Blackbody emission and radiation transport (Part 1)

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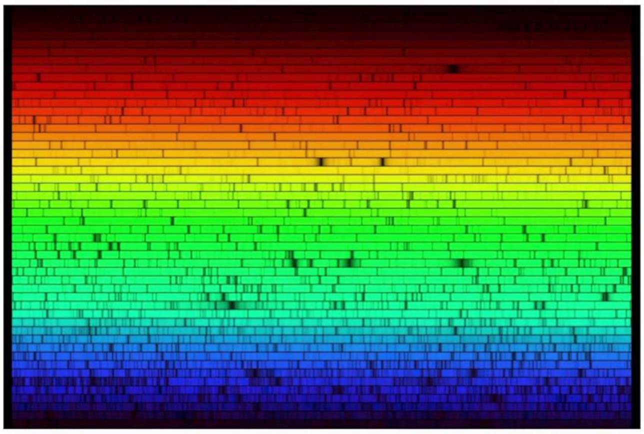

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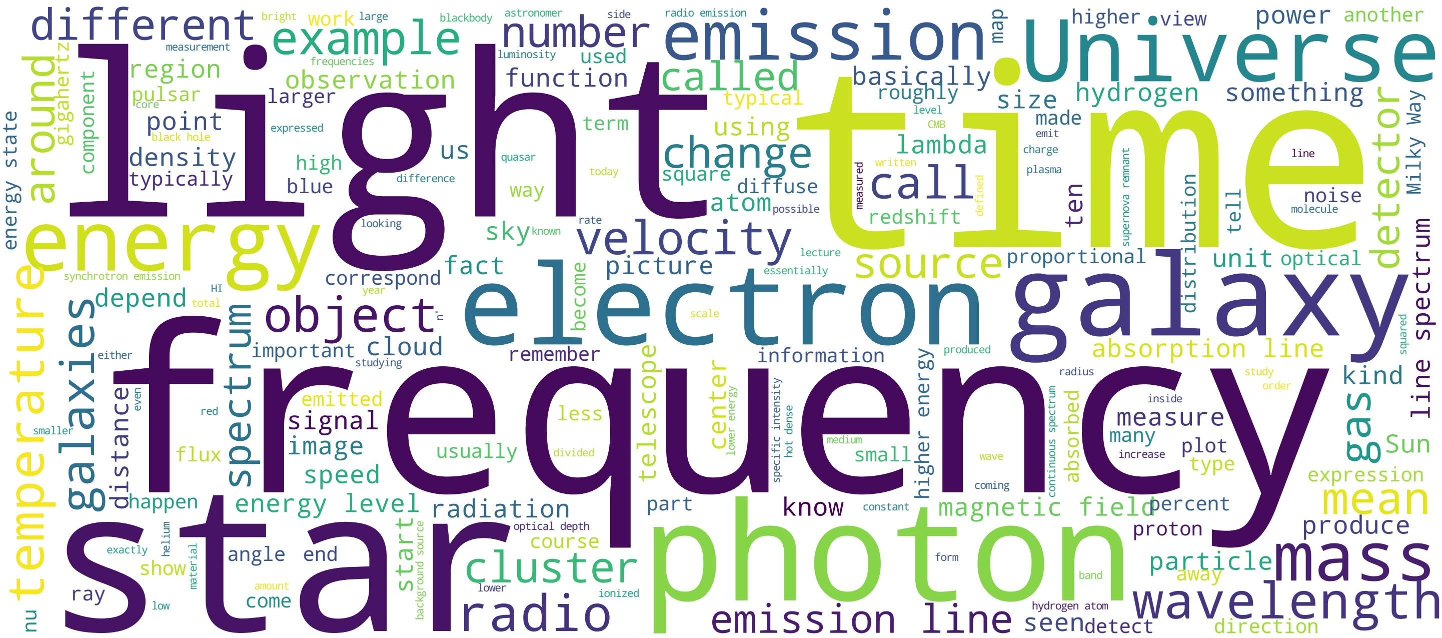

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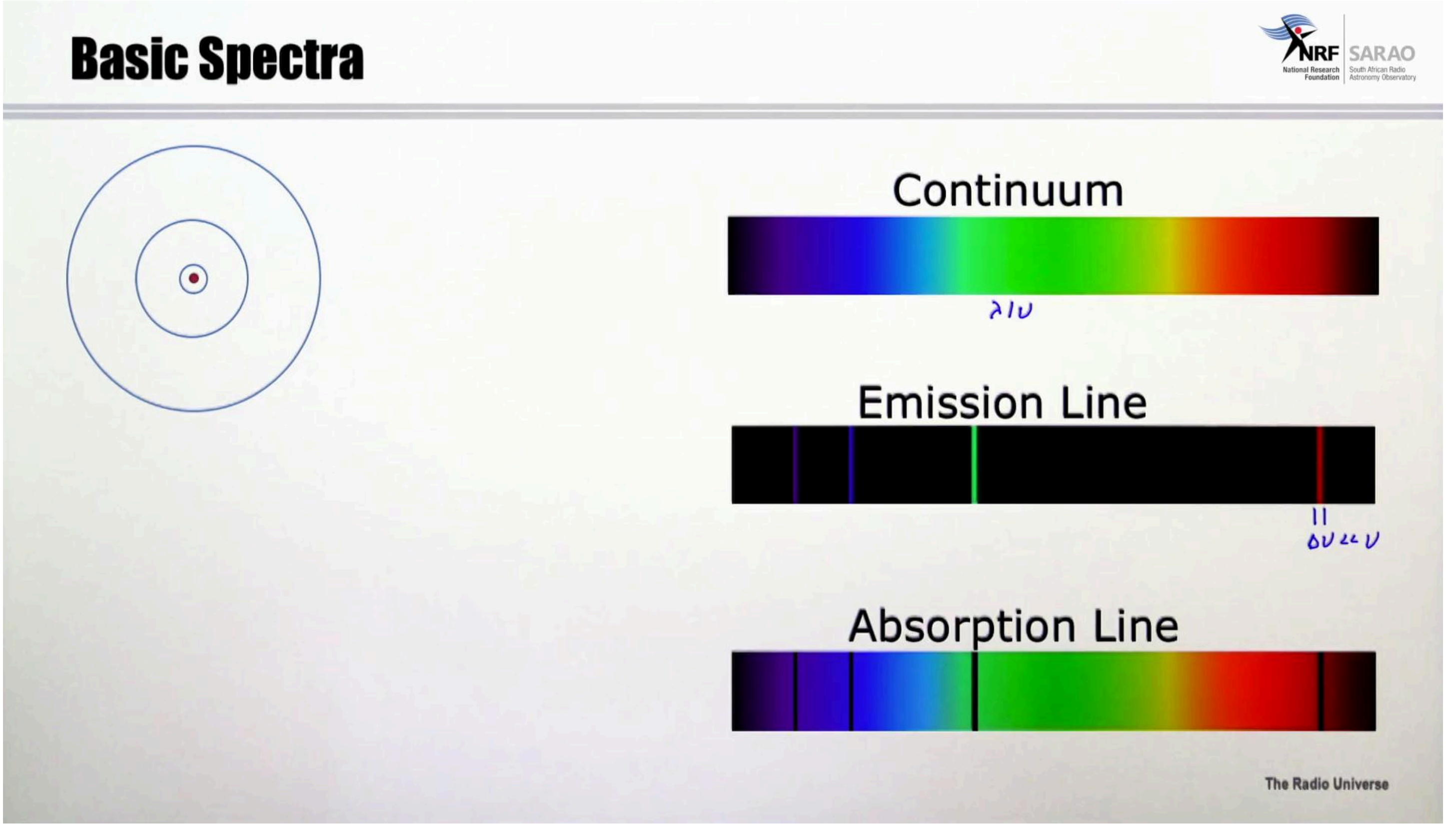
You have already learned that photons are the messengers of the universe carrying information from distant stars and galaxies to arrive at our telescopes. As astronomers we cannot physically interact with the subjects we study. We cannot use a thermometer to measure the temperature of a star or scale to weigh the mass of a black hole. We are forced to deduce the information we desire indirectly by studying the light that these objects produce. Happily for us, photons provide a wealth of information about the objects they come from including things like their temperature, mass, chemical composition, magnetic field strength and velocity. It is also fortunate for us that all objects emit radiation of some kind and so are observable to us and available for study. Our goal is to turn observable quantities which we can measure from our images, for example, a flux density, into a correct diagnosis of the physical conditions in and around the object we're studying. To do this, we will need to have a detailed understanding of the processes which produce the light we see and how this light is affected by its journey to the universe on its way to our telescope. In the next few lectures, we will be focusing on understanding the main processes that give rise to emission at radio wavelengths.

Notes

Summary

0m 05s

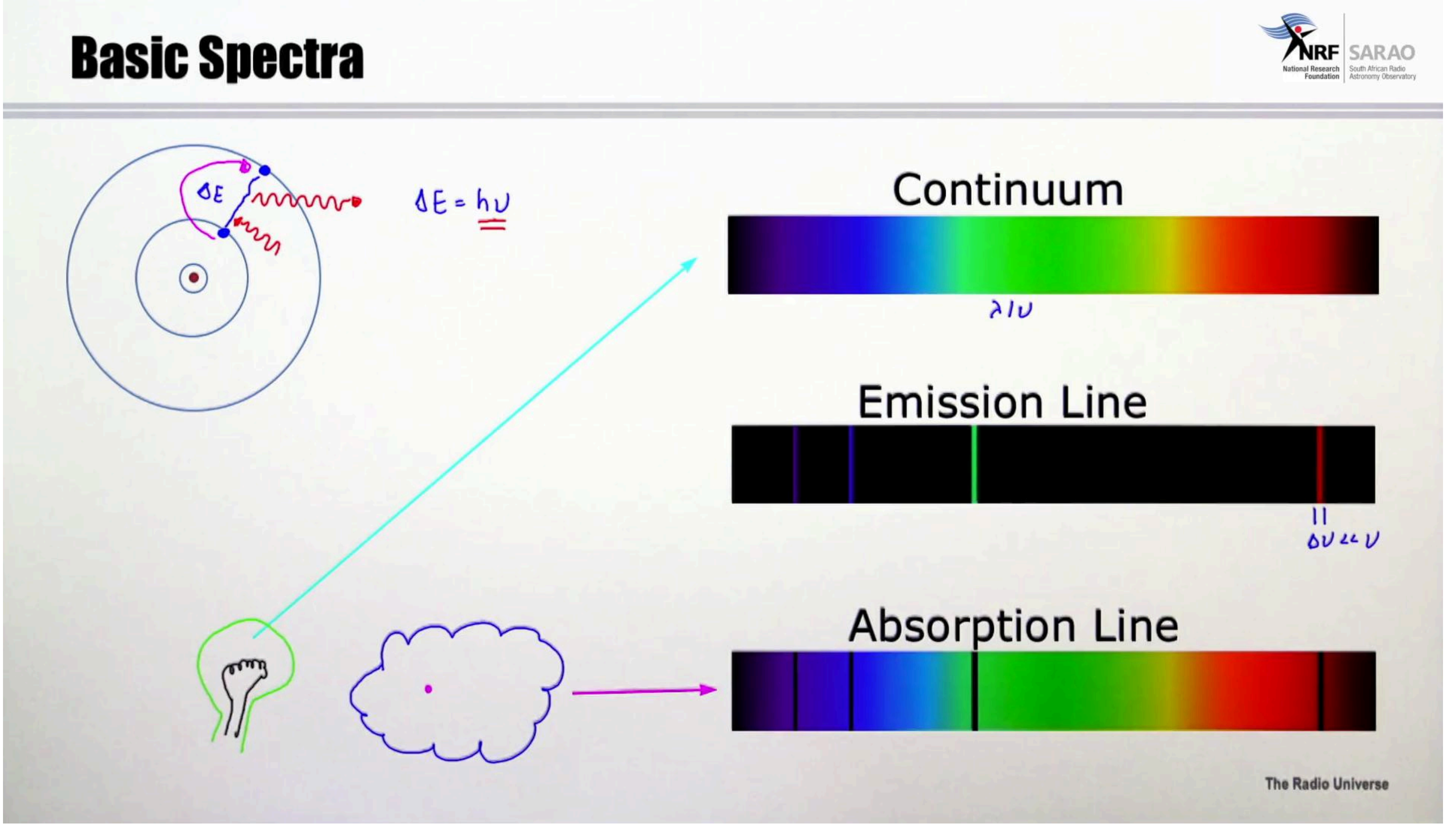


As astronomers we frequently want to examine how the intensity of light changes as a function of either wavelength or frequency. This kind of plot which shows the specific intensity versus wavelength or frequency is called a spectrum and you effectively have three kinds of spectra. You can have a continuum spectrum. This is where you have light at all wavelengths. You can have an emission line spectrum. This is where most of the spectrum doesn't have light but you have light in discrete very narrow regions of wavelength space so here the width of the line is typically very much less than the frequency of the line or you can have an absorption line spectrum which is where you have continuous emission but in very narrow discrete regions the light has been absorbed so the light's intensity is much lower in these narrow discrete regions. You'll notice here that the frequency of the emission line in this plot is the same as the frequency of the absorption line in this plot and that's because emission lines and absorption lines are generated by essentially inverse processes. An emission line is generated when an atom passes from a higher energy state to a lower energy state and the reverse for an absorption line.

Notes

Summary

1m 25s

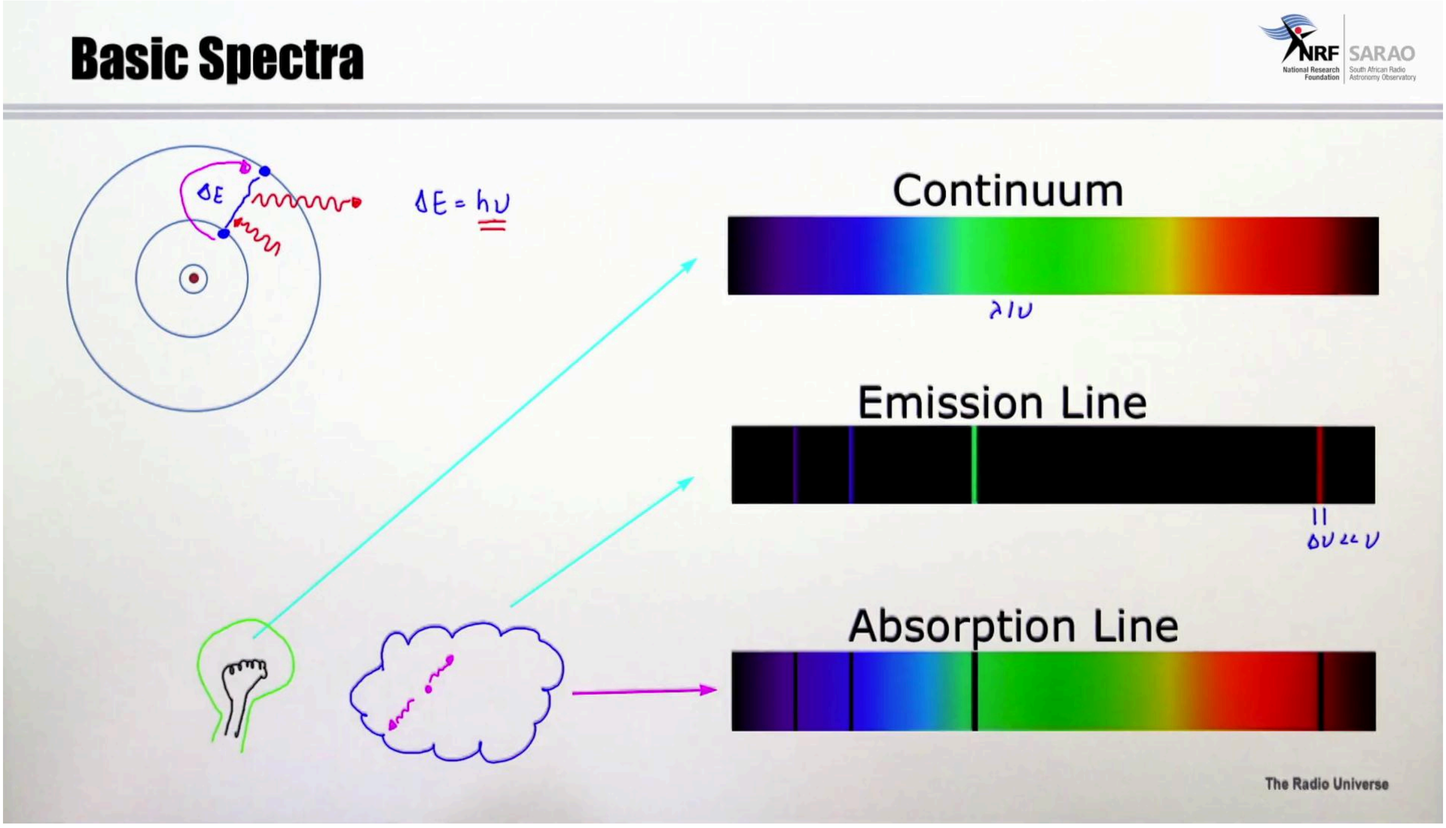


For example, if you had an electron that was orbiting a proton in a higher orbital level and it dropped to a lower orbital level, this change in energy would be seen as an emitted photon which would have a specific frequency which is related to the change in the energy levels here such that the change in energy is equal to ‘h’ times the frequency of the photon. Similarly for an emission line if you absorbed a photon which had exactly this frequency like this amount this frequency, then the electron would jump from a lower energy level to a higher energy level. A continuous spectrum is typically generated by a very hot dense medium. An example of this would be something like a light bulb filament that was glowing. So if you were to look directly at a hot dense medium what you would see would be a continuous spectrum. However, if you look at the same light bulb through a cooler dense gas then what you would see would be an absorption line spectrum and that's because in here atoms would have absorbed some of the energy at these specific frequencies and passed into a higher energy state. And so some of that emission within have been removed by those intervening particles giving you an absorption line spectrum.

Notes

Summary

2m 47s

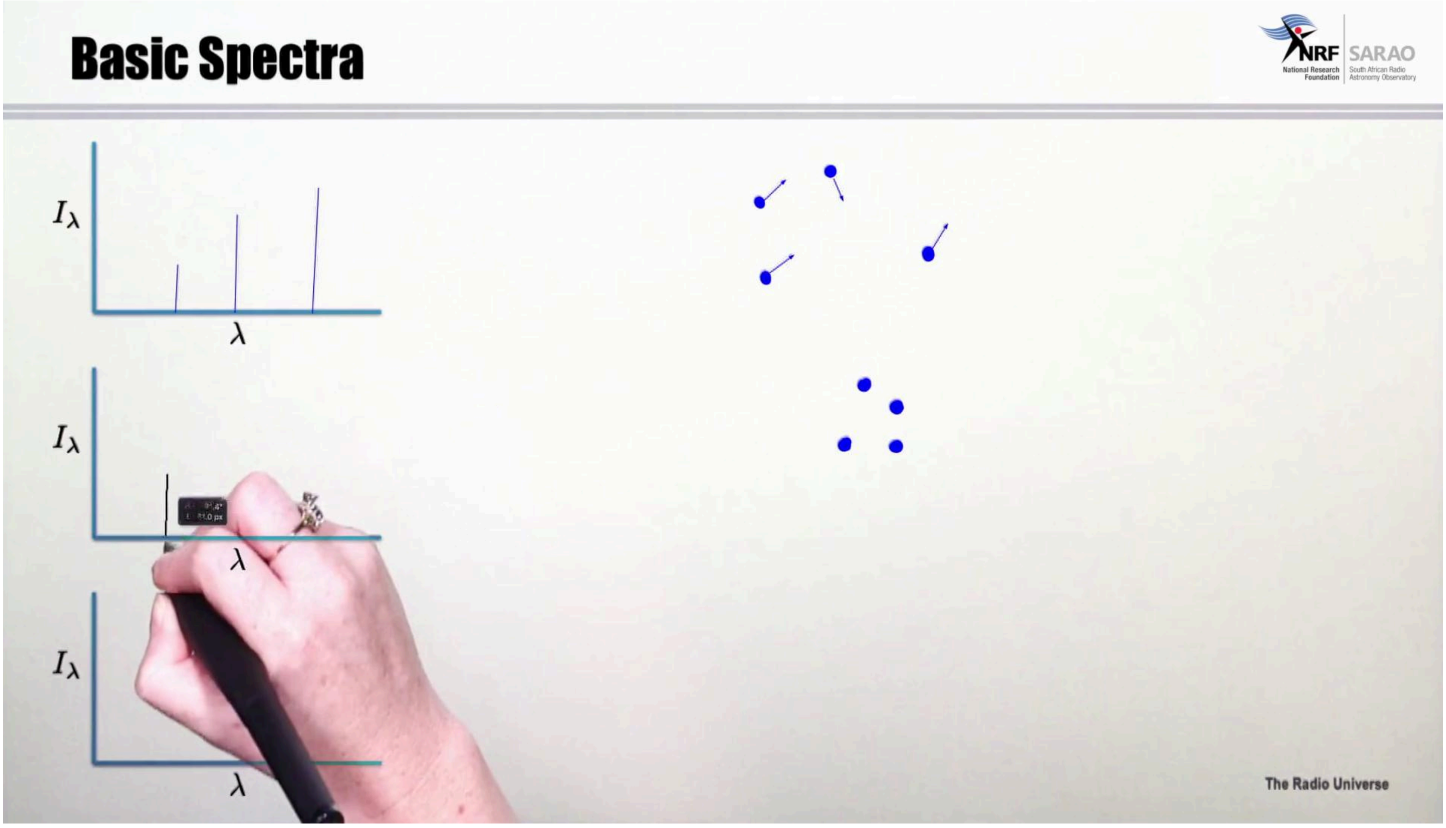


If you look at the same cloud but without the continuum background source then what you would see would be an emission line spectrum and that's because once these atoms have become excited by absorbing photons from the background continuum source they will become de-excited at some point and so emit photons isotropically so they'll emit them in all different directions and so if you look from an angle where you don't have a background source what you'll see is an emission line spectrum.

Notes

Summary

4m 31s

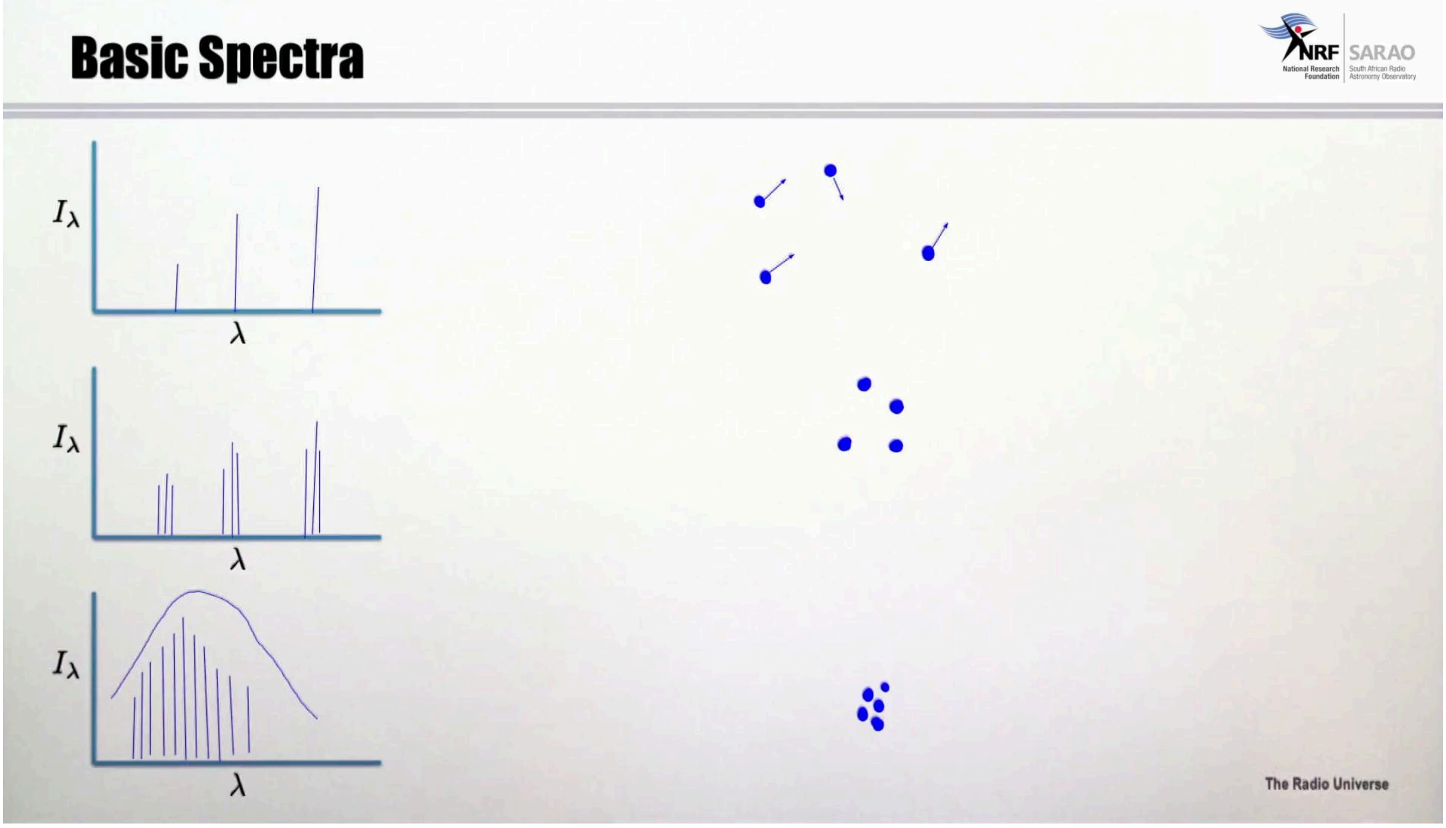


There is a relationship between the discrete emission line spectra that you see from diffuse sources and the continuous spectra that we see from very dense sources and you can think of it this by considering if you have a number of particles in a gas that are very diffuse and there that each have some velocity because they have a temperature associated with this gas. These particles are all moving around at some velocity and very occasionally they bump into each other and when they bump into each other they can collisionally excite themselves. They can be collisionally excited so that electrons pass to a higher energy level and as they spontaneously de-excite, you will get your characteristic emission lines. However, if you now put the same particles closer together what you'll find is that the atoms will distort at the energy levels of the nearby atoms so their electrostatic forces will distort the energy levels of nearby atoms and so when you have the same collisional excitement and de-excitement, the energy levels will not be exactly at the same discrete points that they were before and in fact, there will be split art into a number of narrow lines surrounding the main original lines.

Notes

Summary

5m 03s

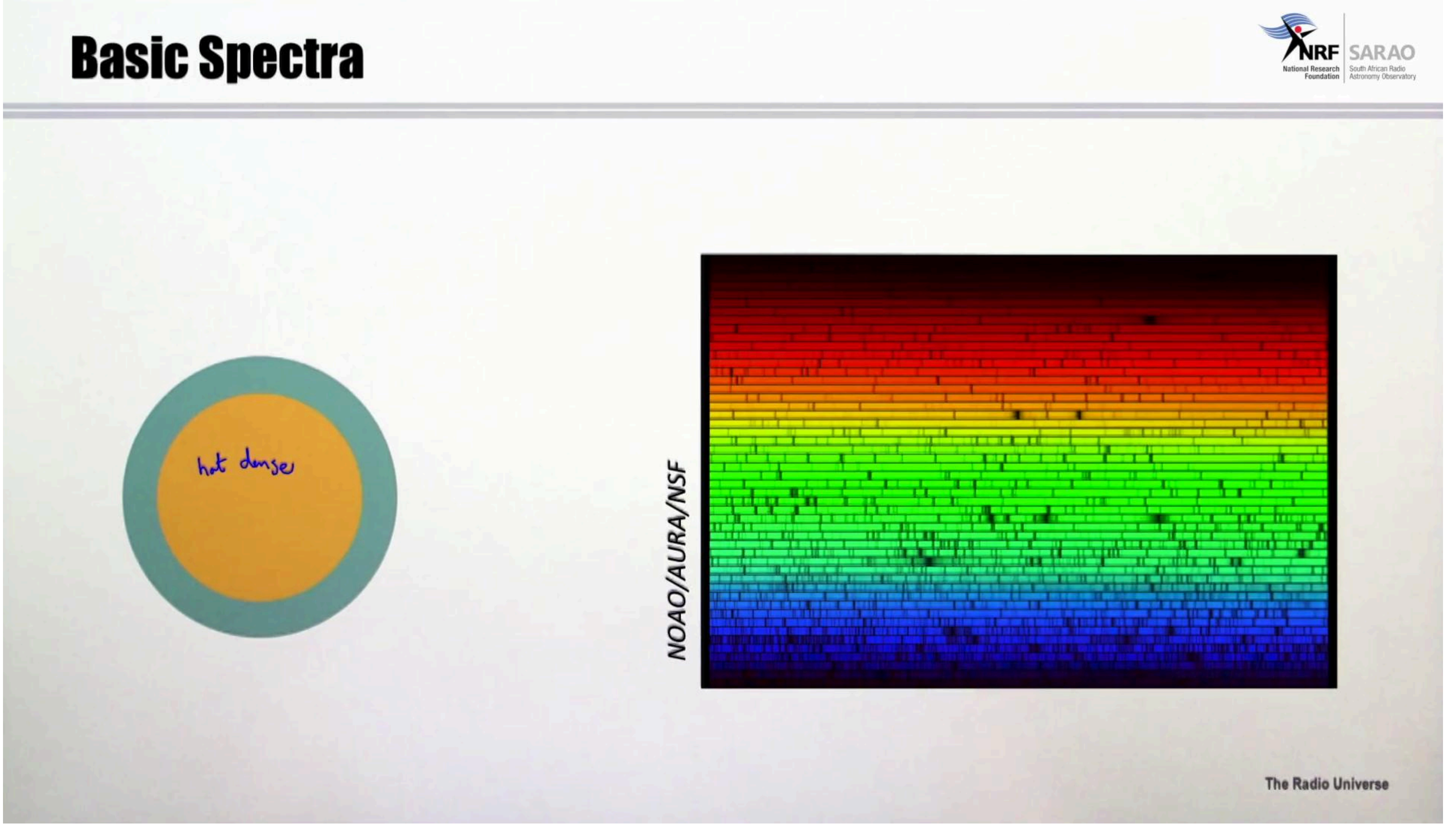


So instead of just having one line now as you pack them denser and denser, you start to get more and more lines. And so at the limit of this we pack them very very close together in a solid then you'll end up splitting the lines into mini mini narrow lines which will then eventually form a continuous spectrum.

Notes

Summary

6m 30s



A very famous example of an absorption line spectrum which is well known to many people is the absorption lines that we see in the spectrum of the Sun. Here we have essentially a hot dense object in the center which is the Sun but it is surrounded by a diffuse much cooler atmosphere which then produces these absorption lines that you see in the spectrum of the Sun, all these little dark patches.

Notes

Summary

7m 01s