# Are standard candles so standard after all?

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**Abstract**

The preprint of Son et al titled *Strong Progenitor Age-bias in Supernova Cosmology. II. Alignment with DESI BAO and Signs of a Non-Accelerating Universe* claims the standard candle assumption for supernovas fails. There is correlation with the peak luminosity and the age of the galaxy where the supernova resides. The conclusion is that the cosmic expansion, although it has been accelerating, is not accelerating anymore and might be even decelerating. Therefore there is no need for dark energy or at least that the cosmological constant is decreasing now.

Why would the progenitors in young galaxies have a lower peak luminosity than in old galaxies? Standard candles are typically white dwarfs, which are dead and do not shine anymore.

The TGD view of the formation of galaxies, of stars and stellar evolution differs dramatically from the standard narrative view and has strong analogies with biology. In particular, stars would be metabolizing entities and galactic blackholes would provide the metabolic energy feed as $M_{89}$ hadrons, which would arrive at the star along magnetic monopole flux tubes and decay to ordinary hadrons at its surface. Part of the nuclei would give rise to solar wind and part would remain at the surface of the star sink downwards forming a layer in which also "cold fusion" could occur as dark fusion and produce energy and heavier nuclei.

The star would die as this feed stops and become a white dwarf. Death could occur at any age. In young galaxies the white dwarfs would be necessarily younger than in old galaxies. In older galaxies the stars would have gathered more ordinary nuclei at their surface and the peak intensity of the supernova would be larger for them.

# 1 Introduction

Sabine Hossenfelder told about findings suggesting that the notion of dark energy might not be needed after all (see this). The analysis of 100 supernovae known as standard candles by Perlmutter, Schmidt and Reese led to the Nobel prize 2011. The recent study by Son et al involving more than 3000 supernovae that should be standard candles however suggested that the Nobel prize was premature.

The article titled *Strong Progenitor Age-bias in Supernova Cosmology. II. Alignment with DESI BAO and Signs of a Non-Accelerating Universe* [E1] (see this) concludes on basis of empirical data that the expansion, although it has been accelerating, is not accelerating anymore and might be even decelerating. The conclusion would be that there is no need for dark energy or at least that the cosmological constant is decreasing now.

Perlmutter, Schmidt and Reese studied supernovae of type Ia SNe known as standard candles assumed to have a peak luminosity, which does not depend on their age or the galaxy in which they belong. These supernovae typically have as progenitors which dwarfs, which are dead stars. These stars do not shine anymore. Since they can be regarded as the final states of stellar evolution, one can argue that their explosions yield the same peak luminosity so that they can serve as standard candles allowing a reliable determination of their distance from the redshift. If this were not the case, one should have a reliable model for the luminosity to deduce the distance.

The analysis of Son et al has, however, led to a conclusion that the luminosity of the standard candle correlates with the age of their progenitor. The younger the progenitor, the lower the peak luminosity. This conclusion is at 5.5 $\sigma$ level. Therefore the distances estimated on the basis of standard candle assumption using redshift are too large. The actual distances would be smaller and no acceleration would be needed in the recent cosmology. Already the earlier findings by DESI suggested that acceleration has been decreasing which could be understood as a decrease of the cosmological constant $\Lambda$. If these findings are true they mean that the $\Lambda CDM$ model is in grave difficulties. Even stellar models might be in difficulties if the properties of a white dwarf depend on the galactic environment they reside in.

The abstract of the article of Son et al gives a more technical summary.

*Supernova (SN) cosmology is based on the key assumption that the luminosity standardization process of Type Ia SNe remains invariant with progenitor age. However, direct and extensive age measurements of SN host galaxies reveal a significant* ($5.5\sigma$) *correlation between standardized SN magnitude and progenitor age, which is expected to introduce a serious systematic bias with redshift in SN cosmology. This systematic bias is largely uncorrected by the commonly used mass-step correction, as progenitor age and host galaxy mass evolve very differently with redshift.*

*After correcting for this age-bias as a function of redshift, the SN dataset aligns more closely with the w0waCDM model recently suggested by the DESI BAO project from a combined analysis using only BAO and CMB data. This result is further supported by an evolution-free test that uses only SNe from young, coeval host galaxies across the full redshift range. When the three cosmological probes (SNe, BAO, CMB) are combined, we find a significantly stronger* ($> 9\sigma$) *tension with the* $\Lambda CDM$ *model than that reported in the DESI papers, suggesting a time-varying dark energy equation of state in a currently non-accelerating universe.*

# 2 TGD view of standard candles

What could be the interpretation of this finding challenging the notion of standard candles in the TGD framework?

## 2.1 TGD view of cosmology

Consider first the TGD based view of cosmology discussed in [L6].

1. In the TGD Universe cosmological constant-like parameter appears as a multiplier of the volume term of the action containing also Kähler action if the twistor lift of TGD, fixing the choice of $H = M^4 \times CP_2$ is accepted. $\Lambda$ is inversely proportional to the square of the p-adic length scale characterizing the size scale of the space-time sheet and is proposed to satisfy the p-adic length scales hypothesis favor primes near powers of 2. An entire hierarchy of cosmological constants is predicted [L6].

   If the observations determine the value of the cosmological constant reflect the p-adic size scale of the observable Universe at the moment when the radiation was emitted. Since this p-adic size scale correlates with the cosmic age, the observed cosmological constant should decrease with cosmic time. This could explain DESI observations.

2. Primordial cosmology is dominated by cosmic strings, unstable against thickening to monopole flux tubes. Flux tubes are characterized by thickness and length [L1]. The scale defined by the cosmological constant emerging naturally in the twistor lift of TGD [K1] corresponds to the p-adic length assignable to the length of the cosmic string.

   The flux tube thickness corresponding to the cosmological constant for standard cosmology is estimated to be about $10^{-4}$ meters. Also thinner and thicker flux tubes are possible and one cannot exclude space-time regions, which are small deformations of pieces of $M^4$ with a non-vanishing cosmological constant. Long cosmic strings explain galactic dark matter as energy of a cosmic string or a bundle of them transversal to the galactic plane.

3. Instead of gravitational condensation, the formation mechanism for the galaxies and stars in the TGD Universe is the thickening of the cosmic string leading to a liberation of its energy and the formation of flux tube tangles. This process would have been initiated by the topologically unavoidable collisions of cosmic strings.

   This mechanism is analogous to inflation [L6, L4, L5, L8, L10] but quantum coherence in astrophysical scales due the arbitrarily large values of gravitational and electric Planck constants [L2, L3] makes exponential expansion un-necessary.

## 2.2 A TGD based view of stellar physics

TGD also suggests a radical modification of stellar physics and stellar evolution [L7] based on new physics predicted by TGD [L9]. This new view leads to a new view of how standard candles fail to be so standard.

1. TGD also allows to consider a radically new view of the Sun itself [L7] based on the TGD based generalization of the standard model predicting a hierarchy of fractally scaled variants of the standard model [L9]. The surface layers in which a phase transition transforming $M_{89}$ hadrons to ordinary hadrons would produce solar wind and solar energy, rather than the fusion in the stellar core.

2. There would be the analog of metabolic energy feed as $M_{89}$ hadrons from the galactic nucleus to the surface of the Sun. Interestingly, the spin axis of the galactic blackhole points towards the Earth.

3. In the Universe of the standard model, star ages as nuclear fusion burns the nuclear fuel in the core. In the TGD Universe, the fuel would be $M_{89}$ hadrons decaying to ordinary nuclei, producing solar wind and radiation, and forming a layer at the surface of the star rather than in its core. The heavier nuclei in the layer would sink to lower depths just as in the case of Earth. This suggests that the thickness of the layer of ordinary nuclei at the surface of the star increases with its age.

4. What could prevent the gravitational collapse of the star? Do the ordinary nuclei at the surface generate the pressure opposing gravitational force? There is indeed evidence for a solid phase in the surface of the Sun [E2]. In the white dwarfs of the standard model, the fusion has ceased in the standard model and they produce only thermal radiation as they cool to eventually collapse to form a supernova. Also in the TGD framework, gravitational collapse leading to a supernova explosion occurs when the feed of $M_{89}$ hadrons from the galactic nucleus has stopped and the star becomes a white dwarf.

5. The star with too low metabolic energy feed from the galactic blackhole starves and dies. Could stars die also at a young age, just as we can do? If so, there would be a spectrum of white dwarfs and standard candles characterized by their life spans.

## 2.3 Standard candles are not so standard in the TGD Universe

Why would the liberated energy, or at least the peak luminosity, be lower in the supernova explosion of the white dwarfs in galaxies of the earlier Universe?

1. Could the reason be that they have not had enough time to collect ordinary matter at their surface serving in a role analogous to fat forming lipid layers of cells before the $M_{89}$ hadron feed ceased? The biological analogy suggests that "cold fusion" as dark fusion at the surface layers could act like fat and produce energy and perhaps even solar wind and radiation energy when the $M_{89}$ hadron feed has ceased.

2. What is important, that the very selection of the white dwarf in early cosmology would select a star that died at a young age! In old galaxies the still existing white dwarfs would have reached a higher age!

3. Why should the metabolic energy feed relate to the activity of the galaxies? Dead galaxies do not give rise to a formation of stars. Is the reason that the metabolic energy source in f the galactic blackhole has depleted? Or have the long monopole flux tube pairs feeding $M_{89}$ hadrons split by reconnections to short closed fluxed tubes? This mechanism could also explain solar spots and the solar cycle and also the changes of the orientation of the Earth's magnetic field. Could the failure of metabolic energy feed also explain the death of a star?

This view would conform with the gradually emerging vision that life, death and consciousness are universal and present in all scales and that the basic phenomena of biology could have counterparts even in stellar and galactic physics.

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