What’s the Matter with the Missing Matter?

Eddy Su

It turns out what we think we know, and what we see don’t add up. There should be much more matter, or stuff, than we have been seeing in the universe.

In 1997, cosmologists predicted that there is a certain amount of matter in the universe. This prediction was that matter would make up 5 percent of the total mass and energy in the universe. However, it was found that about half of the predicted matter could not be found anywhere. This was done through a catalog or census of all the known stars, galaxies, and gas in the universe.

The first thing we must understand is what matter is. Matter here is referring to baryonic matter which is the protons and neutrons. These make up all the elements on the periodic table and essentially anything you know of other than dark matter. Dark matter is a more confusing topic that we will not address here, but it makes up much more of the universe than baryonic matter. The universe is predicted to be composed of 68 percent dark energy, 27 percent dark matter, and 5 percent baryonic matter.

One of the first theories that came up as a solution to all of the missing matter was called the WHIM. The term WHIM is an acronym for warm-hot intergalactic medium and refers to a prediction that there is a very low-density plasma, atoms, and molecules, at a million degrees all throughout the universe. Over the next two decades, there were several developments using X-ray observations. One of these developments occurred recently, in 2018, where the Chandra X-Ray observatory found extragalactic oxygen atoms supporting WHIM.

The problem here is, we did not actually have significant proof in the existence or the exact scale of WHIM. We were unsure if there would be 1 particle per cubic meter or ten; we only know that there is some amount that is too low for us to detect.
This is because, we did not have a method to detect such a low density

In 2007, a phenomenon was observed known as a fast radio burst, often referred to as a FRB. These FRBs are transient radio pulses that last very little time, ranging from a thousandth of a second to a couple of milliseconds. The rarity of these flares makes them hard to predict and localize. A new development has occurred where scientists have determined a method to trace back these FRBs to the galaxies that they originated from. By knowing the distance traveled of the FRBs, we can also calculate the amount of material the signal has passed through (Figure 1). This brings us to use FRBs to find low density areas all throughout the universe.

The first FRB detected and localized occurred quite recently, in April 2018. Astronomers using the ASKAP (Australian Square Kilometre Array Pathfinder) telescope detected the burst. This telescope is able to watch enormous portions of the sky and detect the FRBs. This FRB was then identified by the Keck telescope in Hawaii to originate from a galaxy 4 billion light years away.

Over the course of the next year, they were able to detect five more occurrences and used the dispersion among these six FRBs to make an approximation of the amount of matter the radio waves passed through before reaching our telescopes (Figure 2). This approximation created a curve that aligned with the 5 percent prediction of baryonic matter for the universe.

Although the result of the analysis of these FRBs is stunning, there is still a lot that we don’t know, such as the composition of the matter, and what the distribution of matter is throughout the universe. Also, we have to continue to obtain more information, as
there has been only six data points so far. As time goes on, we hope to continue to find more information in what and where the missing matter is.

**Sources Cited**

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