WHAT ARE WHITE DWARF STARS?

We know what happens when a super-massive star collapses on itself – it results in a supernova, which eventually forms a neutron star or a black hole. But stars this huge make up only 3% of all stars. What happens to the other 97% of mid-range stars, such as our sun, when they run out of fuel?

The sun is estimated to exhaust its hydrogen around six billion years from now. Once this happens, its helium will start fusing into heavier elements. As this happens, the sun will shed its outer layers, forming a spectacular planetary nebula. At the end of this process, all that will remain will be the star's former core – called a white dwarf.

What's fascinating is that a typical white dwarf retains about half the mass of the star it was born from, but in less than a millionth of its size. For e.g., if our sun were to form a white dwarf, half its mass would be packed into an earth-sized object. This means that white dwarfs are extremely dense. A teaspoon of matter from weighs ~4000 kg – this is as heavy as an elephant! It also means that a white dwarf's gravity is very strong, more than 100,000 times stronger than the earth's!

A white dwarf is very hot, around 40 times hotter than our sun. However, in the absence of nuclear activity, it is also very stable. A white dwarf can only lose heat through radiation, which is a slow process. So slow, in fact, that it will take trillions of years for a white dwarf to lose all of its heat, and for its temperature to match that of its surroundings.

An image of the planetary nebula NGC 2818, from the southern constellation of Pyxis, taken by the Hubble Space Telescope.

Credits: NASA, ESA, and the Hubble Heritage Team (STScI/AURA).
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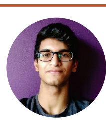

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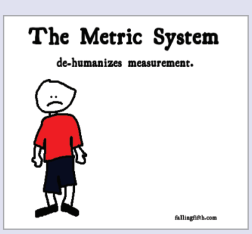
THE EXACT MASS OF A KILOGRAM: REPLACING LE GRAND

Since 1889, we've been using a platinum-iridium cylinder, called Le Grand, as the International Prototype of the Kilogram (IPK). However, careful measurements have detected discrepancies in the mass of Le Grand.

This problem could be addressed by redefining the kilogram in relation to a physical constant that could be measured anywhere in the universe and would yield the same value. It would also mean that the unit would no longer be subject to physical erosion, ambient conditions such as temperature or pressure, the value of gravitational acceleration at a location etc. Many other units in physics have been redefined in this way. For e.g., the metre has been redefined in relation to the speed of light, and the second in relation to the electron transition frequencies in cesium atoms.



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Many physicists proposed that the kilogram be redefined in terms of Planck's constant. In 2011, the International Committee for Weights and Measures formalized this approach based on a unanimous vote by all 55 of its delegates.

For the new definition of a kilogram to be useful, the Planck's constant needed to be measured with a precision that ensures that the transition from Le Grand is seamless. The International Committee for Weights and Measures decided that a more precise value of the Planck's constant would be determined by:

1. Three independent measurements, with
2. Each measurement having an uncertainty < 50 parts per billion,
3. At least two measurements being the result of significantly different experiments/methods,
4. At least one measurement having an uncertainty < 20 parts per billion.

But what is the Planck's constant and how is it related to the kilogram? Find out on page 50.

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