Supernovae and Supernovae Remnants (part 1)

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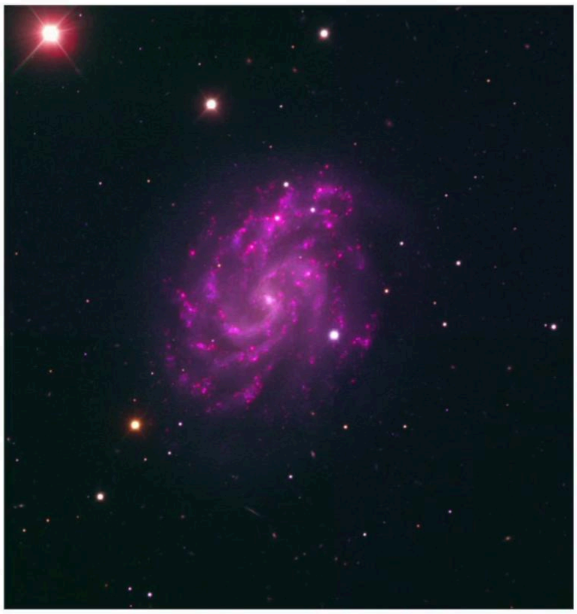
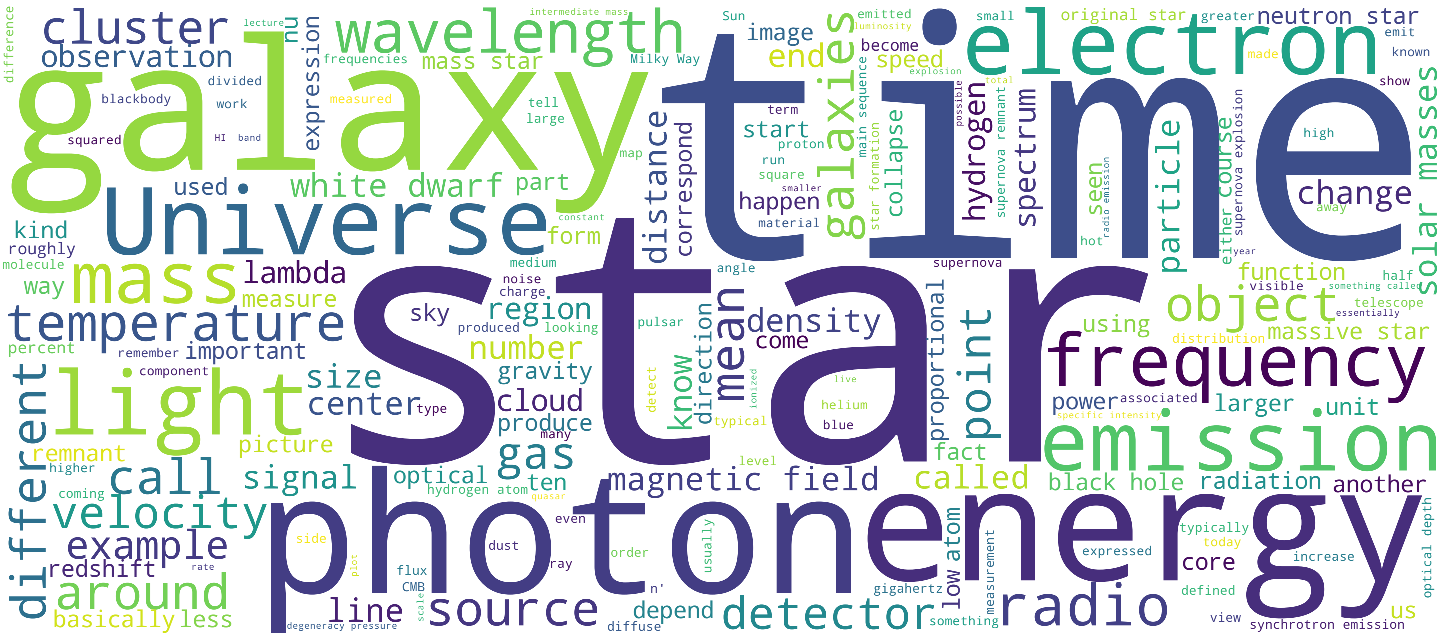


Image credit: ESO



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Video

Massive stars end their lives in spectacular explosions called Supernova. The blast wave following this explosion expands into the surrounding gas and is visible for up to half a million years before it fades away. The blast wave and the material contained within it are known as supernova remnants. In the image behind me, the bright white star to the right of the center of the galaxy is a star which has recently exploded. Supernova and the aftermaths play an important role in processing and redistributing material within a galaxy which ultimately influences how the galaxy evolves with time. The high energies of the explosion result in fusion reactions which produce heavy elements. All elements heavier than iron in the universe are produced in supernova explosions. The explosion also redistributes many of the heavy elements that are produced within massive stars. Without supernova explosions, our solar system and its rocky planets would not have come into existence. The explosion also accelerates particles up to very high relativistic speeds and it is thought that they may be the main source of high-energy cosmic rays which are known to exist within our galaxy.

Notes

Summary

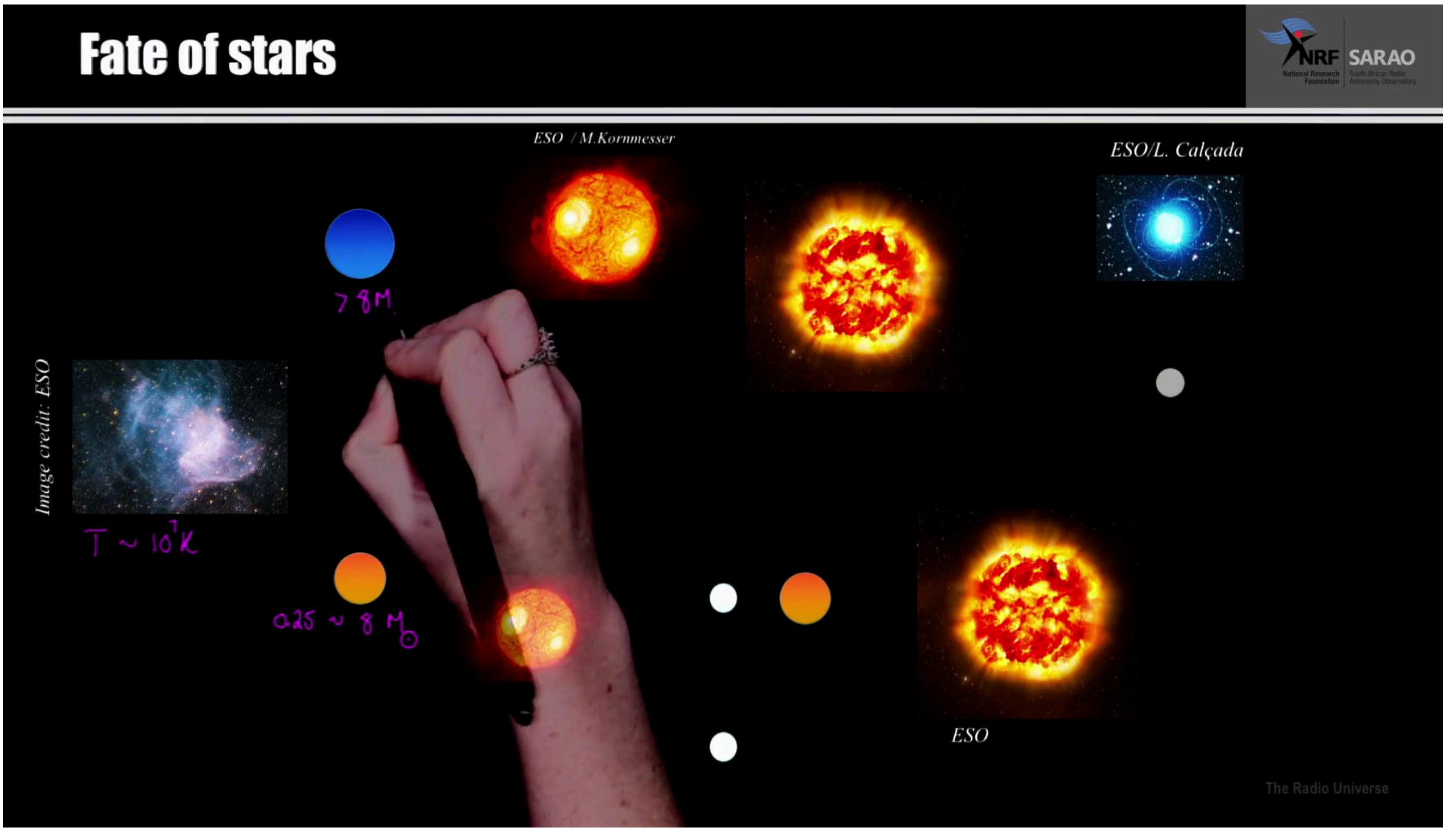
0m 05s

These relativistic electrons combined with magnetic fields result in synchrotron emission and the vast majority of known supernova remnants are synchrotron emitters. In this lecture, we will review the formation and evolution of supernova and their remnants and overview all their radio properties.

Notes

Summary

1m 16s

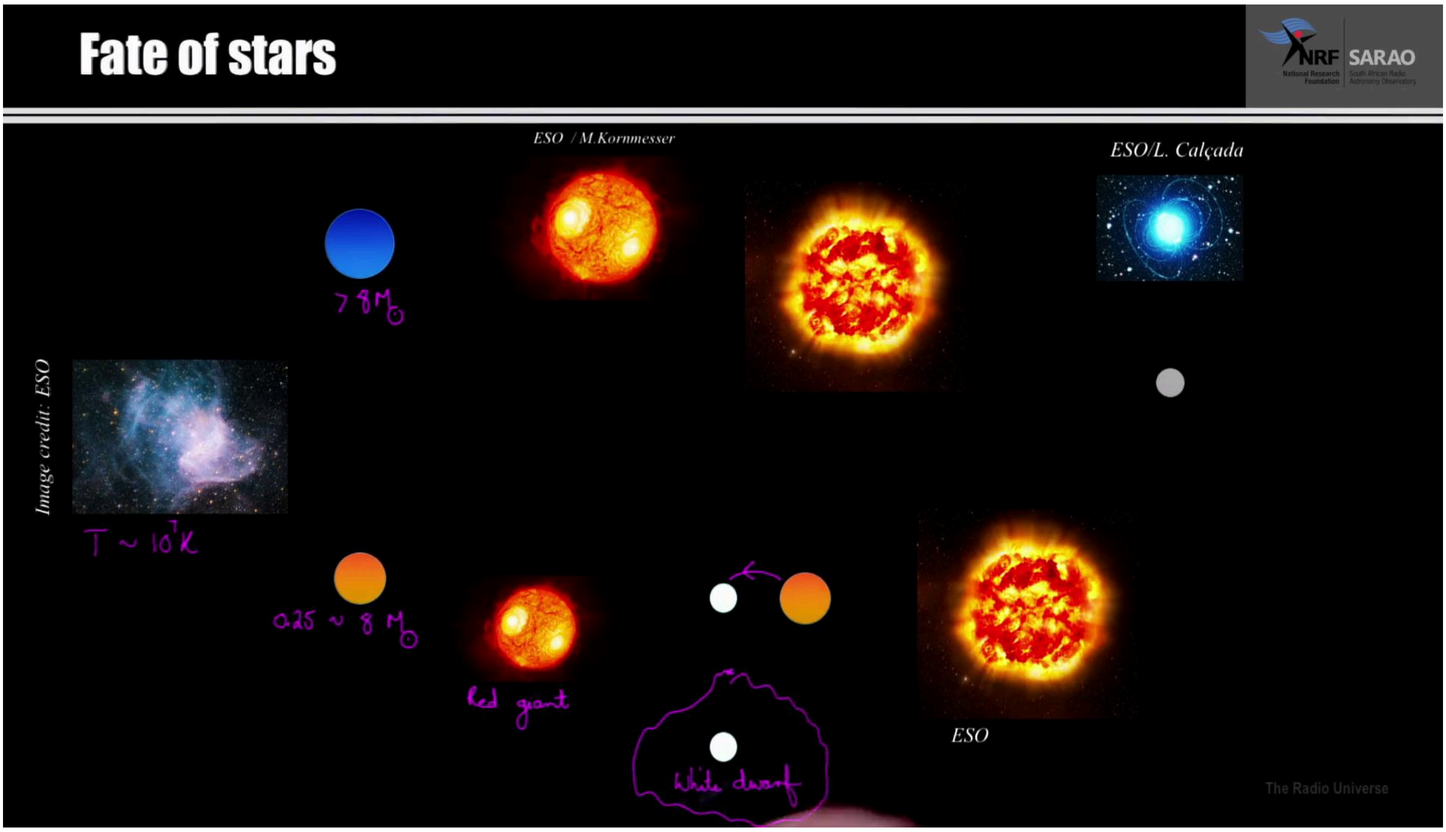


There are at least two major pathways to form a supernova. One is associated with very high mass stars and one is associated with low to intermediate mass stars. Stars essentially start their lives as clouds of dust and gas in the interstellar medium. The cloud collapses under its own gravity and then it becomes compression heated. Some of that heat is radiated away and then the cloud collapses further and even further compression heated and this cycle continues until the cloud becomes very dense and very hot. This is because the cloud is not able to radiate the heat away fast enough to compensate for the heating that occurs as a result of its collapse. Once it reaches a critical temperature of around ten to the seven Kelvin, the star is hot enough and dense enough to start to fuse hydrogen atoms into helium and at this point the star is born. From this point onwards, the life cycle of the star is mainly determined by its initial mass. So for low to intermediate mass stars, it will have one life cycle and we define this as stars that have a mass of around a quarter to eight times the mass of our Sun. Massive stars are defined as stars with a mass of greater than eight times the mass of our Sun.

Notes

Summary

1m 34s

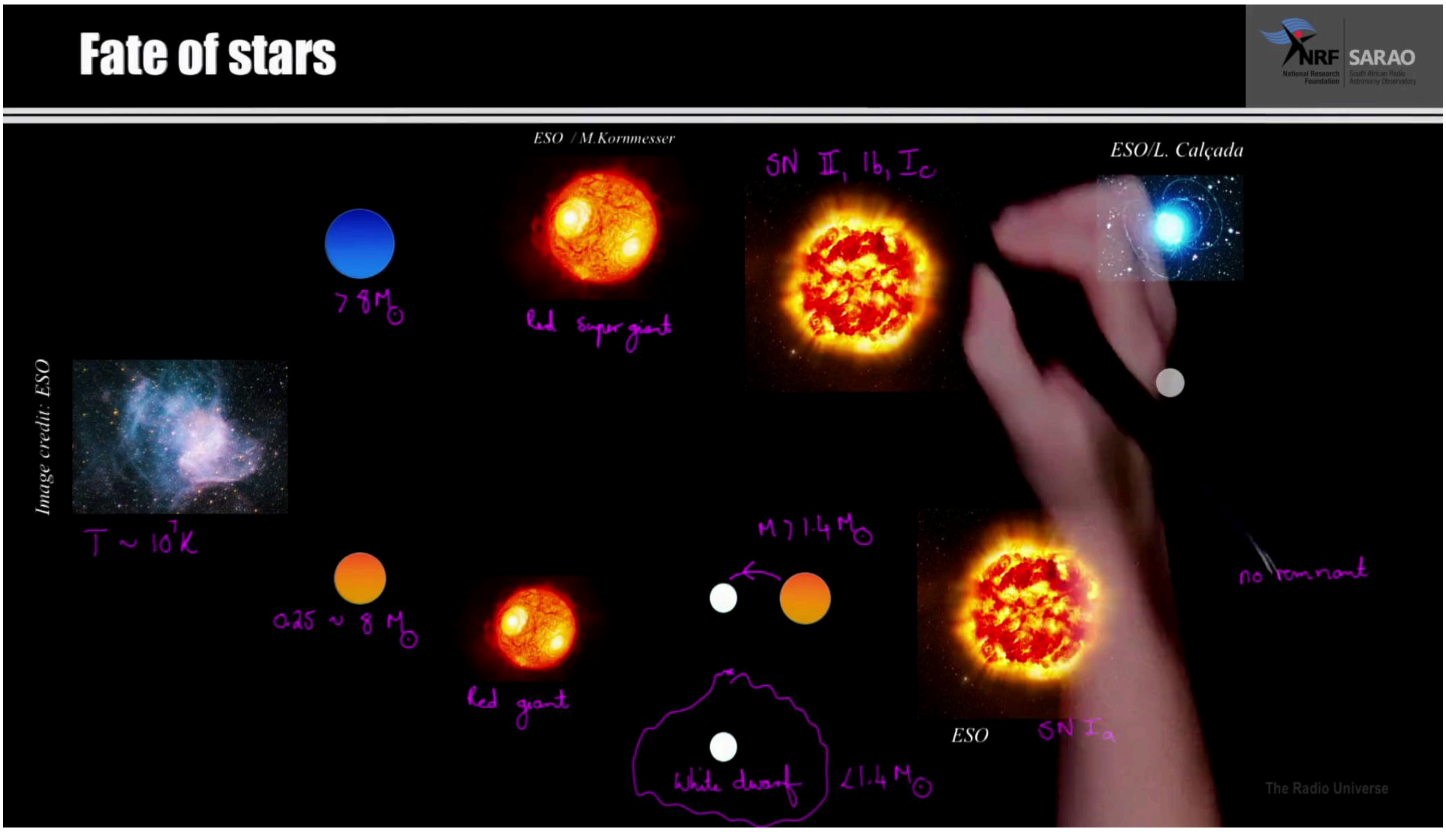


Once the star is born, it will spend most of its life on the main sequence of the star formation. Eventually it will run out of hydrogen in its core to fuse into helium and at this point it will start fusing helium into carbon and it becomes much larger and at this stage it becomes a red giant star. At this stage for most low to intermediate mass stars, the outer layers of the star get blown away and all that you're left with is the central core of this original star which is mostly consists of the carbon that was fused in this last stage. So it's a glowing hot very small carbon remnant known as a white dwarf which is essentially just the core of the star which was at one time fusing material. For most stars this is the end of the line. This white dwarf will be embedded inside something called a planetary nebula which is essentially the outer layers of the star which have been blown away by a stellar wind. But for some stars some white dwarfs, they'll end up in a binary system with another red giant star so those two will be orbiting around each other and in this situation you can have mass transfer between the main-sequence star and the white dwarf.

Notes

Summary

2m 54s

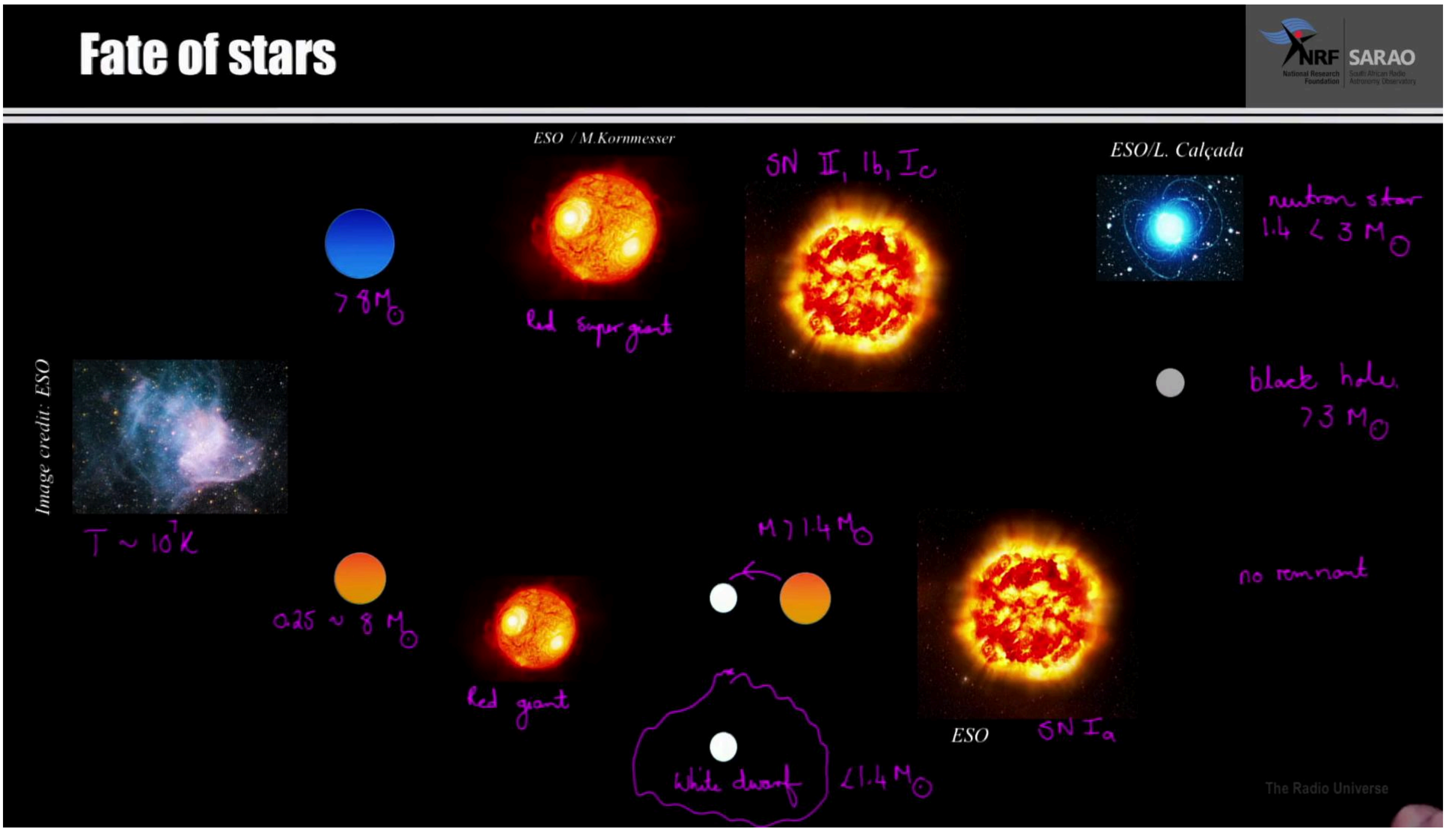


So white dwarfs are stable because of something called electron degeneracy pressure which is only able to sustain the white dwarfs stable state if it has a mass of less than approximately 1.4 solar masses. Once the mass exceeds this limit, the star is no longer stable and at this point a runaway nuclear fusion reaction will happen and there will be a massive supernova explosion. This is called a supernova type-I a. So the mass is transferred and once the mass exceeds this limit, there'll be a massive explosion. In this case, the explosion is so violent that the entire white dwarf is destroyed by it and so there's actually no remnant of the original star left after the explosion. Only the actual explosion material. For high mass stars, they spend most of their lives on the main sequence then they will become red super giant stars. And at some point the star will run out of material to fuse and produce energy to maintain stability against gravity and at this point when it's run out of energy, the gravity of the star will cause it to completely collapse and then there will be an enormous rebound explosion which is also a supernova. These are called type two’s and one b's and one c supernova.

Notes

Summary

4m 20s

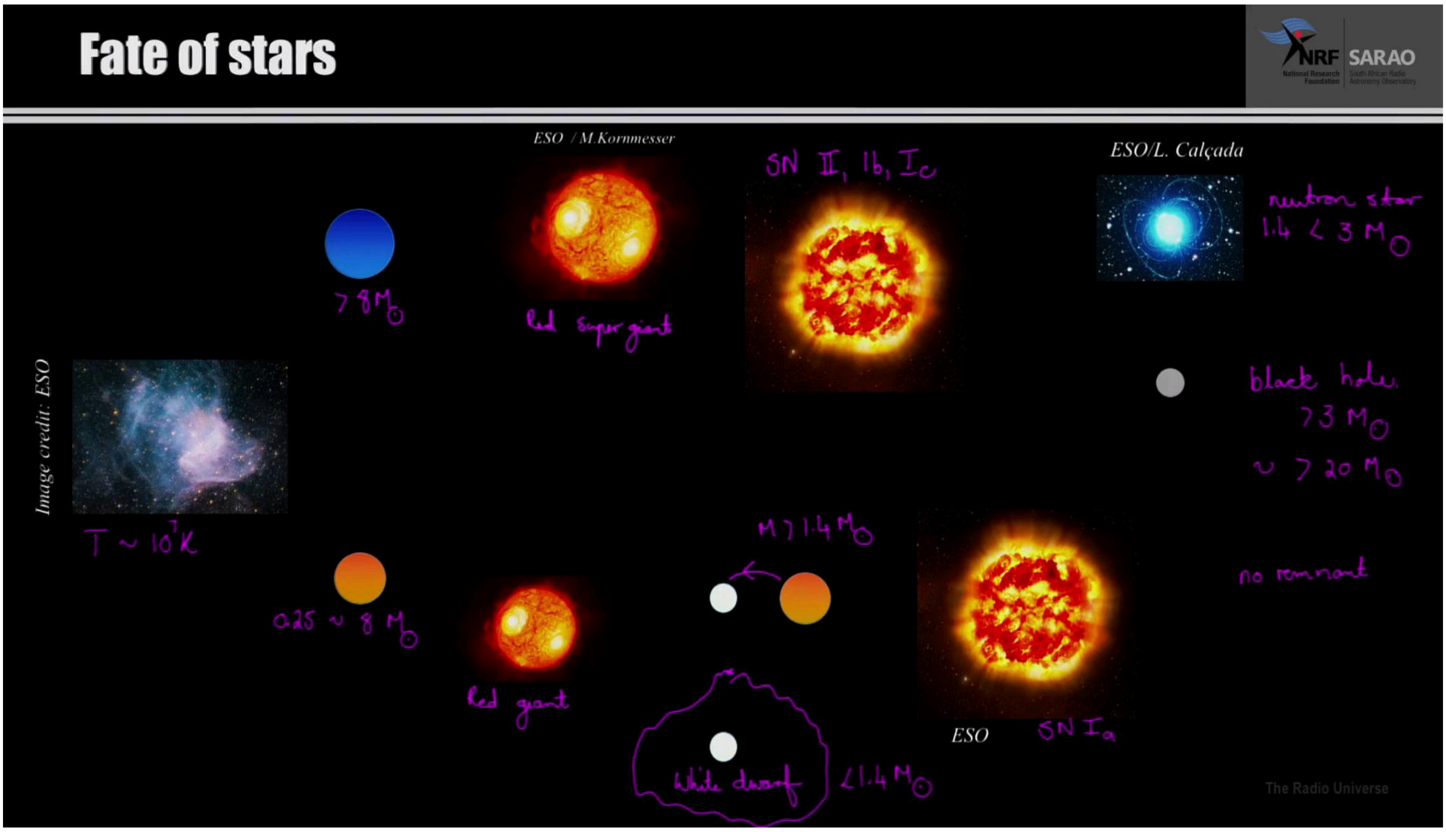


The important thing is that one a's are always associated with this mass transfer and all the other kinds of supernovae are associated with the collapse of a massive star when it runs out of energy. In this instance, there will be a remnant of the original star. You can either have a neutron star remnant which is a kind of very dense small compact object which has approximately the density of the nucleus of an atom or if the star is initially very very massive, it will collapse into a black hole. Here the neutron star is kept stable by neutron degeneracy pressure in the same way that the white dwarf is kept stable by electron degeneracy pressure. And so there is also a critical mass for which a neutron star is going to be stable and this is thought to be around three solar masses. So if the core of the original star is less than three solar masses but greater than 1.4 solar masses then you'll have a neutron star and if the core is greater than three solar masses then you will end up with a black hole as the remnant. So here you'll have the remnant of the star surrounded by the exploded material from the supernova. So here you'll have the remnant of the star surrounded by the exploded material from the supernova.

Notes

Summary

5m 54s



In order to have a core mass of around three solar masses, you probably have to have an originating mass of around greater than 20 solar masses. So the original star's mass was around 20 solar masses to end up being a black hole.

Notes

Summary

7m 15s