The Cosmic Oasis Where We Live: Local Bubble

Frank Liu 14, Jan, 2024

When thinking about the location of where humans are, many would say the Earth, Solar System, Oort Cloud, Milky Way, and then come into the whole universe. However, something is missing between them, which will be discussed in the following.

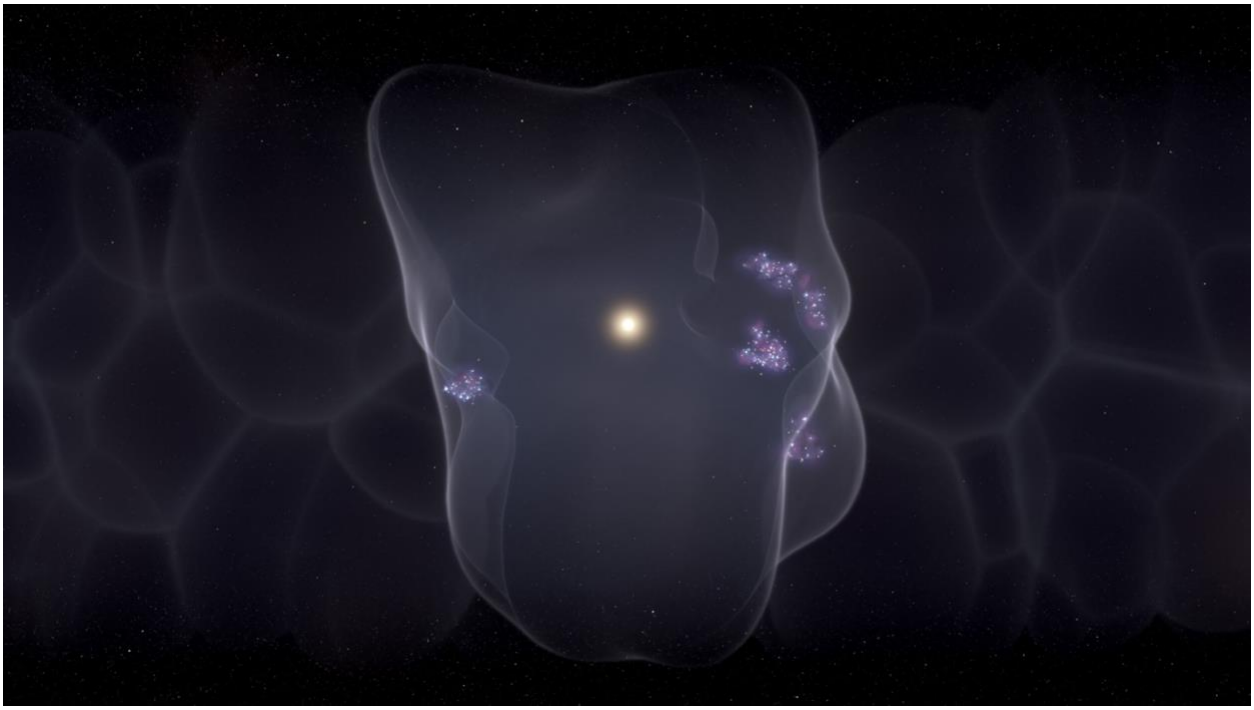
When talking about the local bubble, many may not have an idea what it is, the local bubble is a low-density and high-temperature plasma shell, and our solar system stays in the middle of it right now. What do I mean by right now? because the solar system kept traveling for 4.6 billion years when it was born. The solar system as recorded, has stayed in this local bubble for at least 3 million years.

The local bubble has a lower density of isms (interstellar medium) inside than outside, at the boundary of the bubble is a layer of cold, dense neutral gas and dust. Some people may think or learn the space is completely blank where there is no object there, the vacuum stays between them, but the ism stays there. The ism includes gas in ionic, atomic, and molecular form, as well as dust, and those ism were created by the supernova explosion or coming from the center of Milk Way. If we think of the whole universe as a giant cheese, then the local bubble and other bubbles are holes in the cheese made by the supernova explosions. The local bubble was born 14 million ago, as the start of the supernova explosion, throughout time till now, there have been about 15 supernova explosions, pushing the interstellar gas and medium outward.

"We've calculated that about 15 supernovae have gone off over millions of years to form the Local Bubble that we see today," says Zucker who is now a NASA Hubble Fellow at STScI.

The local bubble was also working as a “womb” for the birth of new stars, by the supernova explosions in the past, and the supernova's shock wave collects gas and dust into a thick, hollow shell that forms the surface of the local bubble. Gas and dust accumulated in local foam shells provide the necessary material for star formation. As the bubble expands, it compresses these clouds of gas and dust in the outer shell, creating conditions suitable for the birth of new stars. Meaning the new stars are mainly found on or near the surface of the local bubble, rather than within it. Even though the expansion of the local bubble has slowed, it still interacts with the surrounding interstellar medium. This continued expansion can still influence star formation

through interstellar material. By that, it comes into a void with a 1000 lightyear in diameter, and our solar system stays in the middle of it.



(Local Bubble)

Even now, the local bubble is also growing at the speed of four miles per second in radius. We have some other constellations in this local bubble community, acting as our “neighbors”, which are Corona Australis, Pipe, Ophiuchus, Lupus, Musca, Chamaeleon, and Taurus.

Now comes to here, some people may have some questions that remain unconvinced, like how exactly did the scientists found the local bubble, in other words, how did they detect the size, shape, and boundary of the local bubble? As mentioned above, talking about the local bubble is a sort of void in the universe, with the density of ism lower inside, this warm bubble diffuses gas that emits X-rays and contains less than one-tenth the normal amount of neutral hydrogen per unit volume. These properties provide two possible methodologies. First, X-ray telescopes like the ROSAT satellite can be used to detect radiation from within the bubble. Second, scientists can detect where the density of hydrogen increases substantially, which marks the boundary of the local bubble. In these two methods, astronomers can find out the shape and size of the local bubble.

(ROAST Satellite)

Another big question worth thinking about is why the local bubble is not “floating” in the space like the bubbles in water even though the density in the local bubble is much lower than the outside. The most direct answer would be that the cosmos is homogenous. On Earth, bubbles float due to buoyancy, essentially the weight of the fluid by Earth’s gravitational field. However, there is not a simple and dominant gravitational field around it to cause a “buoyancy”. So, just like an astronaut wandering in space, the local bubble is not floating in a certain direction. Also, the local bubble may have already finished “floating” and reached an equilibrium, staying in its current position for millions of years. Admittedly, the difference in pressure in different directions may lead to a net force on the local bubble, but ISM is influenced by a variety of factors, including interstellar magnetic fields, stellar winds, and gravity, and these factors work together to form a complex dynamic balance, rather than a simple rise or fall.

After all, what is the significance of this “hole-in-cheese” region? Foremost, one of the principal facts about the local bubble is its comparatively low density of ISMs inside, which means fewer disturbances by gas and a clearer view, contributing to more discoveries in the universe. It also helped with artificial spacecraft. A tiny piece of sand in space can be a fatal threat to spaceships, but low particle density in space alleviates the hazard. In addition, the lower density of the ISM leads to a lower density of celestial bodies, so supernova explosions and collisions between celestial bodies are less frequent, and there are also fewer high-energy particles and radiation that are detrimental to human beings.

There is one more thing intriguing about the local bubble. Scientists deduced that the solar system has traveled for at least 3 million years since it first entered it. Coincidentally, 3 million years ago on the Earth, the first group of human beings appeared as Homo, which is a critical point for human evolution. Did the local bubble play a vital role in the evolution of mankind? Although there is currently no substantial evidence to support this idea, it is certainly a question worth exploring in the future, and we will eventually find out.

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