

What is empty space?

Science cannot easily define
"space": physical, empty space.
Other kinds of space are much
more observable or imaginable.

outer space

geometric space

cyber space

solution space

common space

abstract space

personal space

mental space

white space

negative space

In science and metaphysics, it is debated whether space is ABSOLUTE – a real object with its own solidity and physical properties – or RELATIONAL (defined by the relationships between the objects that exist within it).

Air, on earth, is typically thought of as "empty," but it is actually full of particles.

Air (at 0°C) contains 27 septillion
(2.7×10^{25}) particles per cubic meter.

The best artificial vacuum chambers on earth contain roughly 100 million (1×10^8) particles per cubic meter.

The interstellar medium – the vast “emptiness” between celestial bodies – is itself not actually empty: it still contains a few particles per cubic meter.

Even if all of the particles¹ could be removed from an area of space, space without particles is actually still not truly empty.

Non-ordinary matter occupies this space: quantum fluctuations, such as virtual particles which flicker in and out of existence; dark matter and dark energy; and other equally invisible or unweighable² events.

¹ Particles are matter with mass; they are detectable, quantifiable, and observable.

² Unweighable: a term, coined by Buckminster-Fuller, which refers to the metaphysical, cognitive, or other non-matter elements in the universe.

According to quantum physics,
"it is a mistake to think of any
physical vacuum as some absolutely
empty void."

A true quantum picture of pure "empty space" is an abstractly dense, turbulent, and ever-changing locale of endless fluctuations, never simplifying, resolving, or coming to rest.

Empty space cannot be seen or directly experienced. It is immediately the stuff of abstraction and imagination.

How can density relate to the emptiness it creates?

The state of being "empty" comes from the positive and negative energies within a block of "empty space" canceling themselves out and resulting in zero.

As particles continuously flicker in and out of existence, these instantaneous appearances and disappearances of energy result in net zero (empty space), over and over again.

So do emptiness and density exist as separate units, or are they two required parts of one combined element?

There is a scientific definition for density: "a material's density is defined as its mass per unit volume."

There are non-scientific definitions of density as well: "compactness of matter"; "crowded closely together."

And there is a non-scientific
definition for emptiness:
“holding or containing nothing.”

But emptiness, in context of physics, only returns its relationship to density.

In physics, the strong force³ is the force which holds together the elements of an atom's nucleus: protons and neutrons.

The particles upon which the strong force acts are observable, but the strong force, itself, is not.

How do invisible forces relate to empty space?

³ Strong force: The dynamics of the strong force are carried out by subatomic particles such as quarks. Quarks have a color "charge": red, green, or blue.

Different combinations of color (r, g, b) and orientation (up, down) of quarks create different types of larger particles, such as protons. This is called "quantum chromodynamics," though it has nothing to do with actual color.

Color force

When looking at the universe, there's a point where physics leaves off telling some kind of master narrative, and geology and glaciology take over.

Empty space

Celestial dynamics

Density

Rocks and planetary solids

Cryosphere⁴

4 The cryosphere includes the regions of the Earth's surface where water is solid in form: sea ice, lake ice, river ice, snow cover, glaciers, ice caps, ice sheets, permafrost.

What are the porosities and densities of ice and rock?

Pure ice at 0°C has a density of $917\text{kg}/\text{m}^3$

Water at 0°C has a density of $1000\text{kg}/\text{m}^3$

The density of solid rock ranges from 2500-2800kg/m³

Basalt magma has a density of 2650-2800kg/m³

Andesite magma has a density of 2450-2500kg/m³

Rhyolite magma has a density of 2180-2250kg/m³

Water's solid phase (ice⁵) is less dense than its liquid phase. This is why ice floats in water. Most solids are more dense than their liquids, and will sink, not float, in their liquid forms.

There are only four other substances in the universe which exhibit this same property as ice: diamond, gallium, germanium, and bismuth.

⁵ Ice¹: brightly toned, stately, subtle, silent, commanding, and forceful.

⁵ Ice²: color as suggestion of solidity.

5 Ice³: continues to densify as the temperature drops.

Oceans are often thought of as vast,
empty spaces⁶.

But the density of surface seawater ranges from 1020-1029kg/m³, and seawater's overall density fluctuates based on temperature and overall salt content.

Glaciers, formed from layers of ice made from compacted and accumulated snowfalls, are the results of ongoing densification processes.

The intense combined weights of these frozen layers cause glaciers to move, ever so gradually: down mountains, across plains, or to sea.

As they move, glaciers carry earthly material with them, re-forming the rocks, islands⁷, and landscapes over which they pass.

Liquid rock changes slightly when it transitions from magma, its underground form, to lava, its aboveground form.

Lava has a density of 3100kg/m^3 , and can be as hot as $700\text{-}1200^\circ\text{C}$ when it first erupts from a volcanic vent.

When it is fully solidified⁸, lava becomes igneous rock – one of the two most common types of rock found on the surface of the earth.

⁸ Solid: one of four fundamental states of matter, along with liquid, gas, and plasma. Solids are “characterized by structural rigidity and resistance to changes of shape or volume.”

8b Supersolid: "a spatially ordered material [a solid] with superfluid properties. Superfluidity is a special quantum state of matter in which a substance flows with zero viscosity [frictionless; smoother than water]."

8b2 Experimentalists have not yet been able to find, or create, a supersolid.

9 Island: where rock meets water, on all sides. A landscape where two distinct types of place, or space, meet each other and create an entirely new type of place, or space.

¹⁰ Empty spaces: held in balance, poised for change, and just on the line of structure, or nothing. Dynamic systems, based on suggestions of logic, but without an explanation as to the rules or forces which govern this logic – aside, perhaps, from some desire for beauty, which contributes.

¹⁰ Empty spaces, which resemble parts of the landscape

¹⁰ Empty¹¹ spaces and familiar,
reliable solids

11 Emptiness is vast, made up of endless attempts to uncover it, invisible layer after invisible layer.

