Hi this is Steve Nerlich from Cheap Astronomy www.cheapastro.com and this is *Supernovae - Types I and II.*

This is the first of two podcasts on supernovae.

OK – so there's two types of supernovae – and it's best to start with the Type IIs. Type II supernovae arise from massive stars that undergo core collapse at the end of their main sequence lifetime – where main sequence represents the period during which stars predominately fuse hydrogen. However, Type I supernovae are less easy to categorise. Type Ia supernovae arise from compact white dwarves, which are well past their time on the main sequence - and which explode after they accumulate extra mass.

But Type Ib and Ic supernovae are totally different – they actually arise from enormous stars, bigger than those that produce Type II supernovae. Just like Type IIs they result from the collapse of the massive star's core, but are more likely to produce hypernovae – which are maybe 100 times brighter than an average Type II supernovae and produce powerful gamma ray bursts as their core collapses into a black hole.

What distinguishes Type Is and Type IIs is not so much about the force of the explosion. The essential difference is that Type Is lack hydrogen lines in their spectra while Type IIs have hydrogen lines. More on that later.

One feature which is characteristic of all supernovae is the Chandrasekhar limit – which represents a point of density at which the electromagnetic repulsion between electrons and protons is overcome and the electrons merge with the protons to form neutrons.

In a core collapse supernovae (that's your Type IIs and also your Type Ibs and Ics) a compact core of iron forms and grows. Then when it reaches its Chandrasekhar limit, it collapses as electrons merge with protons to form a much more compact core of neutrons – or some even stranger material we don't know anything about because that strange material immediately disappears inside a black hole. In any case the rest of the star is blown away by the force of the explosion leaving behind a neutron star – or even a black hole – as a supernova remnant.

But Type Ias are an exception to that model. A white dwarf, which is fairly dense object already, can exist in a stable form for billions of years if its mass is low enough that its density stays below the Chandrasekhar density limit. But if its mass approaches 1.4 solar masses – it's in trouble.

Main sequence stars, which may be tens or hundreds of solar masses, don't have this problem as long as they have fuel to sustain active fusion, which creates huge amounts of radiation pressure - which puffs the star out and keeps its density low.

But with white dwarfs, they are already at the end of their main sequence stage and have already burnt most of their fuel. So, unless a white dwarf is spinning so fast that centrifugal forces keep it expanded outwards, once it approaches 1.4 solar masses – its collapse heats the star to a critical point.

Rather than proceeding to form a neutron star, the heat and density re-ignites the white dwarf star into carbon fusion – a very energetic process that is common in big stars whose gravity can contain the energy generated, but in a smaller white dwarf size star, this sudden burst of energy generated throughout the star is enough to blow it to bits. The supernova explosion is generally less luminous that other supernova types and follows a very standard light curve – which is why these supernovae are considered ‘standard candles’ on the basis of an assumed, fixed absolute luminosity.

Now, Type Ibs are a whole different ball game. They represent the end of the life cycle of a very big star of the order of 20 solar masses – commonly known as a Wolf-Rayet star - which was probably even bigger to start with, but has blown away a lot of its outer layers away as stellar wind. And Type Ics might have been even bigger stars to start with, but at the stage they are observed – they have blown off, not only their outer layers of hydrogen, but also deeper layers of helium.

So all this brings us back to understanding the basic difference between Type I and Type II supernovae. Type Is have no hydrogen lines - being an absorption line in a spectroscopic analysis of the explosion. This is because the stars from which they arise have almost no hydrogen - so the part of the supernova's light spectrum that is usually absorbed by hydrogen is clear - that is, no lines.

Type IIs do have hydrogen lines because their stars had hydrogen left before they exploded - unlike Type Is. Progenitor stars of Type Ia supernovae wouldn't have much hydrogen because white dwarfs are the end point of an average star's life span - where most of its hydrogen has already been consumed. Type Ibs and Ics don't have much hydrogen because it's all been blown away in the stellar wind produced by the ridiculously energetic physics of these humungously big stars. These are stars whose life spans are drastically shortened by their own massiveness - burning or blowing off most of their hydrogen in their first few million years.

So let's pull all this together. Type II supernovae are probably the most common core collapse supernovae - representing a star big enough to go supernova and which generally leave behind a neutron star. Type Ib and Ics are bigger explosions, perhaps even hypernovae where you always have a black hole forming - and most of the energy release is in the form of polar gamma ray bursts.

But you can only say probably and generally here, because the Type I and II classification system is based on spectroscopic absorption lines, rather than on the size or the explosive force of the supernova.

Nonetheless, we can predict that likely outcome of supernovae explosions, based on the estimated mass of the progenitor star prior to detonation. As we've already covered here, a small compact white dwarf that gains mass and approaches a total mass of 1.4 solar masses will blow itself to bits as a Type Ia supernova.

A big main sequence star between 9 and 20 solar masses before detonation will explode and leave a remnant neutron star behind. These will be most of your Type IIs. A star above 20 solar masses, will likely leave behind a black hole, perhaps exploding as hypernovas with gamma ray bursts - and these are likely to be your Type Ibs and Type Ics. A star above 50 solar masses forms a black hole, but one that is potentially big enough to suck everything down so you don't get a supernova at all. However, this is a largely theoretical idea since we have no observational evidence of a massive star that suddenly seems to wink out of existence.

Going even bigger, stars above 140 solar masses are called pair instability supernovae - which may well be just Ics. These enormous stars generate such high internal energies, that the photons within them convert to leptons (being electrons and positrons) - resulting in a sudden collapse of the whole star as the radiation pressure within them suddenly cuts out. The force of detonation is so extreme that the star blows itself to bits leaving no remnant behind.

Cool, huh?

Thanks for listening. This is Steve Nerlich from Cheap Astronomy, www.cheapastro.com. Cheap Astronomy offers an educational website where we just bang on about astronomy. No ads, no profit, just good science. Bye.