Five Mind-Bending Paradoxes In Modern Physics.

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1.- Bentley's Paradox In 1692, five years after the first publication of Principia, Rev. Richard Bentley wrote a dis-alarmingly simple yet distressing letter to Newton. He asked a simple question that even Newton had no answer.

The question was: Since gravity was always attractive and never repulsive, this meant that any collection of stars would naturally collapse into themselves. If the universe was finite, then the night sky instead of being eternal and static, the stars should plow into each other and coalesce into a fiery superstar. But he also pointed out that if the universe were infinite, then the force on any object, tugging it to the left or right, would also be infinite, and therefore the stars should be ripped to shreds in fiery cataclysms. Either possibility the universe was finite or infinite was a disaster for the young theory. This problem for the first time in history, revealed the subtle but inherent paradoxes that riddle any theory of gravity when applied to the entire universe.

Newton's response:
In his response to Bentley, Newton wrote that he would prefer an infinite universe but one that was totally uniform. A star that experiences an infinite force from the left also experiences the same amount of force from the right. The forces nullify each other leading to a stable stellar system. According to Newton, the universe was like a gigantic clock wound at the beginning of time by God, which has been ticking away ever since, according to the laws of motion, without divine interference.

Hence Newton's answer was "God" and he solved Bentley's paradox by claiming that god prevented the collapse by making constant interventions and corrections.

2.- Heat Death Paradox In 1862 Lord Kelvin, Hermann Helmholtz and William Rankine, formulated the heat death paradox, also known as Clausius's paradox. It is a reductio ad absurdum argument that uses thermodynamics to show the impossibility of an infinitely old universe.

The paradox: Assuming that the universe is eternal, a question arises: How is it that thermodynamic equilibrium has not already been achieved?

This paradox is based upon the classical model of the universe in which the universe is eternal. Clausius's paradox is a paradox of paradigm. It was necessary to amend the fundamental ideas about the universe, which brought about the change of the paradigm.
The paradox was solved when the paradigm was changed. There are at least two common resolutions to this. Lemme explain.

First is that it doesn't apply to a universe in a steady state where there is a continual destruction and recreation of energy and matter, a theory popular in the early/mid 20th century and, more pertinently, to a universe which does appear to have a starting point (the big bang).
There are many other cosmological theories around which even provide a variation on continuous recreation, but none of them suffer from the "heat death paradox" as none are closed systems in the manner required for classical thermodynamics to apply.

3. Fermi Paradox: The Fermi Paradox is a conjecture made by physicist Enrico Fermi, allegedly over lunch with Edward Teller, amongst others, at Los Alamos in 1950.

The idea is that if technology using life existed elsewhere in the galaxy, the odds are it would have visited by now, given the age of the galaxy and the relatively trivial amount of time it would take a civilization only moderately more advanced than ours to colonize the galaxy.
But why haven't we found an alien life yet? Why haven't they visited us? This is the basis of the,

Fermi paradox: despite there being so many stars out there with so many planets that could conceivably have their own civilizations, why haven't we heard from them?

4. Boltzmann brain: In the physical universe at large, the second law of thermodynamics says that entropy must increase over time—that is, everything will become less orderly.

It's possible, though, for certain areas of the universe to become slightly more orderly as the result of random fluctuations, as long as other parts of the universe become less orderly at the same time. Just a short strand of DNA is so intricately constructed that the probability of it arising as a result of "random fluctuations" in physical material is unthinkably small.
So how is it that there are billions of base pairs in a single cell, trillions of cells in a complex organism, and millions of species on Earth?!

Boltzmann brain is a thought experiment. In this thought experiment, a Boltzmann brain is a fully formed brain, complete with memories of a full human life in our universe, that arises due to extremely rare random fluctuations out of a state of thermodynamic equilibrium. Theoretically, over an extremely large but not infinite amount of time, by sheer chance, atoms in a void could spontaneously come together in such a way as to assemble a functioning human brain.
The BB paradox is an argument against the idea that the universe around us, with its incredibly low-entropy early conditions and consequential arrow of time, is simply a statistical fluctuation within some eternal system that spends most of its time in thermal equilibrium.

5. Black hole information paradox: Law of conservation of information is a core of quantum mechanics. Arguably, it has same importance as superposition principle. Information in terms of quantum mechanics is just a "state" situated within a quantum system (wave-function). Information cannot be created nor destroyed it means a quantum particle can be converted into energy during nuclear fission or fusion, but the precious information of the particle situated in its wavefunction cannot be destroyed.

But when a particle falls in event horizon of black hole it is thought that the particle along with its information is lost, since black hole breaks Time reversal symmetry.

When Stephen Hawking proposed his equations on thermodynamic radiation from black holes, it seemed that, information that was initially present in the particles constituting the radiation, is lost when the absorbed particles meet the singularity.

One of the solutions to the paradox was provided by the Holographic principle which tells that surface area of event horizon increases instead of volume. Information about consumed matter is encoded on the surface area.