ESSAI

Volume 16 Article 25

Spring 2018

Static Universe

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(Chemistry 1551)

If you're ever having a bad day in which you believe your existence is meaningless, just remember that in the grand scheme of things, it is. There's over 400 billion stars in the Milky Way alone, making the amount of stars in the entire universe completely overwhelming. Couple this with the fact that the universe appears to be expanding at an increasing rate, and you really are nothing. However, human existence was not always so "minimal" given that about a century ago the common belief was that the universe was a finite being, excluded from any proliferation.

In the early 20th century the common worldview held that the universe is static. It was the astronomical understanding of the day that the Milky Way was the extent of the universe for at the time the stars in the Milky Way were not moving in any systematic way. Albert Einstein expressed this general opinion in 1917 after Willem de Sitter produced equations that could describe a universe that was expanding, which meant a universe with a beginning. Such a thought seemed foolish and was ultimately rejected by Einstein, claiming that such circumstances irritated him for at the time he was working on field equations that could describe the general layout of matter and space for universe as a whole. In order to settle the debate, Einstein and de Sitter met in order to criticise each other's models and attempt to create a new one. The result of this meeting was two cosmological models, two different solutions to the field equations, and both models needing adjustments (The Expanding Universe).

In De Sitter's model, the universe could only be stable if it contained *no* matter. De Sitter hoped the model might somehow be adjusted to describe the real universe, but only if the density of matter was close enough to zero. Perhaps the most notable thing about his theory involved the effect that an empty universe had on light - the farther away an object was in this universe, the more the light coming from it would seem to have a slowed down frequency (Shu).

Likewise, Einstein's model could not contain matter and still be stable. His equations showed that if the universe was indeed static, the gravitational attraction of the matter would make it all collapse in upon itself. Such a thought seemed ridiculous, for there was no reason to suppose that space was unstable. Thus, Einstein included a cosmological constant to account for the notion of a static universe. This cosmological constant acted as a repulsive force that would balance out gravity and ensure that the universe would not expand or contract if this constant was *not* zero. What's interesting about this however, is that Einstein himself admitted that the constant was only a hypothetical term and was only required for the purpose of making possible an internal equilibrium of matter. Therefore, Einstein discovered he could basically choose its value as long as the value itself reflected the right amount of curvature that required the universe to be considered "closed" (Section 3: Discovery of the Expanding Universe). This really just calls into question the validity of concepts coined by humans and our magnificent ability to twist such concepts as a type of coping mechanism to cope with the absurdity of the world around us. I mean just take Daylight Savings Time for example, but that is beside the point.

The journey to discover that the universe was actually an expanding entity had actually started years before Einstein began pioneering his theory of gravity. This can be attributed to the long series of observational developments in astronomy such as telescopes, instruments that recorded and analyzed light gathered by them, applying measurements to stars to measure distance, and the effort to measure spectra of galaxies eventually led to the realization of an ongoing cosmic expansion. With

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the help of photographs, astronomers began to measure the size of our universe, the Milky Way, by studying the fuzzy "nebulae" mixed in among the point-like images of stars. This proved to be somewhat difficult because they did not know whether these objects were nearby small systems where one star was forming or distant objects enormous like the Milky Way itself.

One of the most noteworthy observations that resulted from this new age of astronomical technology was made at the Lowell Observatory in Arizona. Its founder, Percival Lowell, suspected that spectral lines seen in the light from planetary nebulae, formed when a star can no longer support itself, might also be found in the spectra of spiral nebulae. His assistant Vesto Slipher was then asked by Lowell to get spectra of spiral nebulae. Slipher then realized that for nebulae with extended surfaces, the critical instrument was not a telescope but rather the exposure time needed to photograph spectra of nebulae.

Over the next two years, Slipher measured velocities for other spiral nebulae. The first few measurements revealed approaching nebulae on the south side of our galaxy and receding nebulae on the opposite side. Thus he argued, that it was our galaxy, not the nebulae, that was moving. By 1921 Slipher had velocity measurements for 25 spiral nebulae, but only 3 were approaching. This could really only be explained as the result of large velocities in random directions being imposed by a much smaller systematic contraction.

Fast forward to 1928 in which Edwin Hubble, working at the Mount Wilson Observatory, conducted a campaign to determine the distances of high-luminosity stars and to find out whether they were small systems in the Milky Way or distant systems as big as the Milky Way. A crucial question that was centered around his campaign was whether the frequency of their light differed from the light coming from closer nebulae? If one were to take the visible light spectrum into account today, one would note that a slower frequency corresponds to a longer wavelength of light. Thus, light that is closer to the red end of the spectrum. So in actuality, what Hubble and his assistant, Milton Humason, were seeking was the displacement of lines in the spectrum toward the red (what he coined as a "red shift"). The duo then obtained both velocities and distances which fundamentally led to a linear relationship of the greater the receding velocity of a nebula, the farther the distance. Hubble's study that the light from nebulae showed a “red shift” increasing with distance ruled out the possibility of the two models previously mentioned that were brought forth by Einstein and De Sitter. The universe was in fact not static, and it meant that the light from distant nebulae was red-shifted not from some light effect predicted by De Sitter, but because the nebulae were actually *moving away* (The Expanding Universe). Each of these galaxies was moving away from all the other galaxies! Space itself was expanding between them! There was no special point somewhere where the expansion itself had started, and really our galaxy and all other galaxies are inside that very place! If this idea doesn’t keep you up at night, I am not sure what does.

All in all, the expansion of the universe is seen as one of the most important scientific discoveries, and there have been many observations since Hubble’s relationship publication that have confirmed the model of an expanding universe. So in actuality, if you’re ever having an existential crisis on the vastness of the universe, you can blame Edwin Hubble for proposing an unquantifiable cosmos.

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