# The lives of stars

- Now that we have seen how we can find out various properties of stars – mass, luminosity, distance, radius – we can start to talk about their lives.
- The lives of stars are extremely long – millions, billions or even trillions of years. So how can we understand them at all, when the whole of recorded human history is less than 1% of the life of even the shortest-lived star?
- Luckily, we have a huge sample to work with. There are 200 billion stars in our galaxy alone. With such a large number, all born at different times, all with different masses, we see stars at all stages of their lives.

# The lives of stars

- The most massive stars have the shortest lives. They are also the brightest. This makes it quite easy to work out where star formation is happening, or has recently happened – if you see hot, young bright stars, then they must have formed quite recently.
- A great example is the Pleiades – currently very clearly visible, high in the night sky at about 9pm.

# The lives of stars

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- What you find is that often, where you find hot, blue and therefore massive and young stars, you also find lots and lots of hydrogen gas – like in the Orion Nebula:

# The lives of stars

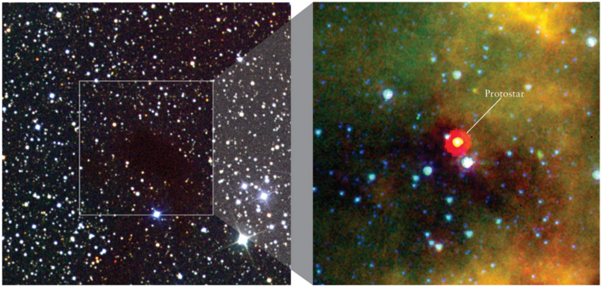
- These regions of hydrogen gas, in which stars are forming, are called **H II regions.** The name comes about because hydrogen gas can be either neutral (H I), or ionised (H II), and these regions are ionised, by the light from the stars forming within them.
- Looking more closely, we see that within the bright H II regions are dense, dark, cold clumps. These are called Bok globules.

# Interstellar extinction and reddening

- Interstellar space is not empty: some parts are obviously not empty, like the Orion Nebula. But star clusters always appear fainter than you would expect from their distance alone. Something, even in apparently empty interstellar space, is absorbing their light. This is called *interstellar extinction*.
- Not only are they fainter, but they are also redder – whatever is absorbing the light is absorbing more blue light than red light. This is interstellar *reddening*.
- Interstellar space is full of dust – small particles, which scatter more blue light than red light.

# Interstellar extinction and reddening

- Because the dust absorbs more blue light than red light, by observing the galaxy in red light you can see further through the dust clouds. You can see even further by observing infrared light.
- When we look at the dense dark clouds within H II regions in infrared light, we see that they have stars within them.




(a) A dark nebula

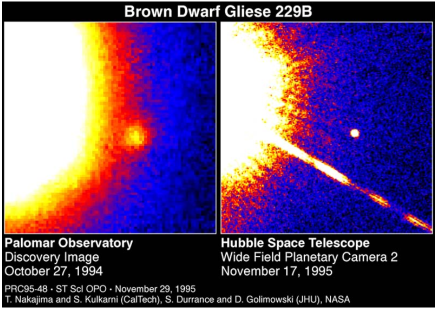
(b) A hidden protostar within the dark nebula

# Star formation

- We understand star formation as starting with a large cold cloud of gas and dust in interstellar space. If it is massive enough (and they can have masses of millions of Solar masses), it can begin to collapse.
- As it collapses, it will fragment into smaller and smaller packets of gas and dust – star masses are limited because a really massive cloud collapsing would heat up enough for the radiation pressure to exceed the force of gravity, stopping the collapse.
- When a star-sized packet of gas and dust has formed, it will collapse into a recognisable body – a protostar. As the cloud collapses, it heats up, and eventually begins to shine. At the moment, its luminosity is powered only by its contraction.

# Star formation

- If the cloud has a mass of more than about 150 solar masses, it will prevent its own collapse. If it has a mass of less than 0.08 solar masses, nothing else will happen – it will contract and cool over billions of years, shining extremely faintly. It will be a brown dwarf.

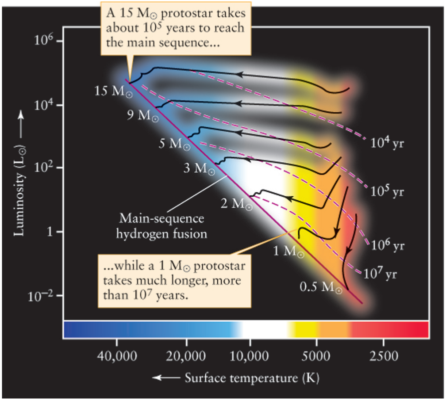


# Star formation

- If its mass is between these values, then as it contracts, eventually its core will reach a critical temperature of about 3,000,000 K. This is hot enough for nuclear fusion to begin, and the object will become a star.
- Its contraction stops, as energy starts to be produced at the centre, and it will evolve over a few thousand years from being large and quite cool to a smaller, hotter, main sequence star.

# Star formation

- The more massive a star, the more quickly it will reach the main sequence.



# Star formation

- Typically, hundreds or thousands of stars form in one go. The result is star clusters like the Pleiades.
- The hot luminous massive members of the cluster blow away the cloud of dust and gas from which they formed, and the cluster become visible at optical wavelengths.