Star Clusters: Crash Course Astronomy #35

Crash Course: Astronomy
https://youtube.com/watch?v=an4rgJ3O21A
https://nerdfighteria.info/v/an4rgJ3O21A

===== Intro (0:00) =====

In the last episode, I talked about stars that are orbiting one another. When it's two stars, it's called a binary; three stars would be a trinary system, and so on. But what happens if you have ten stars? A thousand? A million? What do you call it when stars cluster together?

(Intro)

It's likely that some stars are born individually, but astronomers think that most stars are born in groups, called *clusters*, sometimes hundreds and sometimes hundreds of thousands at a time. There are two kinds of clusters: open (or galactic) clusters and globular clusters.

===== Open Clusters (0:44) =====

Open clusters are loosely bound collections of dozens or thousands of stars, usually in an irregular shape. Some are big enough and close enough to us that they can be seen by the naked eye, faint fuzzy patches in the sky. Galileo was the first to discover, or at least record, the fact that they were actually composed of many stars so close together our unaided eyes couldn't resolve them.

As we'll see in next week's episode, clusters are formed from gigantic clouds of gas and dust. Depending on local conditions, like how massive they are, these clouds can form dozens, hundreds, or thousands of dense clumps, which then contract to form individual stars.

These stars can be bound together by their mutual gravity, forming an open cluster. Unlike the Solar System where the Sun dominates and provides a singular central source of gravity holding the planets under its sway, in a cluster all the stars contribute to the overall gravity, so there's more general gravitational shear.

The stars all orbit the cluster's center of mass, even though there may not be anything at the very center. Not only that, but the stars don't all orbit in a flat plane like our planets do. Instead, their orbits are tilted in all different directions, more like the way long period comets are scattered around the Sun.

Typically an open cluster is a couple of dozen light years across, with stars much closer together than they are in interstellar space. The nearest known star to the Sun is over four light years away, while stars in an open cluster are typically a fraction of a light year apart.

Some clusters are very young, well in an astronomical sense. They're a few million years old. Others are far, far older: billions of years in age. How do we know? By looking at the stars themselves. Remember, hot blue massive stars don't live long before exploding. If a cluster has those kinds of stars it must be pretty youthful. If all it has are much lower mass red dwarfs, it must be much older, all the more massive stars having died off.

In fact, clusters are pretty useful this way. If you assume all the stars in them were born at the same time (a reasonable starting guess), then the age can be found by looking at the most massive stars still on the main sequence (still fusing hydrogen into helium like the Sun is).

The most massive stars can be identified by their spectra, which gives us their mass, and then that can be used to get the cluster's age. You might expect the distribution of cluster ages to be all over the place, with some young, some old, and some middle-aged. But in fact, most clusters are young, and very few are older than roughly 50 million years. That's because they evaporate.

All the stars in the cluster interact with each other via gravity. That means they constantly tug on one another, changing each others' orbits. You may remember from our episode about gravity that the kind of orbit an object has depends on the amount of energy it has. Give it more energy and the orbit gets bigger. Give it enough energy, and it will achieve escape velocity and fly away.

In clusters, the stars are always passing by each other and exchanging energy via their gravity. If a low mass star swings by a higher mass star, it can get a relatively big kick to its energy and get flung into a much higher orbit in the cluster, while the high mass star loses energy, dropping it down toward the center.

Over time, these interactions tend to flick the lower mass stars out of the cluster completely, and the cluster loses stars. It starts with the lowest mass stars, but as they leave, even higher mass stars can be lost this way. Eventually, only the most massive stars are left, and those tend to blow up. Even then, the remaining neutron stars and black holes interact and fling each other away. This process is aided by collisions with gas clouds and the tidal forces or the collected stars in the galaxy itself.

Given enough time, the cluster just disappears. The individual stars are left to orbit the galaxy on their own. About a thousand open clusters are known, but their days are numbered. Eventually, over millions of years, they'll go away, their stars scattered across tens of thousands of light years, merging with the population of other stars in space. So better observe 'em while you can.

===== The Pleiades (4:27) =====

One of the most famous and beautiful open clusters in the sky is the Pleiades about 500 light years from Earth. They appear as a small, tightly-packed collection of six or seven stars to the eye, and a lot of people call them "The Seven Sisters." Through binoculars, several dozen stars can be seen. Most of them look blue, but that's what we in the science business call a "selection effect" or "selection bias." The blue stars are the brightest, so we see them more easily. Through a telescope, redder stars are apparent.

Long exposures of the Pleiades reveal a surprise. The stars are embedded in a dust cloud, which glows blue from reflected and scattered starlight. When I was younger, it was thought that this was the leftover stuff from which the stars formed. But now we know it's a coincidence. By sheer happenstance the cluster is colliding with an unrelated cloud of dust. It's like driving a car through a dust cloud thrown up by a truck that went past you earlier.

By another coincidence, the Pleiades are located in the sky next to the Hyades, the only other cluster with stars resolvable by the naked eye. The Hyades are much closer and appear bigger. In fact, they form the distinctive V-shape of the horns of Taurus the bull.

As someone who enjoys taking out a telescope and observing the sky, I'm a fan of open clusters. A few are favorite targets whenever I'm outside. I love looking at the Pleiades with binoculars. And M35 at the foot of Gemini is another must-see for me in the winter through my telescope. But as much fun as they are to find, and as beautiful as they are to see, they can't hold a candle to globular clusters.

===== Globular Clusters (5:50) =====

These are clusters of not thousands, but hundreds of thousands of stars. They form a roughly spherical shape, hence the term "globular," and generally have a well-defined core with stars scattered around them in a halo that fades away with distance. Most globulars are bigger than open clusters, with diameters perhaps a hundred light years across. Though size is a bit hard to measure since they don't really have an edge. Like open clusters, the stars in them orbit every which way, like bees around a beehive.

Unlike open clusters, though, globulars are *old*. Very old. Most are over ten billion years old. We think they were among the first objects to form after the universe itself did. We know this because in most globulars, the most massive stars are less massive than the Sun. They've been around so long that even stars like the Sun have had enough time to become red giants and die. And that takes a long, long time.

The stars in globular clusters tend to have less heavy elements in them too, which you expect if they're old. Massive stars explode and scatter their heavy elements into the universe, and that takes time. It took billions of years for stars like the Sun to form, the ones with more heavy elements in them. Old stars formed before the universe was seeded with those elements, so they have more lighter elements in them than later-generation stars like the Sun.

Despite being larger than open clusters, globulars have more stars and are denser, which is one reason they live longer than open clusters. Another is that they tend to spend most of their lives outside the galaxy on long, looping orbits. And there's nothing out there to interfere with their solitary existence.

Globulars are great laboratories for stellar astrophysicists. All the stars in them are born at the same time, and so they're the same age. They're also the same distance from Earth, so if you see one star in a globular that's twice as bright as another, it really is twice as luminous. That's handy if you're comparing stars for other characteristics.

Because globulars are so old, they contain a lot of dead stars. We see quite a few white dwarfs as well as neutron stars and black holes in them. If they have stellar companions, they strip off their material, which falls in and emits x-rays. What normal stars are left are low mass red stars, so globulars tend to look red.

Weirdly, there are some blue stars in globulars, called blue stragglers, and they were a mystery at first since they shouldn't be there in such old objects. But astronomers figured out they're actually stars that have physically collided and merged to form a single, higher-mass star. Such collisions are extremely rare in space, but the stars are so tightly packed in globulars that collisions are more common.

We know of about 150 globular clusters orbiting the Milky Way galaxy, our own local collection of stars (that we'll dive into in more detail in an episode very soon) but other galaxy's have more, many hundreds or even thousands.

Globulars are among my very favorite objects to observe with a small telescope. They're bright, compact, and their fuzziness due to so many stars packed so closely together gives them an illusion of activity, again, like bees swarming a hive. They are incredibly beautiful. And that's the view from tens of thousands of light years away.

Imagine what the sky would look like from a planet orbiting a star inside the cluster. The sky would be filled with stars, some so close and luminous, there could be dozens brighter than Venus appears in our sky. At night you might be able to read by starlight.

Sadly though, this fantastic sight is probably more science fiction than science. Because globular stars lack heavy metals, it's unlikely they would've formed planets like Earth. And the stars are so closely packed, that nearby encounters might eject any planets that did form. Such a scene would be amazing, but unfortunately it's probably one that exists only in out imagination.

===== Recap (9:26) =====

Today you learned that open clusters contain hundreds or thousands of stars held together by gravity. They're young, and evaporate over time, their stars let loose to roam space freely. Globular clusters are larger, have hundreds of thousands of stars and are more spherical. They're very old, a significant fraction of the age of the universe itself, and that means their stars have less heavy elements in them, are redder, and probably don't have planets, though we're not really sure.

===== Credits (9:50) =====

Crash Course: Astronomy is produced in association with PBS Digital Studios. Head over to their YouTube channel to catch even more awesome videos. This episode was written by me, Phil Plait. The script was edited by Blake de Pastino and our consultant is Dr. Michelle Thaller. It was directed by Nicholas Jenkins, edited by Nicole Sweeney. The sound designer is Michael Aranda, and the graphics team is Thought Café.

(Crash Course outro)