge with tightly-bound spiral arms to ones with a dimmer central bulge and loosely-bound arms. Then you progress to lenticular galaxies, which are still bright disk-like structures, but with no spiral arms visible.

After that you have the elliptical galaxies which are roughly spherical objects with stars going around in all directions rather than in the orderly orbits of stars in flat disk galaxies. And then, outside of all that – are irregular galaxies which Hubble never put into his sequence and which are often referred to as train-wrecks – being the result of a collision between two large galaxies.

There's an old fashion view that spiral galaxies are young and elliptical galaxies are old – but in fact it's probably the other way around. When you look out into the red-shifted, distant universe – which is really a snapshot of how things looked billions of years ago – you generally find only spiral galaxies and irregular train wreck galaxies.

The confusion about age arises from the fact that ellipticals are generally full of dim, ageing red stars while the spirals have lots of bright and young stars and stellar nurseries. Current thinking is that giant spiral galaxies, like the Milky Way which is around 12 billion years old, keep themselves looking bright and young by eating new gas and dust – often from small dwarf galaxies. This keeps them supplied with new raw materials and a bit of turbulence – the ideal recipe for new star formation.

But when a big galaxy comes close to another big galaxy, it results in a collision rather than an absorption of one by the other. The form of both are disrupted by that collision forming a irregular train wreck galaxy. And having then irrevocably lost their spiral form – the collision components re-organise themselves into an elliptical galaxy.

Anyhow that covers most aspects of the Hubble sequence except the lenticular galaxies – which are disks with no spiral arms – and just what the heck are those spiral arms for anyway? And so to the point of today's podcast.

As you probably know, the apparent spiral arms of spiral galaxies aren't really structures, but density waves. As stars rotate around a galactic disk they get slowed up at certain points in their orbits – so that the density of stars and star clusters all increase at those points. For example, while the solar system is currently in the Orion spur of the Milky Way - we are just passing through. Indeed no star systems are permanent members of any spiral arms. We all just get slowed down, bunched together for a while and then we move on.

What it's probably all about is gravitational resonance built up across the all of the orbits of all the stars and clusters that rotate around the galactic disk. It might be that if enough stars are roughly aligned towards one side of their galactic orbit they generate a cumulative gravitational pull - which then creates drag on other stars and clusters passing by, slowing them down in their orbits in that same region of the galactic disk – and as more stars are slowed up in this drag region – the resonance effect becomes even stronger – which then slows down even more stars and clusters – all of which is creating a kind of temporary traffic jam that we call a density wave.

So over time, the galactic orbit of all stars and clusters across the whole galactic disk are modified so that they all slow up at closely aligned points in their orbits – generally two or maybe four points equally spaced around their galactic orbit. Across the whole galactic disk these aligned points become like spokes in a wheel – except the galaxy is rapidly rotating and its contents behave more like fluid than a solid, so instead of being spokes the density waves appear as spiralling swirls.

The swirl shape probably results from angular momentum effects. Stars in towards the centre of a galactic disk have a much smaller circumference to travel to complete an orbit so they tend to move faster. So when they come to a density wave in their path – they tend to push the density wave forward, which is way spiral arms appears to initially curve forward in the mean orbital direction of the galactic disk. However, stars in the outer parts of the disk, with a much larger circumference to cover, tend to move slower in their orbit and so create a drag on the spiral arm density wave, slowing it down and dragging it backwards so that it curves behind the mean orbital direction of the disk. So, in this way, you get the classic spiral wave pattern of spiral galaxies.

Now since the density waves are areas of denser gas and dust – as well as denser collections of stars – they tend to be much brighter and more colourful than other areas of the galactic disk. They are also common sites of star formation and stellar nurseries – given all that dense gas and dust and turbulence – which makes the density waves seem even brighter still.

Presumably it's the absence of all these effects that distinguishes lenticular galaxies. While they may still have density waves in their disks – and their contents almost certainly are still rapidly orbiting – you no longer see the bright spiral arms because the galactic disk has become exhausted of gas and dust. In addition to that, there's probably also an evolution of form that relates to the whole spiral arm density wave story.

The process of the inner stars pushing the density wave forward means they give up some of their angular momentum to the wave – and this is happening while the outer stars gain momentum when the density wave drags its way through them speeding them up a bit. This steady transfer of angular momentum from inside the disk to outside the disk means the disk will naturally spread outwards – increasing its diameter and reducing the density of the whole disk.

So maybe lenticular galaxies started their life as bright spiral galaxies, but in the absence of a steady diet of dwarf galaxies they dim and as a result of not gaining any new mass, the angular momentum of those galaxies gets steadily spread outwards – until the disk becomes so diffuse that its density waves are no longer visible. Well, that's the theory anyway.

Thanks for listening. This is Steve Nerlich from Cheap Astronomy, www.cheapastro.com. Cheap Astronomy offers an educational website conserving your money and your angular momentum. No ads, no profit, just good science. Bye.