The Dark Secret About Dark Energy (And Its Effects)

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- Title: The Dark Energy Survey: Cosmology Results With $\sim$ 1500 New High-redshift Type Ia Supernovae Using The Full 5-year Dataset
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Have you ever wondered how far away some stars are from Earth? Do you ever think about why this might be the case? To put it simply, there is a mysterious force that seemingly moves them away from each other by expanding the size of the universe! This force is known as dark energy, and it has confused astronomers for decades. Despite knowing its existence, it is still a very new aspect of cosmology that is continually being researched and studied. Fortunately for us, quite a few studies have been performed that try to explain dark energy's strange behavior, like the study performed in this paper.

To understand what is actually being performed, we need to define the parameter that is being measured. Perhaps the most important parameter being studied are supernovae, which are large and powerful explosions of massive stars that occur during their last evolutionary stages of life. Certain kinds of supernova are actually extremely useful for determining the direct effects of dark energy; these are known as Type Ia supernovae, which are found in binary star systems (star systems with two stars). Once a Type Ia supernova explodes, its brightness can be measured directly. Depending on how far away it is from Earth due to the expansion rate of the universe, it can result in a measurement that stretches its light toward longer and redder wavelengths, hence the name redshift [1]. With these redshift measurements, it will provide the researchers in the paper clues as to how dark energy affects the distances or supernovae in the universe.

Now that we know the main parameter of interest, what kind of dataset was studied in the paper? The specific dataset of Type Ia supernovae used was provided by the Dark Energy Survey (DES), a supernova program that characterizes the properties of dark energy through different cosmological measurements. Included in this dataset were 5 years of old supernova data that had redshift measurements ranging from high to low. After a bit of recalibrating, machine-learning, and a bit of statistical analysis, their final sample size results in 1829 supernovae, 194 of which had a low redshift and the rest a high redshift. As a result, they named this specific sample DES-SN5YR and used it for all their analyzes [2]. Some of the analyzes performed include calibrating light curves for each supernova, measuring their exact distances from Earth, among a lot of other things. Other topics discussed in the paper, however, are also super complicated; regardless, there are still a lot of takeaways and conclusions that we can make about their findings and relate them back to our main topic of interest: dark energy!

After thorough investigation, the researchers find that there is indeed strong evidence that the universe expands due to the presence of dark energy. In particular, their sample of Type Ia supernovae had redshifts that were farther away than other supernova samples they compared. They also compared with different universe models (models that assume our universe is flat, dark energy is constant, dark energy varies with time, etc.) to determine how likely it was for dark energy to affect the universe in other ways. One of these ways was how dark energy acts; their findings point toward the fact that it may actually vary with time. Another was seeing how old the universe was, which they found to be younger than previously thought because of their assumption of a constant dark energy model instead. Although it may seem contradictory at first, assuming dark energy to act in different ways helps the researchers to make sense of what ways the universe changes and evolves over time.

This sample of Type Ia supernovae is not definitive, but it is a huge leap forward in terms of dark energy research in cosmology. With further improvements with machine-learning algorithms, larger sample sizes, and observation tools, we can hope that one day we can understand the true nature of dark energy and why it exists in the first place.

[1] Type Ia Supernovae, https://science.nasa.gov/mission/roman-space-telescope/type-ia-supernovae/, accessed: 2025-02-25.

[2] T. M. C. Abbot, M. Acevedo, M. Aguena, and A. Alarcon, The Dark Energy Survey: Cosmology Results With 1500 New High-redshift Type Ia Supernovae Using The Full 5-year Dataset, Arxiv **3**, 26 (2025).