**Intro**

My project focuses on the formation and evolution of Blue supergiants stars which are a rare type of star that have large masses, temperatures, and luminosities. The most common way to classify stars is by their spectral type with O type having the highest temperatures and luminosities and M type having the lowest luminosities. BSGs are mostly O type stars, but some can be classified as B type depending on their temperature, luminosity, and magnitude. Comparing with the sun, which is a G type star with a surface temperature of around 6000K, and solar mass, radii, and luminosity of 1 each, blue supergiant stars have a minimum surface temperature of 11,000K, minimum solar radius of 14 solar radii, minimum solar mass of 10 solar mass have a luminosity of more than 20,000 solar luminosity. A Hertzsprung-Russell diagram can be seen on the right with this version classifying the varying types of stars based on their temperature, luminosity, and magnitude. BSGs are found at the top left of the diagram due to their high temperatures and luminosities. BSGs are located at the top left of the diagram indicating their high temperatures, luminosities and this diagram adds magnitude to one of the axes which is an inverse logarithmic scale that represents the brightness of the stars with lower values being more luminous than higher values. Some celestial objects can have negative values. Some example values of BSGs include Rigel (-7.8) and Zeta Puppis aka Naos (-6.2).

**Aims and objectives**

The main aim of my project is to research each phase of the cycle of BSGs and to gain an understanding about the various phenomena that occur within them which I set up the following objectives to achieve. By comparing both the base properties of BSGs and the formation conditions to solar stars like the sun I can gain an understanding on what the key differences are between these types of stars. By investigating how BSGs evolve into their death stages and the impacts these have on the surrounding universe I can determine which evolutionary path a dying BSG might take based on specific properties. Finally, by analysing stellar processes, such as nuclear fusion, stellar winds and stellar spots, and comparing them to solar stars I can gain an understanding about how these processes differ in larger stars and what causes the difference.

**Initial findings**

I have spent the last few months researching many different topics from different sources My main sources of information have been research papers ranging from old to new, I have also found and used lecture notes from various institutions and reliable sources such as NASA. So far, I have found out a great deal of information about the formation, main sequence phase and death stages of BSGs.

To begin with Giant star forming nebula are comprised of giant molecular clouds that are very densely packed with hydrogen, more so than smaller star producing nebula. The formation of giant stars is a complicated process involving several steps and many forces, with radiative forces playing a key role which is something that plays little to no role in formation of small-mass stars. Also, solar mass stars spend a considerable amount of time as contracting pre-main sequence celestial objects (30 Myr), whereas high mass stars that from via accretional growth from initially low mass stars, begin H burning when around 9Mʘ has been accumulated. BSGs have a considerably shorter life span than smaller stars. Our sun has currently existed for approximately 4-5 billion years, whereas BSGs exist for approximately only 10 million years. This is due to a much higher rate of fuel burning in the core of BSGs which occurs because it is much hotter and therefore there is more energy which allows fusion to occur.

The main difference between the sun and high mass stars is the nuclear fusion process that occurs in the core. In solar stars like the sun, the fusion process is P-P fusion in which Hydrogen undergoes several reactions to form He with a release of energy and heat. Whereas in high mass stars the fusion process is something called the CNO cycle which involves H reacting with carbon, nitrogen and oxygen via several reactions to produce He which can be seen below (describe each step). Each cycle produces around 25 MeV of energy.

One of the most characteristic properties of BSGs is the strong stellar winds that they experience, which is due to the huge amount of radiative pressure in the core. The stellar winds cause a large outflow of material, such as protons, neutrinos, neutrons, and heavy element atoms, out of the star leading to a mass loss over time. The stellar winds can be observed through their distinctive spectral line shape known as a P Cygni profile. This type of profile can either be red shifted when stellar wind scatters light particles, or blue shifted when the stellar winds move towards the observer.

Mass can be described as one of the most important features of a high mass star due to a lot of other properties being a function of mass. For example, the nuclear time scale which is used to determine the length of the main sequence phase by calculating how long fusion will continue for is a function of mass therefore as mass is lost from the star and as mass decreases, the nuclear time scale will change. This will cause changes in the length of the main sequence phase which in turn could lead to other changes in the star’s evolutionary path

After a relatively short main sequence phase when compared to other low mass stellar stars like the sun, and when fusion fuel has nearly run out, mass in the star will start to enter the core causing a gravitational collapse and eventually cause an explosive event called a supernova. This is a highly energetic event which causes material and shockwaves to travel for long distances, affecting everything in its path, anything near the supernova will experience extreme heat and destructive forces. Once this occurs the next stage is determined by the amount of mass in the core. If it exceeds 3 solar masses then a black hole forms with extremely strong gravitational field, whereas if the mass does not exceed 3 solar masses then a neutron star will form. Neutron stars are very small celestial bodies with the mass of a few suns making them one of the densest bodies in the known universe.

**Next steps**

Over the next few months, I will continue to research the CNO cycle to try and determine how it compares to P-P fusion and the main differences the cores experience what happens to the energy produced via the CNO cycle. I will also be looking more into mass loss, how this is affected by stellar winds, and how it leads to changes in the nuclear time scale and if these are substantial changes or minor changes.

I will analyse the final death stages in more detail to determine how constructive and destructive supernovas and black holes are on their local and surrounding galaxies, there have been papers published that theorize that shockwaves from supernovas could cause forces on protostars in molecular clouds which assists in the creation of other stars. This is something that I can investigate to explore the effects of supernovas. Finally, I will look at features that BSGs experience that are both found in solar stars and BSGs and features that are only found in high mass stars. A potential feature to research is stellar spots which are areas where the stars magnetic field, temperature and other features can change when compared to the rest of the star. Stellar flares are another area that I can research more into, flares are often accompanied by coronal mass ejections. Both of these features occur frequently in solar like stars but not much is known if high mass stars experience such phenomena.