What is a neutron star?

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A neutron star is the compressed remnant of a massive star that has exploded as a supernova. When a star between roughly 8 and 20 times the mass of our Sun exhausts its fuel, its core collapses catastrophically — within a fraction of a second, the core goes from the size of Earth to a sphere about 20 kilometres across. The outer layers bounce off this ultra-dense core and explode outward as a supernova. What's left is a neutron star.

How dense is it?

The density is almost incomprehensible. The entire mass of a star (typically 1–2 times the mass of our Sun) is squeezed into a sphere about 20km in diameter — roughly the size of a large city. One teaspoon of neutron star material would weigh about 10 million tonnes. The density is comparable to squeezing the entire human population into the volume of a sugar cube.

Normal matter is mostly empty space — atoms are almost entirely void, with a tiny nucleus surrounded by distant electrons. In a neutron star, that emptiness is crushed out entirely. The pressure is so extreme that electrons and protons are forced to merge into neutrons, packed directly against each other with no gap between them. The entire star is essentially a single, city-sized atomic nucleus. It's the densest stable matter that can exist — one step more, and it would collapse into a black hole.

Pulsars: cosmic lighthouses

Neutron stars often spin extraordinarily fast — some hundreds of times per second, from conservation of angular momentum (like a spinning ice skater pulling in their arms). Many emit powerful beams of radio waves or X-rays from their magnetic poles. If those beams sweep past Earth as the star rotates, we detect regular pulses — hence the name **pulsar**. When the first pulsar was discovered in 1967, the signals were so regular that the discoverers briefly nicknamed the source "LGM-1" (Little Green Men), thinking it might be artificial. It wasn't.

What are gravitational waves?

In 2017, gravitational wave detectors (LIGO and Virgo) detected ripples in spacetime from two neutron stars spiralling into each other and merging. Simultaneously, telescopes detected light from the same event. This neutron star merger also produced gold, platinum, and other heavy elements — the collision of neutron stars is now understood to be one of the main ways heavy elements are forged in the universe. Some of the gold in your jewellery was made in a neutron star collision billions of years ago.