The Physics of Neutron Stars and Pulsars

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One of the most interesting phenomena of the astrophysics is the neutron stars, which are left after of the huge stars which have gone through a supernova explosion. They are super dense stellar remnants existing with their own mass being more than that of the Sun, but having a radius of approximately 10 kilometers. There are many extraordinary physical situations as a result of such strong gravitational and magnetic fields around neutron stars such as the production of pulsars, which are fastly rotating neutron stars capable of producing electromagnetic radiation beams. During the process of making a neutron star, a very massive star slowly exhausts all nuclear fuel and explodes into a core-collapse supernova. The explosion causes the core of the star to be squeezed so that the protons and electrons can come together to form neutrons, and end up having a star of nearly all neutrons. What is obtained is a small astronomical object whose mass may vary between approximately 1.4 and 2 times of the Sun but of the size of a city. The neutron star is so dense that a teaspoon of a material therein used to exist would have approximately one billion tons on Earth (Lattimer, 2020).

The rotation of the neutron stars is one of the most fascinating attributes. Neutron stars travel at a very rapid rate with some of them turning hundreds of times per minute. It is this high rate of rotation, and the high magnetic fields that surround the star that cause pulsars to form. Pulsars refer to neutron stars, which release bursts of radiations at their magnet poles. As the star spins it causes these beams to touch the space in a lighthouse way and when the beam themselves happen to point toward the earth then we will see pulses of radiation coming in periodically. This periodicity may be twenty times more accurate than atomic clocks; some pulsars are that accurate (Kaspi, 2021).

Pulsar has also resulted in great knowledge about the physics of neutron star that is of great value to an astronomer. Pulsars are used as natural laboratory to examine the behavior of matter put under extreme conditions, including ultra-high densities and magnetic fields. Through observing the pulsar radiations, astronomers can determine the internal structure of the neutron stars including the equation of state that controls the behavior of the matter at such a high density. Such studies have also given significant experiments of general relativity because the orbit of binary pulsar systems have enabled scientists in determining the emission of gravitational waves and testing the predictions of the theory formulated by Einstein (Lazarus et al., 2016). Neutron stars and pulsars are also significant sources of information on evolution of the universe besides being used as cosmic laboratories. The fact that a binary neutron star system was discovered in 2017, e.g., presented abundant data regarding the collision of two neutron stars, as well as the generation of gravitational waves and electromagnetic radiation (Abbott et al., 2017). This was the first observation of a neutron star merger, GW170817, which opened new possibilities to study how the heavy elements form and the contribution of neutron stars to overall galaxy development.

Finally, neutron stars and pulsars are the most exotic and the most interesting things in the universe. Their high density, high rotations and the high strength of the magnetic fields in them make them unique laboratories to investigate the basic laws of physics. With this ever-increasing knowledge of these items, they will surely remain instrumental in understanding the essence of matter, gravity and the universe itself.

References

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