BBC **SPACE ODDITIES:** THE STRANGEST PLACES IN THE UNIVERSE

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SPACE ODDITIES

TAKE A TOUR OF THE WEIRDEST SPOTS IN THE UNIVERSE, WHERE THE 'NORMAL' RULES DON'T APPLY. PLACES THAT SQUEEZE TIME, BLOW BUBBLES AND EVEN RAIN GLASS... SIDEWAYS

WORDS: COLIN STUART

THE DIAMOND PLANET

PLANET 55 CANCRI E

Forty-one light-years away lies a star known as either 55 Cancri, or Copernicus. Ripping around it at a roaring pace is the planet 55 Cancri e, also called Janssen. The planet takes a little over 17 hours to complete an orbit.

At eight times the mass of Earth, 55 Cancri e is a scorched super-Earth. The temperature climbs as high as 2,400°C (4,350°F) – enough to melt almost every type of metal.

Back in 2010, a study concluded that the carbon-to-oxygen ratio of the planet's host star was unusually high. If that ratio also exists on 55 Cancri e, then, combined with the planet's vital statistics, models suggest that the carbon would mostly exist in diamond form. It would be a blazingly hot planet that scintillates and sparkles.

The situation may be more nuanced, however. A follow up study found a carbon-to-oxygen ratio that was still higher than the Sun's, but less than previously believed. That leaves the diamond idea on a more unsure footing.

That said, planets don't have to exactly match the carbon-oxygen ratio of their host stars. If the carbon on 55 Cancri e was topped up from some other source, it could still be the most precious planet in the known Universe.

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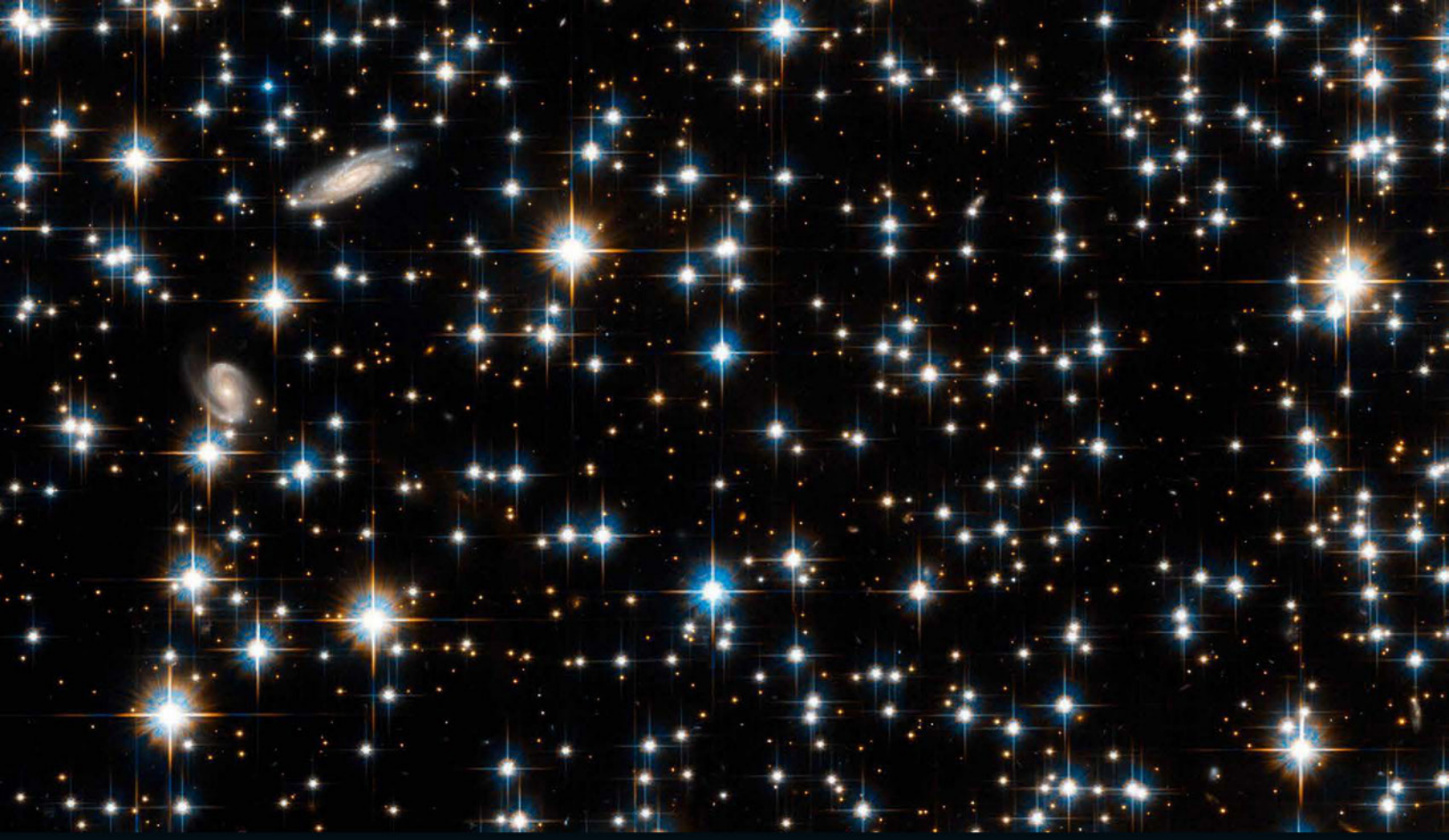
THE MISSHAPEN STAR

VEGA

Vega is one of the most important stars in the sky. It's so bright that the brightness of other stars is measured against it. Astronomers measure a star's brightness on a backwards scale (the lower the value, the higher the brightness) known as apparent magnitude. Vega is the reference point of that scale, with a magnitude of zero. A star of magnitude 1 is 2.5 times dimmer than Vega, whereas a star of magnitude –1 is 2.5 times brighter than Vega.

Vega is also a pole star, at least sometimes. Right now, Earth's north pole is pointing towards Polaris, also known as the North, or Pole, Star. But the alignment of Earth's axis traces a circle over a period of 26,000 years. Vega lies close to the other side of this circle, meaning it was the Pole Star around 14,000 years ago and will be again in almost 12,000 years' time.

Yet the strangest thing about Vega is its shape. Our nearest star – the Sun – is almost a perfect sphere, but that's because it rotates very slowly. It takes the Sun just shy of a month to spin once on its axis. Vega spins a lot faster than that; it's able to complete one revolution in just 12.5 hours. This forces Vega to bulge at its equator, making it distinctly egg-shaped instead of spherical.



THE CURVEBALL CLUSTER ↑

GLOBULAR CLUSTER NGC 6791

Sometimes astronomers think they know how the Universe works, only for the cosmos to throw them a curveball. The Globular Cluster known as NGC 6791 is a particularly baffling example.

Traditionally, star clusters are divided into globular clusters and open clusters. Globular clusters usually contain very old stars, jam-packed together, whereas open clusters contain very young stars that are spread out. But NGC 6791 seems to blur the line between the two.

One way to age a star is to look at the chemical elements it contains. To an astronomer, any element heavier than hydrogen or helium is called a metal. The oldest stars formed when there were very few metals around. Yet stars turn hydrogen and helium into metals, so younger stars inherit metals from the stars that have gone before them.

NGC 6791, however, seems to contain stars that are both old and metal-rich, with twice the abundance of metals of the much younger Sun. It also contains types of stars not normally found in globular clusters. So, NGC 6791 appears to be a new class of cluster, one that's a hybrid of globular and open – a definite oddity.

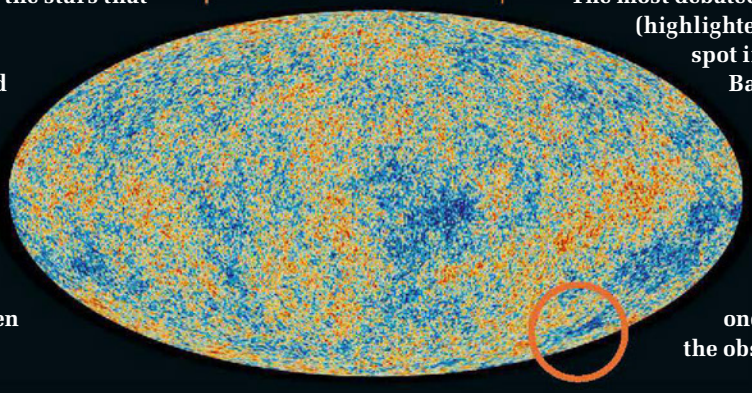
THE AREAS OF NOTHING ↓

SPACE VOIDS

Space is called space for a reason: there's an awful lot of it, but most of it's empty, with stars and galaxies forming islands in the vast, black cosmic ocean. The Universe's average density is just 9.9 attograms per cubic centimetre (where one attogram is a quintillionth of a gram), the equivalent of six protons in a space the size of a sugar cube.

But, remarkably, there are regions of the Universe that contain even less stuff, only about ten per cent of the average. They're known as voids, or even supervoids, and they're huge, typically spanning 30 million to 300 million light-years. Astronomers name them after the constellations we see them in, such as the Fornax Void, Boötes Void and Canis Major Void.

The most debated is the Eridanus supervoid (highlighted below). There's a huge cold spot in the Cosmic Microwave Background (CMB) – the relic radiation from the Big Bang. One explanation for it is that the CMB was robbed of some energy as it passed through a supervoid en route to Earth. If true, the Eridanus supervoid would be one of the largest structures in the observable Universe.



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THE GIANT BUBBLES ←

FERMI BUBBLES, THE MILKY WAY

The Milky Way, the galaxy to which we belong, is shaped like two fried eggs stuck back-to-back. There's a central bulge (the yolks), with a flatter disc (the whites), surrounding it.

Yet back in 2010, astronomers using the Fermi space telescope spotted huge bubbles of radiation coming out from the centre. They've become known as the Fermi Bubbles and stretch some 25,000 light-years above and below the galactic disc. Their combined length is half that of the entire Milky Way.

The bubbles mostly consist of gamma radiation with a border of X-ray radiation. Their size and well-defined edges suggest they were created by a large and sudden release of energy from the galactic centre. Sagittarius A*, the supermassive black hole at the heart of the Milky Way, is likely to have been involved. But how, nobody knows.

THE WOUNDED GLACIER ↑

BLOOD FALLS, ANTARCTICA

Not all of the weirdest places in the Universe are in space. Some are here on Earth. In East Antarctica, you'll find a colour that you don't normally associate with the frozen continent: red. Red seawater flows from the Taylor Glacier, giving it the nickname Blood Falls.

Scientists initially thought the brine contained red algae, but now they know it's that colour because the salty water is rich with iron. It comes from an ancient pool of seawater that was trapped beneath the glacier about 2 million years ago. As it emerges from the subglacial rivers and meets the air, the iron oxidises (rusts) giving the brine its gory tint.

There's life around Blood Falls. When biologists took samples, they found 17 types of microbes living beneath the glacier. Some of which, have even evolved to feed on the iron that gives Blood Falls its distinctive colour.

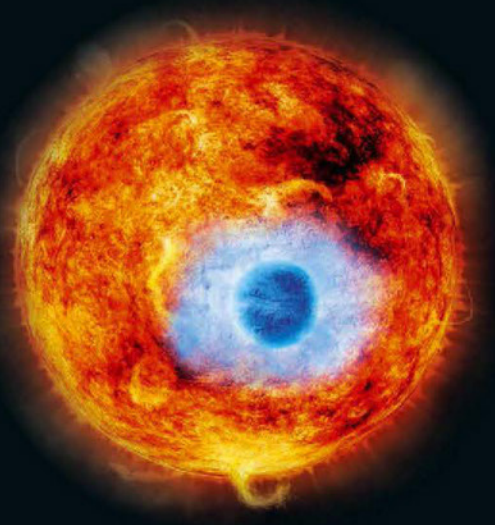
WHERE BLACK HOLES MERGE

GW150914

There are places in the Universe where space and time are stretched and squeezed beyond ordinary comprehension. Places where months, locally, equate to centuries far away. One such place is where two behemoth black holes pirouette around one another in a so-called binary pair, before merging into one.

Einstein told us that just as swimmers, ships and boats create waves as they move through water, objects moving through the Universe create gravitational waves in the fabric of space-time. The closer two black holes get to each other, the more orbital energy they give up. This energy is converted into gravitational waves, which spread out through the Universe like ripples on a pond. The first detection of such waves was made in September 2015 by the Laser Interferometer Gravitational-Wave Observatory (LIGO) in the US, after it picked up the waves produced by the merger of the binary black hole pair christened GW150914.

In the final 20 milliseconds before a collision, the black holes would give out more gravitational energy than the total amount of energy radiated by all the stars in the observable Universe over the same time period. It's also more energy than the Sun will emit in its entire lifetime. After that collision, the black holes enter a 'ringdown' phase and settle together as one.



by COLIN STUART
(@skyponderer)
Colin is an award-winning astronomy author, science writer and speaker, as well as a fellow of the Royal Astronomical Society.

THE PLANET WITH GLASS RAIN

HD 189733 B

Located some 65 light-years away in the constellation of Vulpecula, exoplanet HD 189733 b is larger than Jupiter and 33 times closer to its star than Earth is to the Sun.

Its proximity to its star would give the planet a temperature of almost 1,000°C (1,832°F). Far too hot for liquid water, so the blue light reflecting off it is likely to be from clouds of silicate particles instead. Silicates, such as sand, have melting points of around 1,000°C and molten silicates make glass. So, it probably rains glass on HD 189733b.

But the strangeness doesn't end there. The extreme temperatures on HD 189733 b drive fierce winds that can howl at over 7,000km/h (4,350mph). Meaning the glass rains horizontally.

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