

# The Physics of Stars

by A. C. Phillips

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## Summary:

The Physics of Stars, written by A. C. Phillips, is a comprehensive guide to the physical properties of stars. It covers topics such as stellar structure, stellar evolution, and stellar atmospheres. The book begins with an introduction to the basic principles of stellar physics, including the equations of state, the equations of motion, and the equations of radiative transfer. It then moves on to discuss the structure of stars, including their internal structure, their atmospheres, and their evolution. The book also covers topics such as stellar nucleosynthesis, stellar winds, and stellar explosions.

The book then moves on to discuss the physical properties of stars, including their luminosity, temperature, and composition. It also covers topics such as stellar spectra, stellar rotation, and stellar magnetic fields. The book then moves on to discuss the evolution of stars, including their formation, their evolution through the main sequence, and their eventual death. It also covers topics such as stellar remnants, stellar populations, and stellar clusters. Finally, the book discusses the observational properties of stars, including their spectra, their variability, and their variability in time.

The Physics of Stars is an excellent resource for anyone interested in learning about the physical properties of stars. It provides a comprehensive overview of the subject, and is written in an accessible and engaging style. It is an invaluable resource for students and professionals alike.

## Main ideas:

**#1. *Stellar Evolution: Stars are born, live, and die in a process known as stellar evolution. This process is driven by the balance between gravity and pressure, which determines the structure and evolution of stars.***

Stellar evolution is the process by which stars are born, live, and die. It is driven by the balance between gravity and pressure, which determines the structure and evolution of stars. As stars form, gravity pulls the material together, while pressure from the heat generated by the contraction of the material pushes outward. This balance between gravity and pressure is known as hydrostatic equilibrium. As the star continues to contract, the temperature and pressure in the core increase, allowing nuclear fusion to begin. This process releases energy, which is radiated away from the star, and the star begins to shine.

As the star continues to evolve, the balance between gravity and pressure changes. The core of the star contracts, while the outer layers expand. This causes the star to become brighter and hotter, and it begins to move along the main sequence of the Hertzsprung-Russell diagram. As the star continues to evolve, it will eventually exhaust its nuclear fuel and begin to cool and expand. This is known as the red giant phase, and it marks the end of the stars life. Eventually, the star will collapse and form a white dwarf, neutron star, or black hole, depending on its mass.

Stellar evolution is a complex process, and it is still not fully understood. However, it is clear that it is an essential part of the life cycle of stars, and it is responsible for the diversity of stars that we observe in the universe today.

**#2. *Nuclear Fusion: Nuclear fusion is the process by which stars convert hydrogen into helium, releasing energy in the process. This energy is what powers stars and is responsible for their luminosity.***

Nuclear fusion is a process that occurs in stars, where hydrogen atoms are combined to form helium atoms. This process releases a tremendous amount of energy, which is what powers stars and is responsible for their luminosity. The process of nuclear fusion is initiated by the high temperatures and pressures found in the cores of stars. At these

temperatures and pressures, the nuclei of hydrogen atoms can overcome their mutual repulsion and fuse together to form helium nuclei. This process releases energy in the form of gamma rays, which is then radiated away from the star.

The process of nuclear fusion is a complex one, and it is not yet fully understood. However, scientists have been able to replicate the process in laboratories, and have been able to use it to generate electricity. This process is known as nuclear fusion power, and it is seen as a potential source of clean, renewable energy. Nuclear fusion power plants are currently being developed, and it is hoped that they will be able to provide a reliable source of energy in the future.

**#3. *Stellar Mass: The mass of a star determines its evolution, with more massive stars evolving faster than less massive stars. This is because more massive stars have higher temperatures and densities, which leads to faster nuclear fusion.***

Stellar mass is an important factor in determining the evolution of a star. More massive stars have higher temperatures and densities, which leads to faster nuclear fusion. This means that more massive stars evolve faster than less massive stars. As a star evolves, it changes in size, luminosity, and temperature, and eventually dies. The mass of a star also determines its lifetime, with more massive stars having shorter lifetimes than less massive stars.

The mass of a star also affects its luminosity. More massive stars have higher luminosities than less massive stars, and this is due to the higher temperatures and densities that they possess. This means that more massive stars are brighter than less massive stars. The mass of a star also affects its color, with more massive stars being bluer than less massive stars.

The mass of a star also affects its composition. More massive stars have higher abundances of heavier elements than less massive stars. This is because more massive stars have higher temperatures and densities, which leads to faster nuclear fusion. This means that more massive stars have higher abundances of elements such as carbon, nitrogen, and oxygen than less massive stars.

In summary, the mass of a star is an important factor in determining its evolution, luminosity, color, and composition. More massive stars have higher temperatures and densities, which leads to faster nuclear fusion and shorter lifetimes. They also have higher luminosities, bluer colors, and higher abundances of heavier elements than less massive stars.

**#4. *Stellar Structure: Stars have a layered structure, with the core being the hottest and densest region. The outer layers are cooler and less dense, and are responsible for the star's luminosity.***

The core of a star is the hottest and densest region, and is composed of a plasma of hydrogen and helium. This plasma is held together by the strong nuclear force, and is responsible for the star's energy production. The core is surrounded by a radiative zone, where energy is transported outward by radiation. This is followed by a convective zone, where energy is transported outward by convection. Finally, the outermost layer is the photosphere, which is the visible surface of the star. This is where the star's light is emitted.

The structure of a star is determined by its mass and composition. More massive stars have larger cores and radiative zones, while less massive stars have smaller cores and radiative zones. The composition of the star also affects its structure, with stars composed of heavier elements having larger cores and radiative zones. The structure of a star also changes over time, as the star ages and its core contracts and heats up.

The structure of a star is an important factor in determining its evolution. The core of a star is responsible for its energy production, and the outer layers are responsible for its luminosity. As a star ages, its structure changes, and this affects its evolution. Understanding the structure of a star is essential for understanding its evolution and its role in the universe.

**#5. *Stellar Atmospheres: Stars have atmospheres that are composed of gas and dust. These atmospheres are responsible for the star's color and can be used to study the star's composition and evolution.***

Stellar atmospheres are composed of gas and dust, and are responsible for the stars colors. By studying the composition and evolution of stellar atmospheres, we can gain insight into the stars themselves. The composition of a stars atmosphere is determined by the elements present in the star, and the temperature and pressure of the stars environment. The temperature and pressure of the stars environment can be determined by measuring the stars luminosity and its distance from Earth.

The composition of a stars atmosphere can be studied by analyzing the light that is emitted from the star. By studying the spectrum of the stars light, astronomers can determine the elements present in the stars atmosphere. This information can be used to determine the stars age, mass, and other properties. Additionally, the composition of a stars atmosphere can be used to study the stars evolution. By studying the composition of a stars atmosphere over time, astronomers can gain insight into how the star has changed over its lifetime.

The study of stellar atmospheres is an important part of astronomy, as it provides insight into the stars themselves. By studying the composition and evolution of stellar atmospheres, astronomers can gain a better understanding of the stars and their evolution. Additionally, the study of stellar atmospheres can provide insight into the formation and evolution of galaxies and the universe as a whole.

**#6. *Stellar Spectra: Stars emit light in a range of wavelengths, which can be used to study the star's composition and temperature. This is known as stellar spectroscopy.***

Stellar spectra are a powerful tool for studying stars. By analyzing the light emitted by a star, astronomers can determine its composition, temperature, and other properties. This is done by breaking the light up into its component wavelengths, or colors, and measuring the intensity of each wavelength. This is known as stellar spectroscopy.

The spectrum of a star is composed of a series of bright and dark lines, which are caused by the absorption and emission of light by the atoms in the stars atmosphere. By studying the pattern of lines in a stars spectrum, astronomers can determine the elements present in the stars atmosphere, as well as its temperature and other properties.

Stellar spectra can also be used to measure the speed of a star. By measuring the Doppler shift of the spectral lines, astronomers can determine the radial velocity of a star, which can be used to measure its motion through space.

Stellar spectra are an invaluable tool for studying stars, and have been used to make many important discoveries about the nature of stars and the universe. By studying the spectra of stars, astronomers can learn about the composition, temperature, and motion of stars, as well as their evolution over time.

**#7. *Stellar Magnitude: The brightness of a star is measured in terms of its magnitude. This is used to compare the brightness of stars and can be used to measure distances in space.***

Stellar magnitude is a measure of the brightness of a star. It is used to compare the brightness of stars and can be used to measure distances in space. Magnitude is measured on a logarithmic scale, with brighter stars having a lower magnitude and dimmer stars having a higher magnitude. The brightest stars have a magnitude of -1, while the faintest stars visible to the naked eye have a magnitude of 6. The magnitude scale is divided into six categories, with the brightest stars being classified as first magnitude and the faintest stars being classified as sixth magnitude.

The magnitude scale is based on the apparent brightness of stars as seen from Earth. This means that the magnitude of a star can change depending on its distance from Earth. A star that is closer to Earth will appear brighter than a star that is farther away, even if they have the same intrinsic brightness. This means that the magnitude of a star can be used to measure its distance from Earth.

The magnitude scale is also used to measure the brightness of other celestial objects, such as galaxies and nebulae. In this case, the magnitude is measured in terms of the total amount of light emitted by the object. This is known as the

absolute magnitude. The absolute magnitude of a star is usually much brighter than its apparent magnitude, since it takes into account the distance of the star from Earth.

The magnitude scale is an important tool for astronomers, as it allows them to compare the brightness of stars and other celestial objects. It also allows them to measure distances in space, which is essential for understanding the structure of the universe.

**#8. *Stellar Clusters: Stars can form in clusters, which are groups of stars that are bound together by gravity. These clusters can be used to study the formation and evolution of stars.***

Stellar clusters are an important tool for understanding the formation and evolution of stars. These clusters are groups of stars that are bound together by gravity, and they can provide valuable insight into the processes that shape stars. By studying the properties of stars in a cluster, such as their masses, ages, and chemical compositions, astronomers can gain a better understanding of how stars form and evolve. Stellar clusters can also be used to study the dynamics of star formation, such as the effects of stellar winds and supernovae on the surrounding interstellar medium. Additionally, stellar clusters can be used to study the evolution of galaxies, as they provide a snapshot of the star formation history of a particular region of space.

The study of stellar clusters is also important for understanding the structure and evolution of galaxies. By studying the properties of stars in a cluster, astronomers can gain insight into the formation and evolution of galaxies. For example, by studying the ages of stars in a cluster, astronomers can determine the age of the cluster and the age of the galaxy in which it resides. Additionally, by studying the chemical compositions of stars in a cluster, astronomers can gain insight into the chemical evolution of the galaxy. Finally, by studying the dynamics of stars in a cluster, astronomers can gain insight into the structure and evolution of the galaxy.

**#9. *Binary Stars: Binary stars are two stars that orbit each other. These systems can be used to study the evolution of stars and can provide insight into the formation of planets.***

Binary stars are two stars that orbit each other, and they are of great interest to astronomers. By studying binary stars, we can gain insight into the evolution of stars and the formation of planets. Binary stars can be classified into two main types: detached binaries and contact binaries. Detached binaries are two stars that orbit each other at a distance, while contact binaries are two stars that are so close that they share a common atmosphere.

The study of binary stars can provide us with valuable information about the evolution of stars. By studying the orbital parameters of binary stars, we can learn about the masses of the stars, their luminosities, and their temperatures. We can also learn about the age of the stars and the composition of their atmospheres. Additionally, by studying the orbital parameters of binary stars, we can gain insight into the formation of planets.

Binary stars can also be used to study the evolution of stars. By studying the orbital parameters of binary stars, we can learn about the evolution of the stars over time. We can also learn about the effects of stellar winds and other phenomena on the evolution of stars. Additionally, by studying the orbital parameters of binary stars, we can gain insight into the formation of planets.

Binary stars are an important part of astronomy, and they can provide us with valuable information about the evolution of stars and the formation of planets. By studying the orbital parameters of binary stars, we can gain insight into the evolution of stars and the formation of planets.

**#10. *Stellar Winds: Stars emit a stream of particles known as a stellar wind. This wind can be used to study the composition of stars and can be used to measure the star's mass.***

Stellar winds are a powerful force in the universe, and they can tell us a great deal about the stars they originate from. Stellar winds are composed of particles such as protons, electrons, and ions, and they are emitted from the surface of

stars. The composition of the stellar wind can tell us about the composition of the star itself, and the strength of the stellar wind can be used to measure the stars mass. Stellar winds can also be used to study the evolution of stars, as they can provide clues about the stars age and the rate at which it is losing mass. By studying the stellar winds of stars, we can gain a better understanding of the stars themselves and the universe in which they exist.

The study of stellar winds is an important part of astrophysics, and it has been used to gain insight into the structure and evolution of stars. By studying the composition of the stellar wind, we can learn about the composition of the star itself, and by studying the strength of the stellar wind, we can measure the stars mass. By studying the rate at which the stellar wind is emitted, we can gain insight into the stars age and the rate at which it is losing mass. By studying the stellar winds of stars, we can gain a better understanding of the stars themselves and the universe in which they exist.

**#11. *Stellar Activity: Stars can exhibit activity, such as flares and coronal mass ejections. These activities can be used to study the star's magnetic field and can provide insight into the star's evolution.***

Stellar activity is a phenomenon that occurs in stars and can be used to study the stars magnetic field. Flares and coronal mass ejections are two of the most common types of stellar activity. Flares are sudden, intense bursts of radiation that are released from the stars surface. They are usually caused by the stars magnetic field becoming unstable and releasing energy. Coronal mass ejections are large clouds of plasma that are ejected from the stars surface. They are usually caused by the stars magnetic field becoming twisted and releasing energy.

Studying stellar activity can provide insight into the stars evolution. By studying the flares and coronal mass ejections, astronomers can learn about the stars magnetic field and how it changes over time. This can help them understand how the star is evolving and how it will continue to evolve in the future. Additionally, studying stellar activity can help astronomers understand how stars interact with their environment and how they affect the interstellar medium.

Overall, stellar activity is an important phenomenon that can be used to study stars and their evolution. By studying the flares and coronal mass ejections, astronomers can gain insight into the stars magnetic field and how it changes over time. This can help them understand how the star is evolving and how it will continue to evolve in the future.

**#12. *Stellar Remnants: When a star dies, it leaves behind a remnant, such as a white dwarf, neutron star, or black hole. These remnants can be used to study the evolution of stars and the formation of galaxies.***

Stellar remnants are the remains of stars that have reached the end of their life cycles. These remnants can be used to study the evolution of stars and the formation of galaxies. When a star dies, it leaves behind a remnant, such as a white dwarf, neutron star, or black hole. White dwarfs are the most common type of stellar remnant, and are composed of the core of a star that has exhausted its nuclear fuel. Neutron stars are the densest type of stellar remnant, and are formed when a massive star collapses under its own gravity. Black holes are the most extreme type of stellar remnant, and are formed when a massive star collapses in on itself, creating a region of space-time from which nothing, not even light, can escape.

Studying stellar remnants can provide insight into the life cycles of stars and the formation of galaxies. By studying the composition of stellar remnants, astronomers can learn about the processes that occur during a stars life cycle, such as nuclear fusion and the formation of elements. By studying the distribution of stellar remnants in the universe, astronomers can learn about the formation and evolution of galaxies. Stellar remnants can also be used to study the effects of gravity on the structure of the universe, as well as the effects of dark matter and dark energy.

The study of stellar remnants is an important part of astronomy, and can provide valuable insight into the evolution of stars and the formation of galaxies. By studying the composition and distribution of stellar remnants, astronomers can gain a better understanding of the life cycles of stars and the formation of galaxies.

**#13. *Stellar Evolution Models: Models of stellar evolution are used to study the evolution of stars. These***

***models can be used to predict the future evolution of stars and can provide insight into the formation of galaxies.***

Stellar evolution models are used to study the evolution of stars over time. These models are based on the physical laws of nature, such as the laws of thermodynamics, and take into account the various processes that affect a stars evolution, such as nuclear fusion, mass loss, and stellar winds. By using these models, astronomers can predict the future evolution of stars and gain insight into the formation of galaxies.

The models are based on the assumption that stars form from a cloud of gas and dust, and that the stars evolution is determined by the balance between the energy generated by nuclear fusion and the energy lost through radiation. As the star ages, its internal structure changes, and the stars luminosity, temperature, and other properties change as well. By studying the evolution of stars, astronomers can learn about the formation and evolution of galaxies, and gain insight into the structure and evolution of the universe.

Stellar evolution models are also used to study the evolution of stars in binary systems, where two stars orbit each other. By studying the evolution of binary stars, astronomers can learn about the formation and evolution of binary star systems, and gain insight into the structure and evolution of the universe.

Stellar evolution models are an important tool for astronomers, as they provide insight into the formation and evolution of stars and galaxies. By studying the evolution of stars, astronomers can gain a better understanding of the universe and its structure.

***#14. Stellar Populations: Stars can be grouped into populations, which are groups of stars that have similar properties. These populations can be used to study the formation and evolution of stars.***

Stellar populations are groups of stars that share similar properties, such as age, composition, and motion. By studying these populations, astronomers can gain insight into the formation and evolution of stars. Stellar populations can be divided into two main categories: Population I and Population II. Population I stars are younger, hotter, and more metal-rich than Population II stars. Population I stars are found in the spiral arms of galaxies, while Population II stars are found in the galactic halo and bulge. By studying the properties of these two populations, astronomers can learn about the formation and evolution of galaxies.

In addition to these two main populations, there are also intermediate populations, which are stars that have properties that are intermediate between Population I and Population II stars. These intermediate populations can provide insight into the formation of stars in different environments. By studying the properties of these populations, astronomers can learn about the formation and evolution of stars in different regions of the galaxy.

Stellar populations can also be used to study the evolution of stars over time. By studying the properties of stars in different populations, astronomers can learn about how stars evolve over time. This can provide insight into the formation and evolution of galaxies, as well as the evolution of the universe as a whole.

***#15. Stellar Interactions: Stars can interact with each other, such as through collisions or gravitational interactions. These interactions can be used to study the evolution of stars and the formation of galaxies.***

Stellar interactions are an important part of the study of stars and galaxies. When two stars interact, they can either collide or be gravitationally bound to each other. Collisions between stars can result in the formation of new stars, while gravitational interactions can cause stars to move closer together or farther apart. These interactions can also affect the evolution of stars, as they can cause stars to spin faster or slower, or even to merge together.

Gravitational interactions between stars can also be used to study the formation of galaxies. When stars interact gravitationally, they can form clusters or even entire galaxies. These interactions can also affect the distribution of matter in galaxies, as stars can move around and interact with each other, resulting in the formation of new stars and the



redistribution of matter.

The study of stellar interactions is an important part of understanding the evolution of stars and galaxies. By studying the interactions between stars, we can gain insight into the formation and evolution of galaxies, as well as the structure and dynamics of stars.

**#16. *Stellar Nucleosynthesis: Stars produce elements through a process known as nucleosynthesis. This process is responsible for the formation of the elements in the universe and can be used to study the evolution of stars.***

Stellar nucleosynthesis is the process by which stars produce elements from the simplest of atoms, hydrogen and helium. This process occurs in the core of stars, where temperatures and pressures are high enough to cause nuclear reactions. These reactions involve the fusion of lighter elements into heavier ones, releasing energy in the process. This energy is what powers stars, and is responsible for the production of the elements in the universe.

The process of stellar nucleosynthesis is complex and involves a variety of different reactions. These reactions are driven by the temperature and pressure in the core of the star, and the rate of these reactions is determined by the mass of the star. As the star evolves, the temperature and pressure in the core increase, allowing for more complex reactions to take place. This leads to the production of heavier elements, such as carbon, oxygen, and iron.

The study of stellar nucleosynthesis is important for understanding the evolution of stars and the formation of the elements in the universe. By studying the reactions that take place in the core of stars, we can gain insight into the history of the universe and the formation of the elements that make up our world.

**#17. *Stellar Mass Loss: Stars can lose mass through a variety of processes, such as stellar winds and supernovae. This mass loss can be used to study the evolution of stars and the formation of galaxies.***

Stellar mass loss is an important process in the evolution of stars and the formation of galaxies. As stars age, they can lose mass through a variety of processes, such as stellar winds and supernovae. This mass loss can be used to study the evolution of stars and the formation of galaxies. Stellar winds are a type of mass loss that occurs when a star ejects material from its outer layers. This material is composed of gas and dust, and can be accelerated to high speeds by the stars radiation pressure. Supernovae are another type of mass loss that occurs when a star reaches the end of its life and explodes. This explosion can eject a large amount of material into space, including heavy elements such as iron and nickel.

The mass loss from stars can have a significant impact on the evolution of galaxies. As stars lose mass, they can become less luminous and can eventually fade away. This can lead to a decrease in the total amount of light emitted by a galaxy, which can affect its overall structure. Additionally, the material ejected by stars can be used to form new stars and planets, which can help to build up the population of a galaxy. Finally, the heavy elements produced by supernovae can be used to form new stars and planets, which can help to enrich the interstellar medium with elements necessary for life.

In summary, stellar mass loss is an important process in the evolution of stars and the formation of galaxies. By studying the mass loss from stars, we can gain insight into the formation and evolution of galaxies, as well as the formation of new stars and planets.

**#18. *Stellar Metallicity: Stars have a range of metallicities, which is the amount of elements heavier than hydrogen and helium. This can be used to study the evolution of stars and the formation of galaxies.***

Stellar metallicity is an important factor in understanding the evolution of stars and galaxies. It is the measure of the abundance of elements heavier than hydrogen and helium in a star. Metallicity is usually expressed as a fraction of the total mass of the star, with higher fractions indicating a higher abundance of heavier elements. This abundance is

determined by the stars formation history, as well as its age and environment.

The metallicity of a star can be used to study its evolution. Stars with higher metallicities tend to be older, as they have had more time to form heavier elements. This can be used to determine the age of a star, as well as its evolutionary history. Additionally, the metallicity of a star can be used to study the formation of galaxies. Stars with higher metallicities tend to be found in more metal-rich galaxies, indicating that the galaxy formed from material with a higher abundance of heavier elements.

The metallicity of a star can also be used to study its composition. Stars with higher metallicities tend to have higher abundances of elements such as carbon, nitrogen, and oxygen. This can be used to study the chemical composition of stars, as well as the formation of planets and other objects in the universe.

Overall, stellar metallicity is an important factor in understanding the evolution of stars and galaxies. It can be used to study the age of a star, the formation of galaxies, and the chemical composition of stars. By studying the metallicity of stars, we can gain a better understanding of the universe and its evolution.

**#19. *Stellar Dynamics: Stars can interact with each other through gravitational interactions, such as through the formation of binary stars or stellar clusters. This can be used to study the evolution of stars and the formation of galaxies.***

Stellar dynamics is the study of the motion of stars in a gravitational field. It is a branch of astrophysics that deals with the motion of stars in a gravitational field, and the effects of that motion on the structure and evolution of galaxies. Stellar dynamics can be used to study the formation and evolution of stars, the formation of galaxies, and the structure of the Milky Way. It can also be used to study the dynamics of stellar clusters, binary stars, and other stellar systems.

The motion of stars in a gravitational field is governed by Newton's laws of motion and gravity. These laws describe how stars interact with each other through gravitational forces, and how they move in response to those forces. By studying the motion of stars, we can learn about the structure and evolution of galaxies, and the formation of stars and stellar clusters. We can also use stellar dynamics to study the dynamics of binary stars, and other stellar systems.

Stellar dynamics can also be used to study the evolution of stars. By studying the motion of stars, we can learn about the formation of stars, the evolution of stellar clusters, and the structure of the Milky Way. We can also use stellar dynamics to study the dynamics of binary stars, and other stellar systems. By studying the motion of stars, we can gain insight into the structure and evolution of galaxies, and the formation of stars and stellar clusters.

**#20. *Stellar Evolution in Galaxies: Stars evolve differently in different galaxies, due to the different conditions in each galaxy. This can be used to study the evolution of stars and the formation of galaxies.***

Stellar evolution in galaxies is a complex process that is affected by a variety of factors. In general, the evolution of stars in a galaxy is determined by the age, mass, and composition of the stars, as well as the environment in which they are located. For example, stars in a younger, more active galaxy will evolve more quickly than those in an older, quiescent galaxy. Additionally, the composition of the interstellar medium, which is the material between stars, can affect the evolution of stars. For example, stars in a galaxy with a higher metallicity, or abundance of elements heavier than hydrogen and helium, will evolve more quickly than those in a galaxy with a lower metallicity.

The study of stellar evolution in galaxies can provide insight into the formation and evolution of galaxies. By studying the evolution of stars in different galaxies, astronomers can learn about the conditions in which galaxies form and evolve. Additionally, by studying the evolution of stars in different galaxies, astronomers can learn about the chemical evolution of galaxies, as well as the evolution of the interstellar medium. Finally, by studying the evolution of stars in different galaxies, astronomers can learn about the evolution of the universe as a whole.