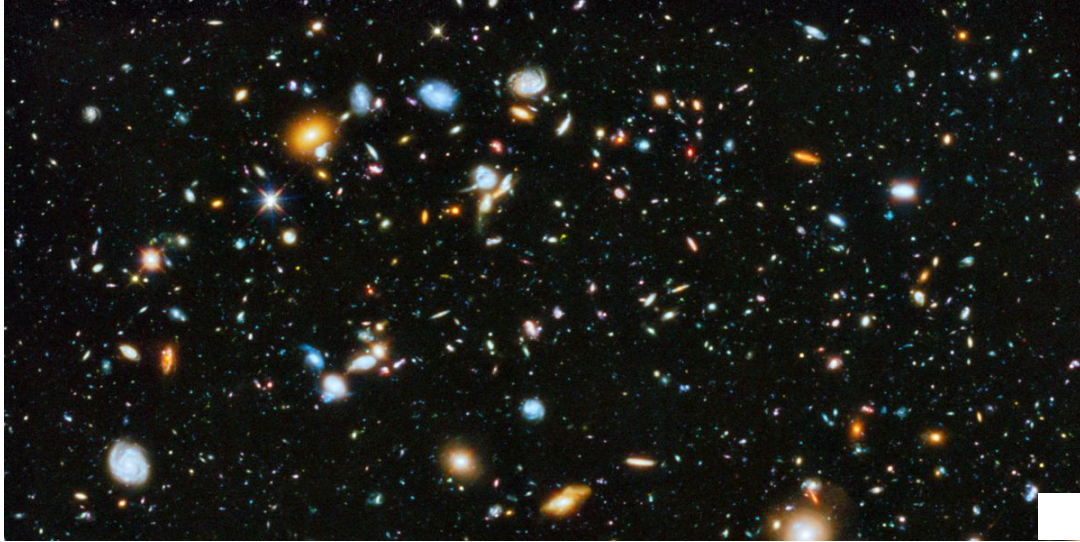


How Many Particles Are in the Observable Universe?

Numberphile is on the case.



BY JAY BENNETT PUBLISHED: JUL 11, 2017

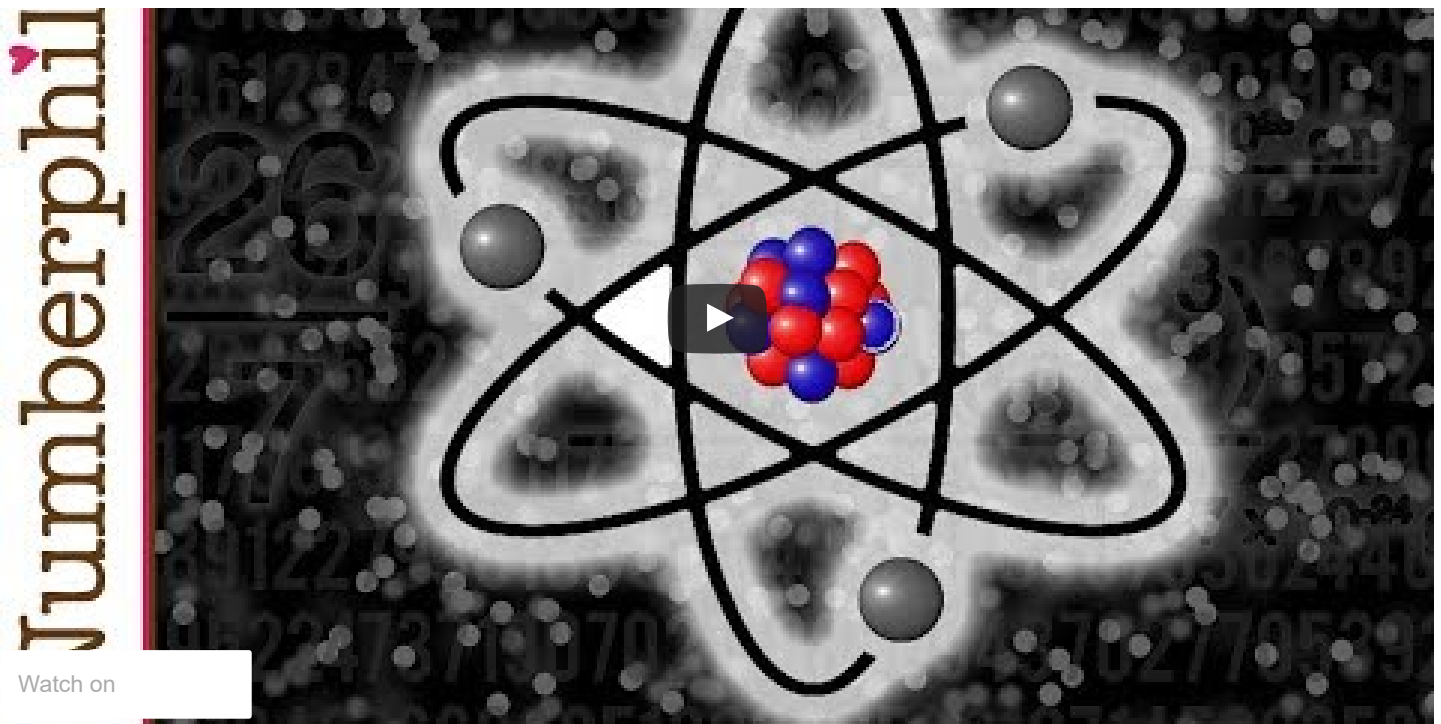


NASA/ESA

When it comes to astronomical questions, it doesn't get much bigger than the one Numberphile recently attempted to answer: How many particles in the universe? Given that an estimated five *trillion* hydrogen atoms can fit on the head of a pin, and each of those hydrogen atoms has four particles (one electron, and three quarks in the proton), we can safely assume that the number of particles in the entire observable universe is, well, pretty much beyond comprehension.

But don't tell Tony Padilla of the University of Nottingham. The physics professor developed a way to estimate the total number of particles in the universe, not counting photons or neutrinos, due to their lack of or near-lack-of mass.

How many particles in the Universe? - Numberphile



For his calculations, Padilla uses data from the [Planck space telescope](#) that was used to measure the Cosmic Microwave Background (CMB), which is the oldest light we can see that has traveled the farthest and therefore represents something of a boundary for the universe. Planck data can give us a good estimate for the density and radius of the observable universe.

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Another variable you need is the fraction of matter that is stored in baryons, which are particles made up of three smaller particles called quarks. (The most common baryons by far are protons and neutrons, so Padilla only considers those two in this example.) Finally, consider the mass of a proton and a neutron (about the same), and you have everything you need to come up with a good estimate for how many particles are in the observable universe.

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In essence, Padilla takes the total density of the universe, multiplies it by the fraction of the density that is just baryons (protons and neutrons), multiplies *that density* by the volume of the universe to get the mass of all the

baryons, and then he divides *that mass* by the mass of one bayron to get the total number of baryons in the universe. But we are not looking for the number of baryons, we are looking for the number of particles.

Each baryon is made up of three quarks, which are the particles we are counting. What's more, the total number of protons will equal the total number of electrons, which is the other particle we are counting. And in addition to that, we know that 75 percent of the universe is hydrogen and 25 percent is helium, and in a calculation of this scale, the rest is negligible. Using this information, Padilla calculates the number of baryons that are neutrons, the number that are protons, and the corresponding number of electrons. Now we multiply all the protons and neutrons by three for the quarks, and we have our number.

So how many are there? 3.28×10^{80} . Or more than a vigintillion but less than acentillion. Or:

[illegible]

So, pretty much incomprehensible. However, given the enormity of the universe, even that incomprehensible number doesn't fill up much of the total volume. If there are 3.28×10^{80} particles in the universe, that means there is only about *one particle per cubic meter*. The majority of space is, after all, empty space.

Padilla takes his thought experiment one step further to estimate how long it would take humans, given the current rate of population expansion, to absorb every particle in the universe. For that, you are going to have to watch the video above, and the answer might surprise you.



JAY BENNETT

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