Formation and evolution of the galaxy

4.2 Stellar species, age, and metallicity

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4.2.1 Stellar species

- Population I, Population II - A method of classifying stars. Stars with a high metal content are Population I, and those with a low metal content are Population II.
- O and B type stars In the Harvard classification, there are two types: O, B, A, F, G, K, and M, which correspond to different temperatures depending on the type and strength of the absorption spectrum, R, N, and S, which correspond to different chemical compositions.
- Open cluster: A cluster of stars that are relatively loosely gathered together, with tens to hundreds of stars. It is not dense. It is located in the spiral arm of the galactic disk and is made up of stars of Population I. O and B types are prominent.

4.2.1 Stellar species

- Slow-velocity stars: Stars that move relatively slowly compared to other stars in the Milky Way. They usually have orbits that are different from the direction of rotation of the galactic center or disk, and their speeds are often less than or close to 100 km/s.
- Spiral arms: A spiral structure found in spiral galaxies, where stars, gas, and dust gather and spread out in a spiral shape. The arms contain many young blue stars (OB-type stars), nebulae, and molecular clouds. Spiral arms are thought to be formed by "density waves" that compress material in the galactic disk.

4.2.1 Stellar species

- RR Lyrae variable stars: Stars whose brightness changes periodically. The brightness cycle is usually regular, about 0.2 to 1 day. Their spectral types are mainly A to F (hot, bluish-white stars).
- Globular cluster: A cluster of hundreds of thousands of stars densely packed together in an almost spherical shape. The density of stars increases sharply towards the center. There are many Population II stars.
- High-velocity stars: Stars moving at unusually high speeds within the Milky Way (several hundred km/s) and having orbits that are different from those of the galactic disk and center. Their speeds can exceed 300 km/s, and in some cases, even exceed 1000 km/s.

4.2.1 Stellar species

- Andromeda Galaxy M31: The largest galaxy closest to the Milky Way. It has a spiral structure and a diameter about twice that of the Milky Way. It has several small companion galaxies, including M32.
- Galactic halo: A spherical or elliptical region surrounding a galaxy, a thin structure that surrounds the galaxy's disk and central bulge. The density of matter is lower than that of the disk and bulge.
- Elliptical Galaxy M32: A compact elliptical galaxy with no spiral arms or star-forming regions. The central star density is very high.

4.2.1 Stellar species

- NGC205: One of the companion galaxies of M31, it is located in the same region as M31 and M32. Its mass is 4 billion solar masses, slightly heavier than M32.
- Cepheid: A type of pulsating variable star whose brightness changes periodically, it is a very important "standard light source" in astronomy. The period of brightness change is about 1 to 100 days, which is longer than that of RR Lyrae variables.
- Open cluster: A group of stars that were born at roughly the same time from the same molecular cloud within the galaxy and are loosely bound together by gravity.

4.2.2 Stellar ages

- Hyades: An open star cluster in the constellation Taurus, containing 400 to 500 stars. Most of the stars are young, primarily of Population I, and are visible to the naked eye.
- Isochrones: Calculating isochrones is the process of simulating stellar evolution and plotting the luminosity and temperature of a star at a specific age on an HR diagram.

4.2.2 Stellar ages

- Moving cluster: A group of stars whose apparent motion vectors on the celestial sphere are nearly identical. Most of them are open clusters.
- Convergence point method: A method for determining the distance of newborn open clusters, called moving clusters, from their proper motion and tangential velocity
- Annual parallax: The phenomenon in which the position of a celestial object appears to change on the celestial sphere due to the Earth's revolution, and its magnitude.
- Distance index: The difference between apparent magnitude and absolute magnitude. Units are magnitudes.

4.2.2 Age of stars

- Red Giant Branch: The red giant branch is a stage in stellar evolution where a star evolves into a cooler, more luminous region after leaving the main sequence. During this stage, the star stops fusion of hydrogen, changes its internal structure, and expands significantly to become a "red giant."
- Asymptotic Giant Branch: The asymptotic giant branch is a stage in the evolution of a star that occurs after the red giant branch and the horizontal branch. The outer layers expand, and the star becomes even larger and more luminous than in the red giant branch.

4.2.3 Stellar metallicity

- Spectroscopy: A technique for analyzing light by breaking it down into its wavelengths (or frequencies). It is widely used in astronomy to study the properties of celestial bodies such as stars, galaxies, and planets.
- Big Bang Nucleosynthesis: Big Bang Nucleosynthesis is the process by which light elements were produced through nuclear reactions that occurred immediately after the birth of the universe.
- Nuclear fusion reaction: Nuclear fusion reaction occurs when light atomic nuclei join together to form heavy atomic nuclei, releasing a great deal of energy. This is why the sun and stars shine.