XXVIIB. The Discovery of the Accelerating Universe (1999)

Ω AND Λ FROM 42 HIGH-REDSHIFT SUPERNOVAE, Perlmutter et. al. (1999)

Named by Science magazine as the 'Scientific Breakthrough of the Year" for 1998.

The Supernova Cosmology Project, SCP

Attempts to measure the deceleration parameter Λ were stymied for **lack of high-redshift supernovae**. The Supernova Cosmology Project was started in 1988 to address this problem. The primary goal of the project is the determination of the cosmological parameters of the universe using the magnitude-redshift relation of type Ia supernovae. The Project developed techniques, including instrumentation, analysis, and observing strategies, that make it possible to systematically study high-redshift supernovae. As of 1998 March, more than 75 type Ia supernovae at redshifts **z = 0.18 to 0.86** have been discovered and studied by the Supernova Cosmology Project. (Perlmutter et al.)

$z \quad \sigma_z \quad m_X^{peak} \quad \sigma_X^{peak} \quad A_X \quad K_{BX} \quad m_B^{peak} \quad m_B^{eff} \quad \sigma_{m_B^{eff}}$

$ZD := READPRN(\text{"SCP SNE IA DATA - Perlmutter Data Only.txt"})$ $\quad rows(ZD) = 42$

$zd := READPRN(\text{"CALAN-TOLOLO SNE IA DATA.txt"})$ $\quad rows(zd) = 18$

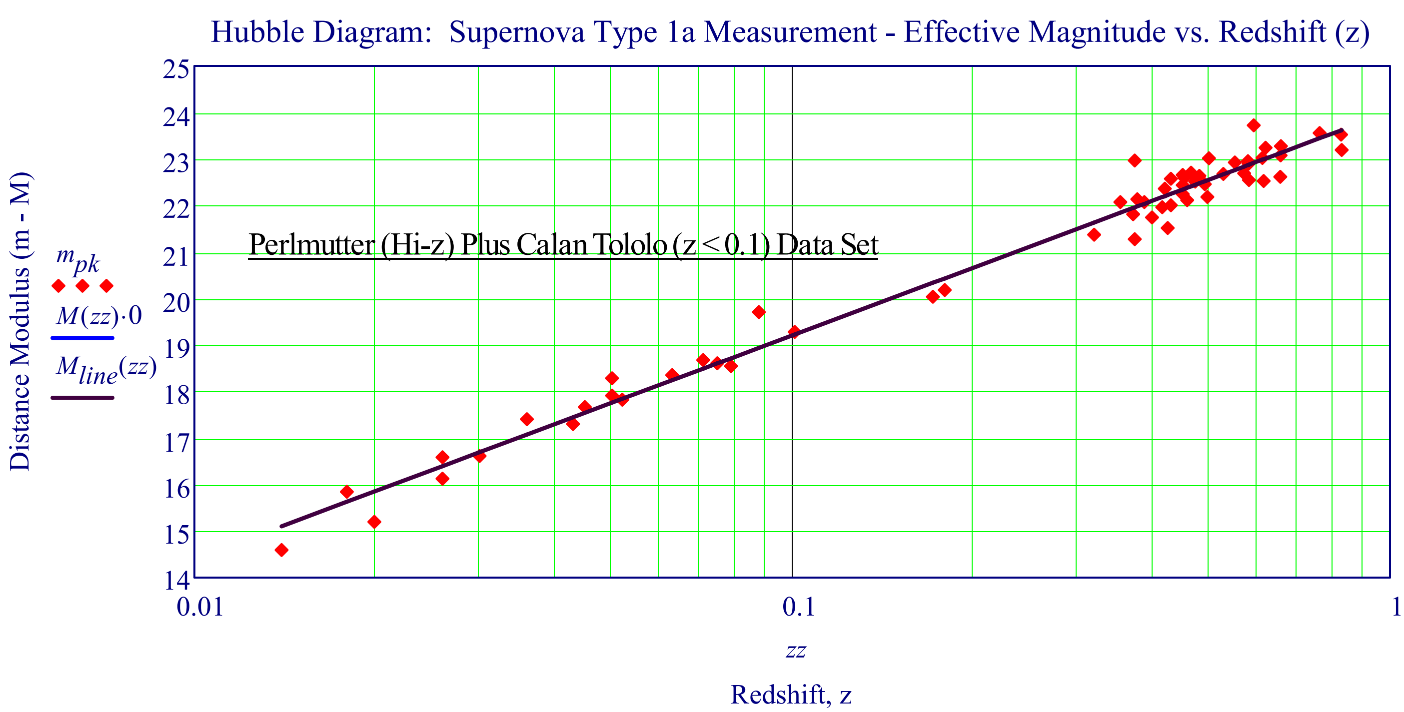
Merge Data Files: $ZD := stack(zd, ZD) \qquad ZD := csort(ZD, 0)$

Fit a Logfit Function and Straight Line to Magnitude vs. Redshift Data

$zz := ZD^{\langle 0 \rangle} \qquad max(zz) = 0.83 \qquad m_{pk} := ZD^{\langle 2 \rangle} \qquad max(m_{pk}) = 23.73$

$ab := logfit(zz, m_{pk}, vg) \qquad M(z) := ab_0 \cdot ln(z + ab_1) + ab_2$

$ba := line(log(zz), m_{pk}) \qquad M_{line}(z) := ba_0 + ba_1 \cdot log(z) \qquad ba_1 = 4.803$



Find the Percent of z > 0.1 Supernovae that are above the Regression Line, Mline

$$PercentAboveMean := \left(\sum_{n=30}^{59} if\left(m_{pk_n} - M_{line}(zz_n) > 0, 1, 0\right) \right) \frac{1}{30}$$

$PercentAboveMean = 56.667 \cdot \%$

This shows that the Velocities of the High z Galaxies are statistically increasing faster than the mean Hubble Constant. **The Expansion is Accelerating.**

XXVIIC. The 5 Year Dark Energy Survey (DESI) and Supernovae - 2024

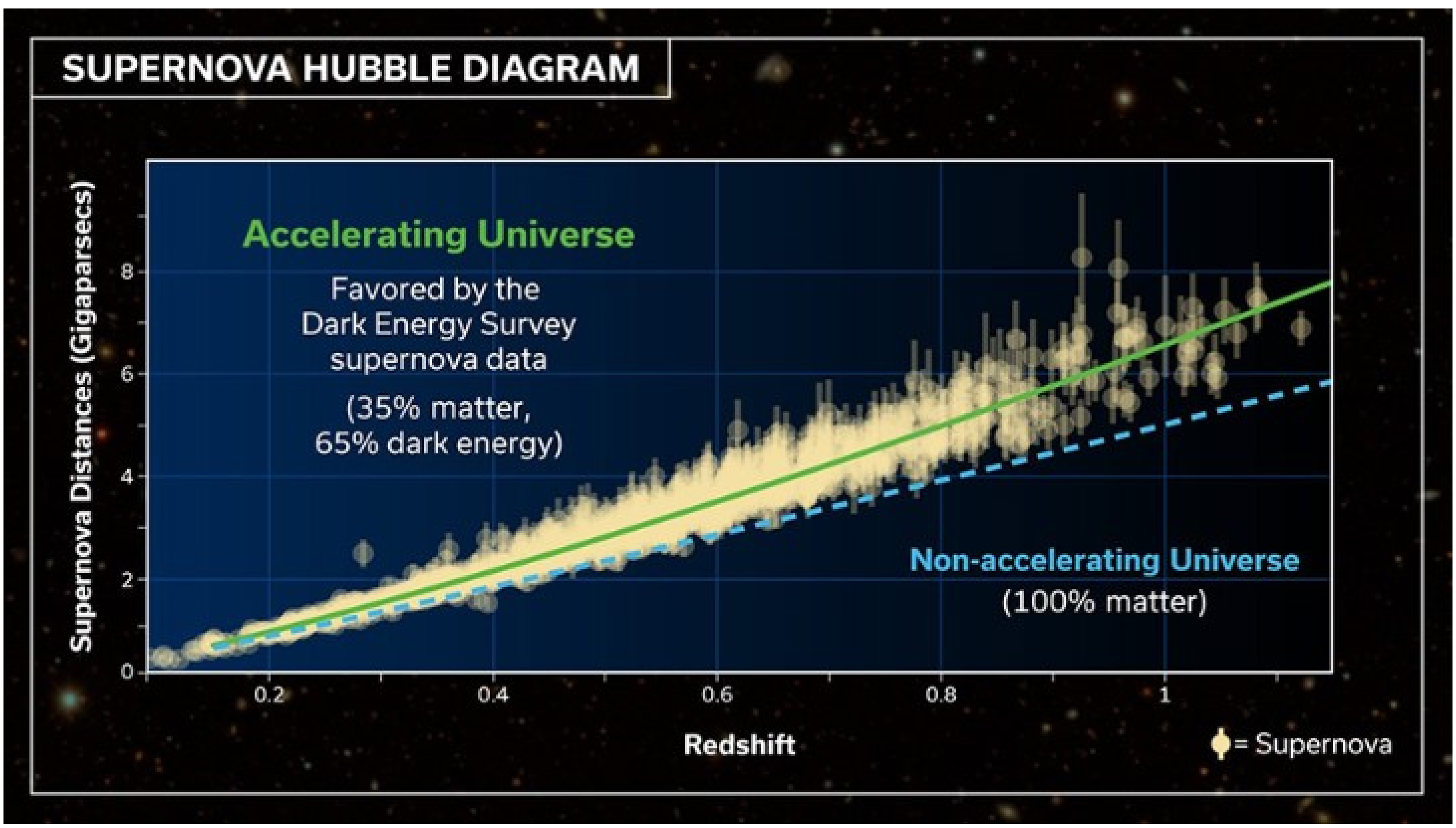
Refer to the Article:
The Dark Energy Survey (DES): Cosmology Results With ≈1500 New High-redshift Type Ia Supernovae Using The Full 5-year Dataset January 9, 2024 https://arxiv.org/abs/2401.02929

https://skyandtelescope.org/astronomy-news/cosmology/how-strong-is-dark-energy-intriguing-findings-from-new-supernova-catalog/

We have known for nearly 100 years that the universe is expanding. But only at the turn of the 21st century did astronomers discover that the expansion was actually speeding up.
Now, this new study suggests ***that this phenomenon might be weaker than we thought.***
The Previous value for Λ was 69%. This DES Study gives Λ = 65%. See Plot Below.

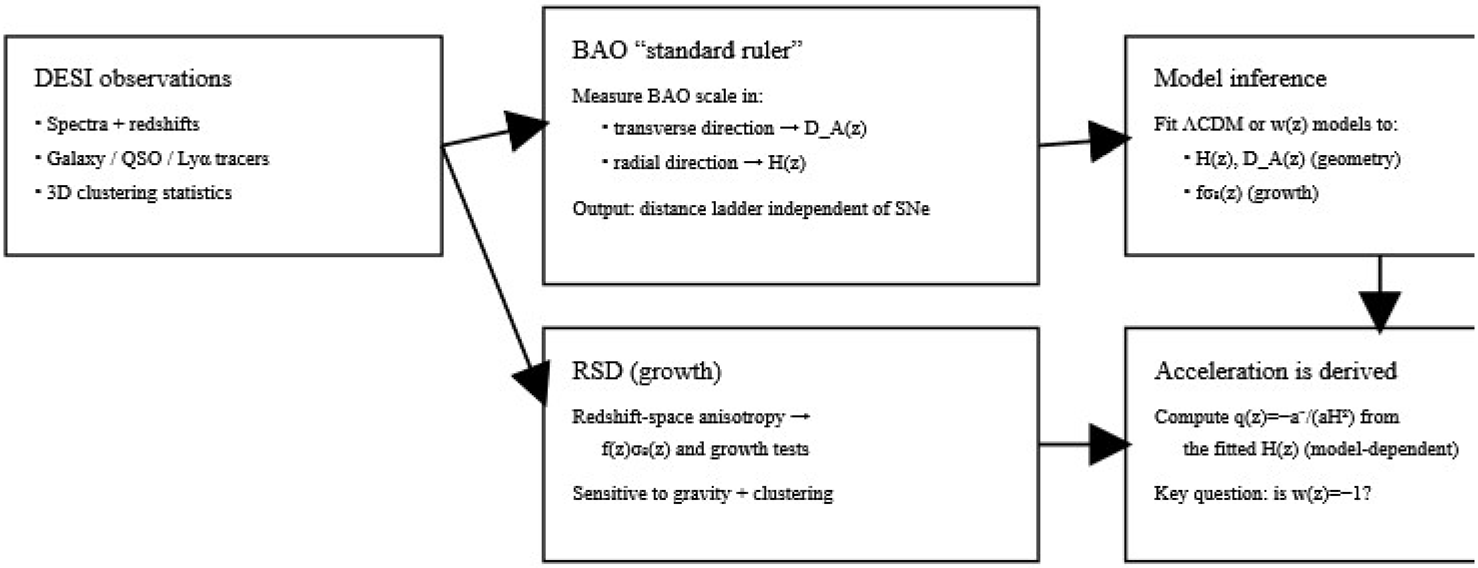
The largest sample of Type Ia supernovae ever made by a single telescope sheds light on dark energy.

The Dark Energy Survey (DES) was conceived to characterize the properties of dark matter and dark energy with **unprecedented precision and accuracy** through **four primary observational probes** (The Dark Energy Survey Collaboration 2005; Bernstein et al. 2012; Dark Energy Survey Collaboration 2016; Lahav et al.2020).
An example of a supernova discovered by the Dark Energy Survey (DES) within the field covered by one of the individual detectors in the Dark Energy Camera. The supernova exploded in a spiral galaxy with redshift = 0.04528, which corresponds to a light-travel time of about 0.6 billion years. This is one of the nearest supernovae in the sample. In the inset, the supernova is a small dot at the upper-right of the bright galaxy center. ***DES collaboration***



During a five-year survey, astronomers used a special camera mounted on the **Víctor M. Blanco 4-meter Telescope** at Cerro Tololo Inter-American Observatory to discover **1,635 Type Ia supernovae from hundreds of different galaxies** spread over a huge range of distances. The light from these supernovae is anywhere between 1 billion and 9 billion years old. Using the aforementioned standard-candle technique, the team calculated the universe's expansion rate — and **established the first good constraints on dark energy.**

How DESI Contains Expansion History and Dark Enegry



Takeaway: DESI tightly constrains $H(z)$ and $D\_A(z)$; "less acceleration" comes from best-fit model comparisons (ΛCDM vs evolving $w(z)$) across probes.

DESI: BAO/RSD to→ Expansion History to→ Inference: Acceleration or Not

DESI to BAO to Expansion Inferences

This section explains
How DESI observations constrain the cosmic expansion history and how claims about acceleration are inferred.

Result of DESI Survery.pdf

1. DESI Observations
The Dark Energy Spectroscopic Instrument (DESI) measures precise redshifts for galaxies, quasars, and the Lyman-a forest. These observations provide three-dimensional maps of large-scale structure.

2. Baryon Acoustic Oscillations (BAO) — Geometry
DESI measures the BAO feature as a standard ruler in galaxy clustering. The transverse BAO scale constrains the angular-diameter distance $D_A(z)$, while the radial BAO scale constrains the Hubble expansion rate H(z). These measurements provide a distance ladder independent of supernovae.

3. Redshift-Space Distortions (RSD) — Growth of Structure
Anisotropies in redshift space arise from galaxy peculiar velocities. DESI uses these redshift-space distortions to measure the growth rate of structure, typically expressed as $f(z)\sigma_8(z)$. These measurements test gravity and clustering physics.

4. Model Inference
Cosmological models such as ΛCDM or evolving dark energy parameterizations w(z) are fitted simultaneously to H(z), D_A(z), and fs8(z). The choice of model directly affects the inferred expansion history.

5. Acceleration Is Derived, Not Directly Observed
Cosmic acceleration is quantified by the deceleration parameter $q(z) = -(\ddot{a})/(aH^2)$. DESI does not measure $\ddot{a}$ directly. Instead, q(z) is computed from the best-fit H(z) after adopting a cosmological model. Therefore, conclusions about acceleration are model-dependent.

6. Interpretation of Recent DESI Results
DESI BAO measurements are consistent with ΛCDM, but when combined with other probes (CMB, supernovae, weak lensing), the data allow mild deviations from a constant dark-energy equation of state w = -1. These results weaken, but do not eliminate, the evidence for strong late-time acceleration.

Key takeaway: DESI tightly constrains the expansion history H(z). Statements about 'less acceleration' arise from comparing best-fit cosmological models, not from a direct measurement of acceleration itself.