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Tapping, Ken

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HOW BIG CAN STARS GET?

Ken Tapping, 20th February, 2018

Stars come in a wide range of sizes. The smallest star we have found so far is 2MASS J0523-1403, which is 125,000 km in diameter, compared with the Sun's 1.4 million. The largest "mature adult" star found so far in our galaxy is the Pistol Star, with a diameter of about 400 million kilometres. It has this strange name because it is embedded in a cloud that allegedly looks something like a pistol. There are smaller stellar objects, such as white dwarf stars, about the size of the Earth, neutron stars a few kilometres in diameter, and stellar black holes, which are smaller still. However, all these are remnants of dead stars. The largest stars are the red giants and supergiants, such as UY Scuti, which is 2.5 billion kilometres in diameter. Red giants easily visible to the unaided eye include Betelgeux, Aldebaran and Antares.

Stars form from the collapse of clouds of cosmic gas and dust. The impact of the material on the growing lump makes it hot, and its increasing mass drives up the pressure in the core. If the lump collects enough material, the compression and temperature become high enough for nuclear fusion to start, and we have a star. Smaller lumps become planets, gradually cooling off. There is also a limit to how big a star can be. This is set mainly by "radiation pressure".

If someone throws a ball and you catch it, you feel the force of the impact pushing at your hand. Electromagnetic waves, such as light, infrared radiation and radio waves come in little packets called photons. If one of these hits something, the impact creates a momentary force. When a continuous stream of them hits a surface, they generate a pressure - radiation pressure. The pressure of sunlight hitting the Earth is tiny. However, it is still enough to harness. Research spacecraft with huge sails have used this force for propulsion. Inside a star, where colossal amounts of energy are being produced, mainly in the form of light and infrared, radiation pressure is strong enough to affect a star's structure. For a star to be stable, three forces need to be in balance: gravity pulling inwards, plus gas pressure and radiation pressure pushing outwards.

For dwarf stars like the Sun this is not a problem, but as stars get more massive, the energy output and therefore the radiation pressure rise rapidly. Doubling the mass of a star can increase its energy output by a factor of sixteen. The Pistol Star has about 28 times the Sun's mass, and produces about a million times more energy. As the mass increases, the radiation pressure pushing outwards grows faster than the gravitational force holding the star together. Eventually, the star swells up and its outer parts get pushed off into space. This sets the upper size limit; stars bigger than this cannot hold together.

Over the life of a star, the waste products from the fusion reactions making it shine accumulate in its core. Energy production then takes place in a shell surrounding the waste material, like a fire burning above a thick layer of hot ash. The energy output goes up hugely. With more energy being produced, and closer to the surface, the radiation pressure increases. The outer parts of the star are pushed outward, and the star swells into a red giant. Really big red giants are scarcely able to hold together, with radiation pressure pushing their outer layers into space as a "super solar wind". Stars in this phase of their lives may vary wildly in brightness, sneeze off their material and then collapse and explode, briefly outshining all the billions of other stars in their galaxy put together.

Before dawn, Jupiter lies low in the south. Mars is to its left, just above the red star Antares, which means rival of Ares, the Greek god of war. Saturn lies low in the southeast. The Moon will reach First Quarter on the 22nd.

Ken Tapping is an astronomer with the NRC's Dominion Radio Astrophysical Observatory, Penticton, BC, V2A 6J9.

Tel (250) 497-2300, Fax (250) 497-2355

E-mail: ken.tapping@nrc-cnrc.gc.ca