

## Sirius – Assignment

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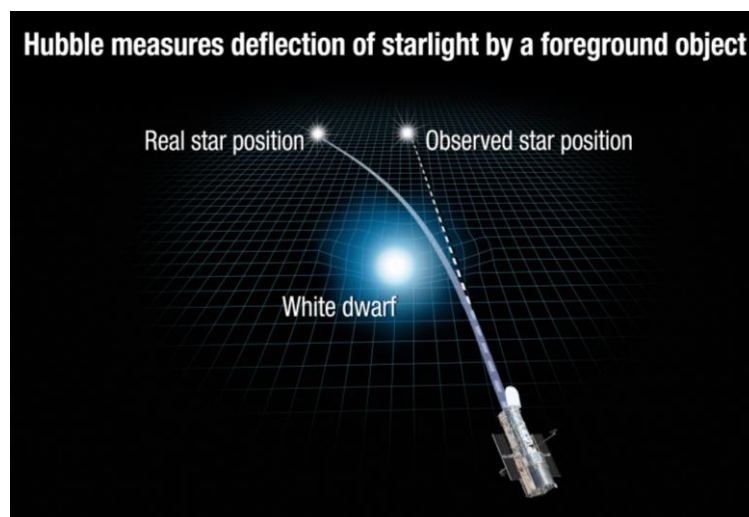
Sirius is the brightest star in the night sky. With a visual apparent magnitude of  $-1.46$ , Sirius is almost twice as bright as Canopus, the next brightest star. As the brightest star in the night sky, it appears in some of the earliest astronomical records.

The heliacal rising of a star is the first day when this star becomes visible again in the east in the light of dawn just before sunrise. The heliacal rising of Sirius is remarkably regular compared to other stars, with a period of almost exactly 365.25 days holding it constant relative to the solar year.

Sirius was originally composed of two bright bluish stars. Sirius A is about twice as massive as the Sun and 25 times as luminous as the Sun, but has a significantly lower luminosity than other bright stars such as Canopus, Betelgeuse, or Rigel. The initially more massive of these, Sirius B, consumed its hydrogen fuel and became a red giant before shedding its outer layers and collapsing into its current state as a white dwarf around 120 million years ago.

One remarkable aspect of Sirius B is its close proximity to Earth. At a distance of 8.6 light years, the Sirius system is one of Earth's nearest neighbours. This proximity provides astronomers with a unique opportunity to study a white dwarf up close and in detail. White dwarfs are the remnants of stars after they have exhausted their nuclear fuel (Hydrogen and Helium) and shed their outer layers. What remains is a highly dense core composed mainly of carbon and oxygen, packed into a volume roughly the size of Earth.

By observing Sirius B, scientists were able to investigate the mass and density of white dwarfs accurately through astrometric and spectroscopic observations. They have a staggering density - a teaspoon of white dwarf material would weigh several tons on Earth. This density arises from the gravitational collapse of the star's core, which is counterbalanced by electron degeneracy pressure - the repulsion between electrons that prevents further collapse.



Measurement of white dwarf's mass using microlensing

The cooling behaviour of Sirius B was tracked, which revealed the cooling processes of white dwarfs, crucial for understanding the later stages of stellar evolution. As white dwarfs cool, they gradually dim and fade, eventually becoming "black dwarfs" that no longer emit

significant amounts of light. By studying the luminosity and temperature of Sirius B over time, astronomers can refine models of stellar cooling and gain insights into the age of the system and the chemical evolution of white dwarfs and their progenitor stars. Because the universe's oldest stars are only 10 billion to 20 billion years old there are no known black dwarfs—yet.

While direct observations of planets around Sirius B are not feasible, studies of white dwarfs like Sirius B can indirectly shed light on the fate of planetary systems. The presence of heavy elements in a white dwarf's atmosphere, such as metals or rocky material, can indicate the accretion of planetary debris. Analysing the composition of white dwarf atmospheres provides clues about the diversity in composition of planetary systems in the universe.

Moreover, white dwarfs serve as celestial laboratories where scientists can explore the behaviour of matter under extreme conditions not achievable in terrestrial laboratories. Researchers can probe the effects of strong gravitational fields on matter and test predictions of quantum mechanics and general relativity. Sirius B's orbital motion around Sirius A has been studied in detail, which helped test theories of binary star dynamics and gravitational interactions between stars. Precise measurements of the Sirius system's orbit have been used to test the predictions of general relativity and constrain the masses and orbits of both stars.

Furthermore, white dwarfs explain the fate of planetary systems. As stars that weigh less than 1.4 solar masses evolve into white dwarfs, any orbiting planets may be disrupted or engulfed, leaving behind signatures that can be detected by astronomers. White dwarfs like Sirius B have undergone extensive convective mixing during their evolution, which can bring internal material to the surface. The presence of certain elements in the atmosphere, particularly heavier elements like metals (iron, nickel, etc.), provides evidence of convective dredge-up episodes and sheds light on the internal dynamics of the star during its red giant phase. By studying the accreted material, scientists can infer the compositions of white dwarf atmospheres. Study of abundance patterns and its comparison with theoretical models of stellar nucleosynthesis revealed signatures of accretion events and processes such as diffusion, gravitational settling, and radiative levitation.



Accretion disks get hotter as matter gets closer to the core

In summary, Sirius B, with its proximity and unique characteristics, offers a window into the later stages of stellar evolution and serves as a valuable laboratory for advancing our understanding of fundamental astrophysical processes. White dwarfs, in general, play a crucial role in unravelling the mysteries of the cosmos and provide invaluable insights into the nature of matter, gravity, and the universe as a whole.