Star Formation

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02.21.2018
For most of their lives, main-sequence stars “burn” _______, converting it into _______ via nuclear fusion.

A. Carbon, hydrogen
B. Hydrogen, helium
C. Oxygen, hydrogen
D. Helium, nitrogen

All stars begin their lives as protostars that are initially _______.

A. Much hotter
B. The same size
C. Smaller in size
D. Bigger in size
The Era of Reionization

About ~500 million years after the Big Bang, stars began to form for the first time, and universe ceased being dark in the optical (“visible”) wavelengths, since stars shine.

This event is called reionization. Why? The universe stopped being ionized after recombination, but now with the formation of stars ions return because a star is hot enough to ionize atoms of gas making up the universe.

The first stars were huge, and when they exploded at the ends of their lives, casting off their outer layers, they thus seeded the cosmos with the material necessary to make the next generation of (smaller) stars we know and love.

Also left behind supermassive black holes as galaxy cores.
Protostars

A gas cloud (mainly of hydrogen and helium) can become Jeans unstable, by being massive and/or large enough to collapse (symmetrically into sphere, with gravity), heating up as shrinking.

Collapse ceases when fusion ignited, pressure building up.

Protostars can come in different sizes. Bigger ones become bigger stars, and the bigger they are, the faster they fall (faster they burn out: living fast and dying young).

http://ircamera.as.arizona.edu/NatSci102/NatSci102/lectures/suninterior.htm
Dwarf Stars

Still-born stars are brown dwarfs. Not heavy/big enough to become stars. Just giant balls of gas, like planet Jupiter, except even more vast (couple of orders of magnitude)

Don’t collapse further because even without fusion gas certainly has an intrinsic pressure, can balance out gravity, especially if not much mass, producing not much force

On the other hand, red dwarfs are between brown dwarfs and our sun in mass. They are cool and burn hydrogen very slowly, living for billions / trillions of years in theory

Possibly most common star in the Milky Way, but faint

Out of H? Become blue dwarf stars, but universe still too young to have seen any. Eventually, blue->white->black
Nebular Nurseries

- Gigantic dusty clouds of gaseous atoms and molecules often many light years across within even larger nebulae (hundreds or thousands ly) constitute stellar nurseries.

- It takes thousands of years (cosmic blink of an eye).

- Radio, infrared, x-rays can penetrate the curtain of dust.

- Coldness of space actually aids in star formation (that is why the universe had to cool down before birth of stars, to $\sim 100$ degrees Kelvin, to prevent hot diffusion).

- Lack of heat means gravity can do its work, and not have gas pressure disperse the particles attracting each other.

Joke: [https://www.youtube.com/watch?v=K9vIK2_l22U](https://www.youtube.com/watch?v=K9vIK2_l22U)
NGC 604 in galaxy M33
Discussion Exercise: Planet Formation / Star Formation

How do stellar and planetary formation sound similar?

Do they start with the same/similar initial conditions?

Review: how are they inter-related, connected? Can you get one without the other, yes or no? Why or why not?
Star Clusters

▷ Stars automatically like to form in groups because they develop from immense clouds with enough material for many stars: the formal term for their bunches is cluster

▷ Young, loose, irregular clusters are called open (or, “galactic”) clusters, while old, dense, symmetric clusters are known as globular clusters, found everywhere

▷ Open clusters still have loose gas, while globular ones, with more stars, have used it all up (to make new stars)

▷ Not all stars observed in clusters. During gravitational collapse of gas and stars to form a cluster, through random motion some stars attain escape velocity, leave
Some globular clusters are failed galaxies, with black holes.

Jewel Box (open) cluster
On the main sequence, larger stars are _______ than/as smaller stars, in general.

A. The same temperature  
B. Colder  
C. Hotter  
D. Darker

With the exceptions of the red giants and supergiants, the larger stars are also _______.

A. Brighter  
B. Dimmer  
C. Faster-rotating  
D. Younger
Homework and Quotes

🔍 Next Quiz

🔍 Purpose of having one per class is to enhance learning, prevent cram

🔍 Clear who are not doing the reading: bi-modal distribution

🔍 Ask for help

"The world is full of obvious things which nobody by any chance ever observes."

Sherlock Holmes Quote
- The Hound of the Baskervilles
  Chapter 3: "The Problem"

'You see, but you do not observe. The distinction is clear.'

Sherlock Holmes Quote
- A Scandal in Bohemia

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