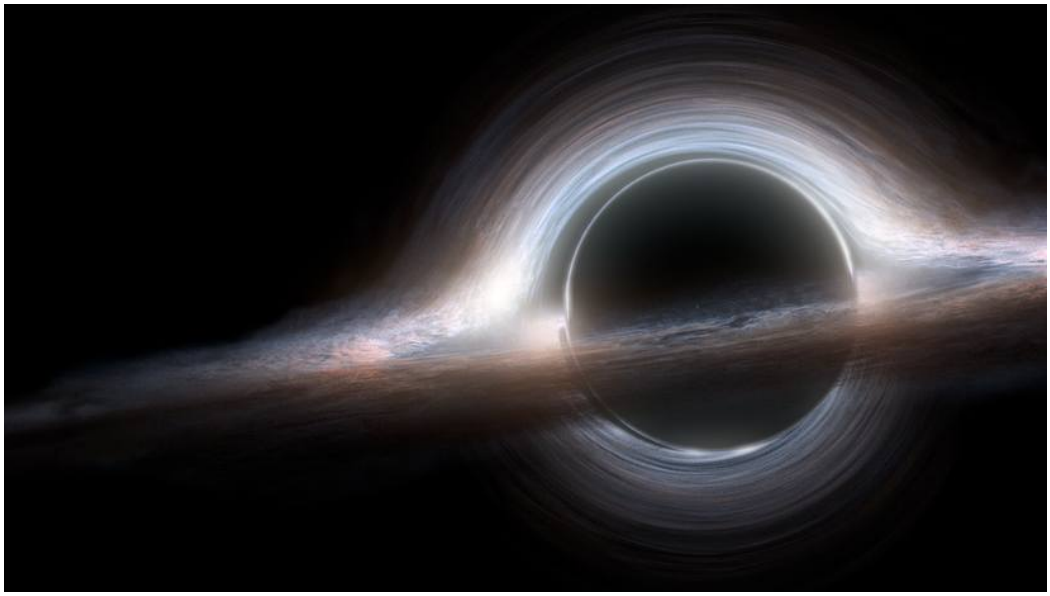
Are You Calling Me Dense?

by Robert Bee



We're about to take a trip into the way out, some would say wacky, world of extreme objects of the universe. It is very much modern astronomy. This is pure armchair stuff, well beyond our amateur telescopes' reach. I sub-title this article "The Weird Mob". 'Weird' because everything I am about to describe is firmly believed in by scientists and astronomers but defies your and my ability to imagine it.

Let's start with simple white dwarfs. Did I say 'simple'? You could see a white dwarf with a big enough telescope. In fact there is one orbiting Sirius, our sky's brightest star but it is so faint it is lost in Sirius' glare.

When a star of similar size to our Sun reaches the end of its life, there is a process which ultimately has the star shucking off its outer hydrogen and helium layers (to form a beautiful planetary nebula) while its remnant core of heavier elements compresses under gravity to leave a star about the size of Earth made out of very dense weird material.

Enter a term called **'electron degeneracy'**, a fantastic creature out of quantum physics. It's enough to know that a thimble full of this stuff would weigh as much as my Toyota Camry. The star is initially very hot, around 100,000°C, thus white, but it has no internal energy source and eventually cools over billions of years until it is an invisible cinder – a black dwarf.

Our Sun will end up as a white dwarf in about 5 billion years. When Sirius' companion was originally identified as a white dwarf in the 1860s, the astronomers couldn't believe what they saw and rejected their observations. But, to paraphrase Shakespeare (Julius Caesar, Act 1 Sc.2): "The fault, dear Brutus, is not in the stars, but in our theories…" It wasn't until 1920 when electron degeneracy was theorized that the white dwarf could be understood.

It gets even weirder from here on. If the star was much more massive than our Sun, when it runs out of hydrogen at its core it won't go quietly like a planetary nebula – it will go with a tremendous bang! If it's between three to about eight times our Sun's mass, it will explode and leave behind an object that almost beggars belief. They call it a Neutron Star.

The central core of the star is compressed by a mighty gravity-driven implosion that just keeps going and going inwards until, impossibly, it gets beyond the point where all the protons and neutrons are totally cheek-to-jowl. Quantum physics at work again. With a humungous 'bounce', the star explodes outwards in what we see as a supernova, and leaves the compressed core of pure neutrons, with no space between them. Neutron degeneracy, a very strange state of matter. This star makes a white dwarf look like a bag of feathers.

A typical neutron star would be about 30 km diameter with a mass that of our Sun. A thimbleful would weigh as much as Mt Everest. They give out no light and were first discovered as pulsating radio waves, called 'pulsars' with no visible light source. The explanation of neutron stars came afterwards after much theory searching.

But it gets wackier. If the original star was larger than about eight Suns, when the star finally explodes its remnant core gets compressed even beyond a neutron star, if such a thing can be imagined, to such an extreme density and minute size that space-time is bent in on itself and no form of radiation, not even light, can escape from it. It becomes totally invisible, on any wavelength, to the outside universe. A Black Hole! The stuff of science-fiction.

Though invisible, they can be detected by the gravitational affect they have on the stars around them and by the last-gasp emission of X-rays that in-falling material emits. Some, in theory, are so dense they have shrunk to a geometric point, a singularity. Physicists abhor a singularity, but no-one told the black holes.

Sucking, sucking, hole so black

Perhaps it's not just light you lack.

Lost dimensions one, two, three

Curse that singularity. (R Bee, 2007)

Black holes do exist. Every galaxy has at least one. There is a monster black hole lurking at the very center of our galaxy.

If you've been able to imagine this zoo of strange objects, you've done well. But it gets stranger than this. To quote Eddington: "The Universe is not only stranger than we imagine; it is stranger than we can imagine."