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In The Clear Sky: The Cosmology of the Stars

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Abstract - In the universe that we live, in we are surrounded by trees, plants, animals, our human beings, oxygen and various other gases that make up the atmosphere. The Milky Way of the universe comprises planets, the moon, and the sun; which is a star like the other stars in the universe. This article looks at the stars within our universe and serves to inform and emphasise their role and formation to, astronomists, astrophysicists, cosmologists and, the general reader who are interested to know more about the cosmology of the stars.

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Abstract - In the universe that we live, in we are surrounded by trees, plants, animals, our human beings, oxygen and various other gases that make up the atmosphere. The Milky Way of the universe comprises planets, the moon, and the sun; which is a star like the other stars in the universe. This article looks at the stars within our universe and serves to inform and emphasise their role and formation to, astronomists, astrophysicists, cosmologists and, the general reader who are interested to know more about the cosmology of the stars.

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On a clear night, the sky is inhabited by thousands, if not millions, of stars that vary in brightness, some of which form part of the Milky Way; an elongated cloudy stripe of stars. The discovery of stars as comprising the Milky Way, was first observed by Galileo Galilei in 1610, and supported by Thomas Wright in 1750. However, Thomas Wright suggested that individual stars formed a conglomerate in the shape of a flat disc which we, today, call the galaxy (Giancoli, 1998).

The galaxy contains about 10^{11} stars with a total mass of approximately 3×10^{41} kg (Giancoli, 1998). From the Shakespearean poem 'Let Me Not to the Marriage of True Minds', the 'star' played an important role in those days for survival and religious purposes. In many parts of the world it was used for celestial navigation and orientation, out at sea, when one was lost and caught up in the storms. Today it is used by astronomers to track the motion of the planets and the position of the sun by grouping them into constellations (Forbes, 1909). One way in which farmers regulated their agricultural practices was by creating calendars by observing the motion of the sun and/or moon against the background stars and horizon (Tøndering, no date supplied).

Stars are formed both within and outside the Milky Way (Giancoli, 1998) i.e. they exist in the galaxy and intergalactically (Hubble News Desk, no date supplied). When stars cluster together they form globular stars and these stars appear cloudy to the naked eyes. Since they appear cloudy they are called nebula; because these globular stars exist in variations whereby they may actually be glowing clouds of gas or dust. In general, stars that appear as globular clusters occur in constellations such as Andromeda, Orion or even Hercules. They appear as gaseous nebula in the constellation, Carina. Apart from globular stars, there are also stars that are elliptical in shape and that are analogous to the shape of our galaxy i.e. disk-like. The reason for this elliptical stars are visualised at an angle (something like a flying freeze-bee). These stars are extragalactic i.e. they are in existence beyond the stars we are able to see clearly i.e. they are faint in the Milky Way.

The galaxy contains many types of stars known as (1) red gaints, white dwarfs, neutron stars, black holes, and exploding stars called novac and supernovac. In addition these are galaxies that are brighter than our ordinary galaxies. These galaxies are called quasars. It is important to remember that the brightness we see on Earth, is due to the nearest star to Earth i.e. the sun because the radiation from the sun is uniform to release brightness. The other stars of the Milky Way do not emit radiation in a uniform fashion (Giancoli, 1998 and Rishan Singh, personal writing).

Every night the sky remains unchanged. In the sky there are stars which remain unchanged except for their position relative to each other (Royal Greenwich Observatory, no date supplied). There are some variations in that the novac and supernovac do change a lot. Since the stars are so far away from us, precise measurements of the distance of one star relative to another are difficult to attain. Moreover, each star of a different mass and is unique to itself. Since these stars are at different distances to us, they emit brightness or radiation of different wavelengths (Giancoli, 1998).

Astronomers can determine the mass, age, chemical composition (Bahcall, 2000) and surface temperature (Giancoli, 1998) of a star by observing its spectrum, luminosity, brightness and motion through space (Bahcall, 2000; Giancoli, 1998). The wavelength of light that a star or galaxy emits is directly proportional to the surface temperature of the star. This means that a star that has a lower surface temperature would appear dim (low luminosity) because it would emit a shorter wavelength of light. In contrast, this is not the case when a star has a surface temperature that favours brightness from the blue wavelength of light emitted (Giancoli, 1998; Rishan Singh, personal writing). It is a researched fact that the surface temperature of stars range between 50.000 Kelvin (K) (blue) to 3500 K (red) (Giancoli, 1998) with high temperature and pressure centres (cores) are called white dwarfs (Mengel *et al.*, 1979). These white dwarfs form a part of the main sequence of stars (Mengel *et al.*, 1979) that form part of the Milky Way (Rishan Singh, personal writing). In contrast, red giants have higher luminosity with lower core temperatures (Giancoli, 1998) i.e. red spectrum emission (Rishan

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Singh, personal writing). According to Mengel *et al* (1979), the mass and luminosity of a star determines the duration at which a star would form part of the main sequence. It has been estimated that the sun would be part of the Milky Way for about 10^{10} years. To date no red dwarf (small stars) has reached the age of the Earth i.e. 14 billion years and it is not expected to attain this age (Richmond, no date supplied).

The lifecycle of a star can range from 1 day to hundreds and millions of years and as human-beings it is difficult to follow the exact life cycle of the variety of star types, which has been mentioned previously. In terms of the evolutionary existence of stars, a star is born and its fate determined by the forces of nature, mainly gravity (Rishan Singh, personal writing). A star is born when gravity causes hydrogen clouds to contract (Giancoli, 1998). However, the contraction of other gaseous clouds can also induce star formation (Giancoli, 1998; Rishan Singh, personal writing). The majority of those clouds consist of hydrogen with about 25 % helium and a few percent of other heavier elements (Woodward, 1978).

The contraction of gaseous clouds causes them to break/fragment into smaller masses. These smaller masses contain a centre that is slightly heavier than the point to which it is situated near to, as was the case of the original gaseous cloud. Gravity causes these smaller masses to contract further, forming protostars (Giancoli, 1998; Rishan Singh, personal writing).

Protostars are made up of particles. When these particles move inwards, the kinetic energy of these stars increase (Giancoli, 1998). Kinetic energy is defined as the energy that is required for one star to move (Rishan Singh, personal writing and definition). When the kinetic energy is sufficiently high, the Coulomb force of repulsion between hydrogen nuclei is overcome causing them to fuse. This is called nuclear fusion (Bahcall, 2000; Giancoli, 1998). Coulomb's force is defined as the force between charged particles at rest; it has magnitude and direction (Giancoli, 1998).

The few percent of heavy metals that constitute the gaseous cloud (Woodward, 1978), is a determinant and regulatory factor of the magnetic field and it also has a profound influence on the duration that a star will burn its fuel (Pizzolato, 2001). Older stars have less metalicity compared to younger stars as those stars die; portions of their outer layers get shred into the atmosphere. These shredded portions get re-used during the formation of new stars and planets. The outflow from supernovae provides the optimal medium in which star formation can occur (NASA Goddard Space Flight Center, no date supplied). An interesting key point of note is that the magnetic field can act as an inhibitor of rotation in older stars, such as the sun, because the level of surface gravity in the sun is lower compared to the other stars (Berdyugina, 2005) in the galaxy (Rishan Singh, personal writing). The structure of the galaxy, its evolution as well as the age and origin of stars can be determined from the motion of a star (ESA, no date supplied).

During nuclear fusion, a lot of energy is released which inhibits gravitational contraction causing a young star to stabilise and exist. This also applies to the sun, whose formation involves the fusion of 4 protons resulting in a $^{4}_{2}He$ nucleus. The reaction releases gamma rays and neutrinos and it occurs at the core of the star where the temperature is extremely high. As the helium within the core increases, hydrogen continues to 'burn' in the shell around it. When the hydrogen is consumed, the production energy decreases causing the gravitational force and coulombs force of repulsion to increase. This causes the hydrogen in the shell around the core to 'burn' more fiercely because the increase in temperature causes the outer envelope of the star to expand and cool. The low surface temperature causes the star to emit light in the longer wavelength i.e. red spectrum. These stars are called red giants since they are expanded in size and are more luminous, as mentioned (Giancoli, 1998). This group of stars (giants and even supergiants) (Iben, 1991) are referred to as eruptive variables by astronomers because these stars experience a sudden increase in luminosity because of flares and/or mass ejection events (AAVSO, 2010).

The actual fate of a star depends on the mass of the star relative to the solar mass of the red giant stage i.e. the change from a black dwarf to a black hole (discussion follows). If the star has a mass that is greater than 1.4 solar masses, then further fusion occurs causing the star to expand as it gains internal energy. The core increases in temperature and the star gets brighter and brighter. This is called a white dwarf. However, there are stars which have a residue mass of more than 1.4 solar masses and these are massive in size. In those stars, the kinetic energy is so high that iron can fuse in clouding elements that are heavier even though these reactions are endogonic in nature. These energy-requiring reactions cause iron and nickel to breakup into helium and eventually into protons and neutrons; but also can cause protons to join to electrons to form neutrons (Giancoli, 1998).

A nucleus of neutrons is formed as the core of a hydrogen cloud contracts under gravity. The size of the star depends on the conjugation of protons and electrons and it is called a neutronstar. These stars, just like all stars, have an outer envelope and the energy released by gravity would by some natural catastrophe cause the formation of a supernova (Giancoli, 1998; Goddard Space Flight Center, no date supplied; Rishan Singh, personal writing), a type of star that has the potential to show drastic change because it is formed from many elements of the periodic table (Giancoli, 1998; Iben, 1991). These stars are known as cataclysmic or explosive variable stars (Iben, 1991). The explosion of a supernova releases energy that emits brightness that is a billion times greater over a few days

Global Journal of Science Frontier Research (A) Volume XII Issue IV Version I June 2012

and fades away in time (Giancoli, 1998).

The backbone of supernova formation is the pulsar, a rapidly rotating star, which is known themselves to be a neutron star that emits sharp pulses of radiation at regular intervals. Their rapid rotatory nature is due to their angle of momentum being conserved while contraction occurs as their inertia decreases (Giancoli, 1998). These stars are known as pulsating variables stars because their size determines the period (seconds, months, years etc.) during which expanding and contracting occurs (AAVSO, 2010).

When the mass of a star is greater than 2-3 solar masses, the gravitational force would be so strong that the light that is emitted would not be able to escape i.e. it would be pulled back in by gravity. This means that the speed of light is less than the escape velocity. Such a star we would not be able to see since no light is emitted and therefore it would be black to astronomers. This is called a black hole (Fryer, 2003; Giancoli, 1998).

In all type of stars, the force of gravity is continually trying to cause the star to collapse, but this is counteracted by the pressure of hot gas and/or radiation in the star's interior. This is called hydrostatic support (NASA, 2010). It is important for us to acknowledge the greatness in God's creation and the history the stars of our universe have been through and to commend those people who have made it back home alive using the astronomists, physicists, cosmologists and to the general reader, putting the cosmology of the stars in societal context.

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