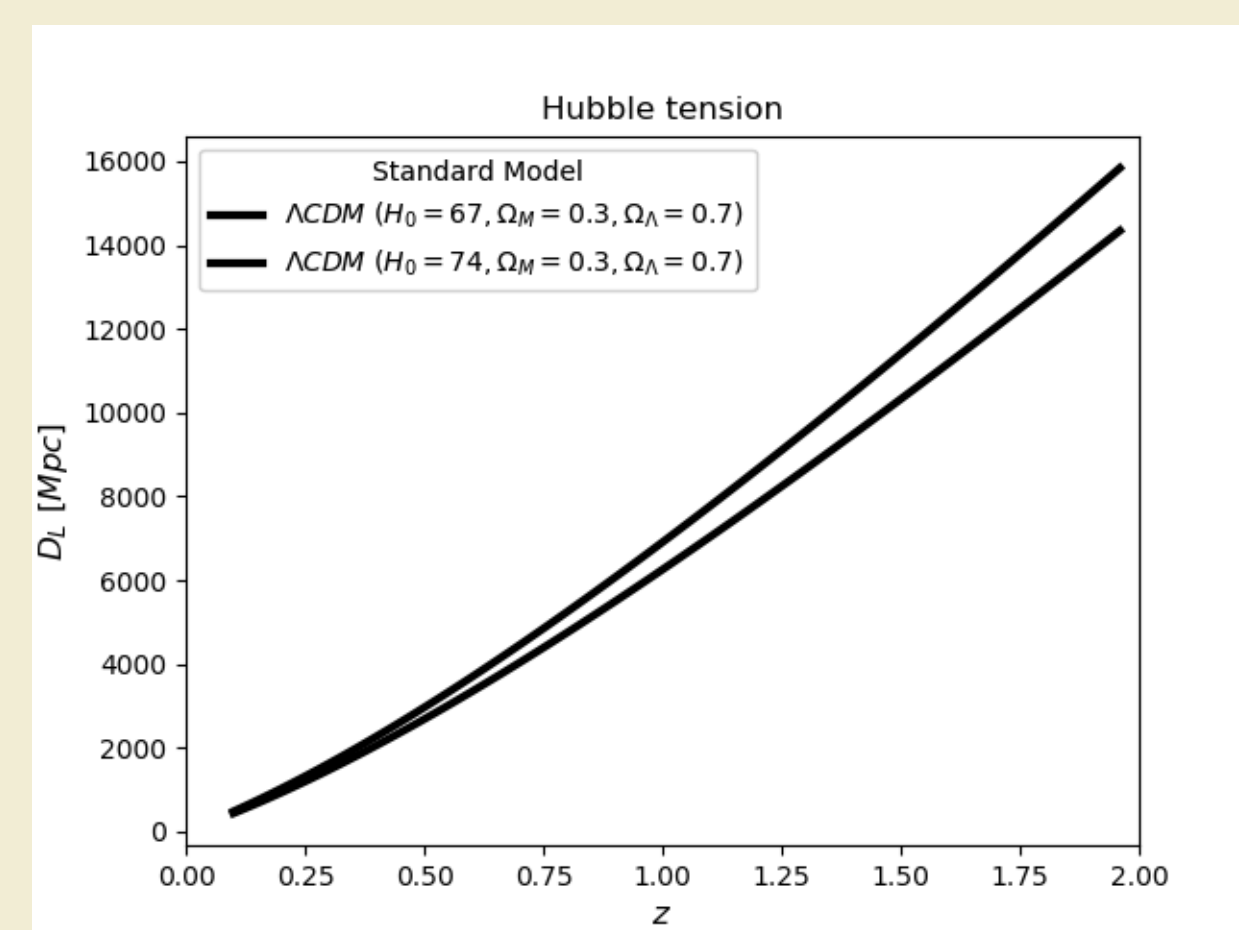


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## Abstract

This work shows how the misleading k-correction applied to Type-Ia supernovae data is one of the causes of the Hubble tension. The other cause comes from an inappropriate relation stated between luminosity and angular distances. Fortunately (or unfortunately), both mistakes almost cancel out providing a close to reality LCDM model, but with some persisting Hubble tension. Applying a more appropriate C-correction to JLA type Ia supernovae sample, along with the luminosity-angular distance relation provided by the Expansion Lensing paradigm, a  $\Lambda$ -Matter universe is inferred. The Hubble tension comes therefore from the different inferred universes derived from Type Ia supernovae and CMB data analysis.

### Hubble tension



consensus cosmology is broken

### $\Lambda$ CDM universe: cause of tension

Theory formulation  
 Theoretical physicist

errors at frontier

Theory validation  
 Experimental physicist

errors at frontier

Instrumentation  
 Engineering/Physicist

JLA Supernovae analysis

Misleading:  $D_L = D_A(1+z)^2$

$\Rightarrow$  errors partially canceled  
 $\Rightarrow$  seemed to agree with  $\Lambda$ CDM

Misleading: K-correction

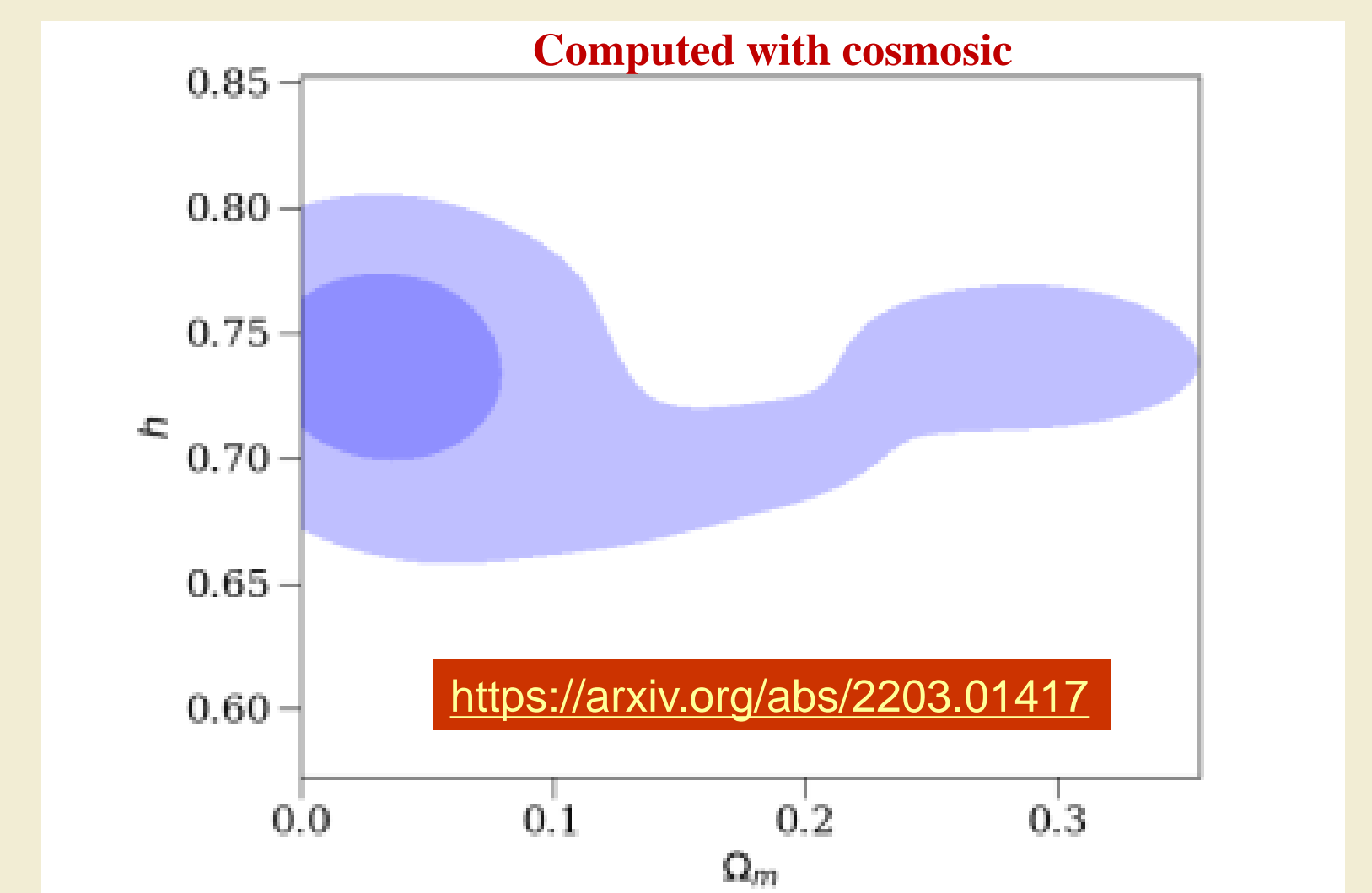
but Hubble tension appeared  
 revealing the faults

### $\Lambda$ -Matter universe

JLA Supernovae analysis

Expansion lensing:  $D_L = D_A(1+z)$

C-correction



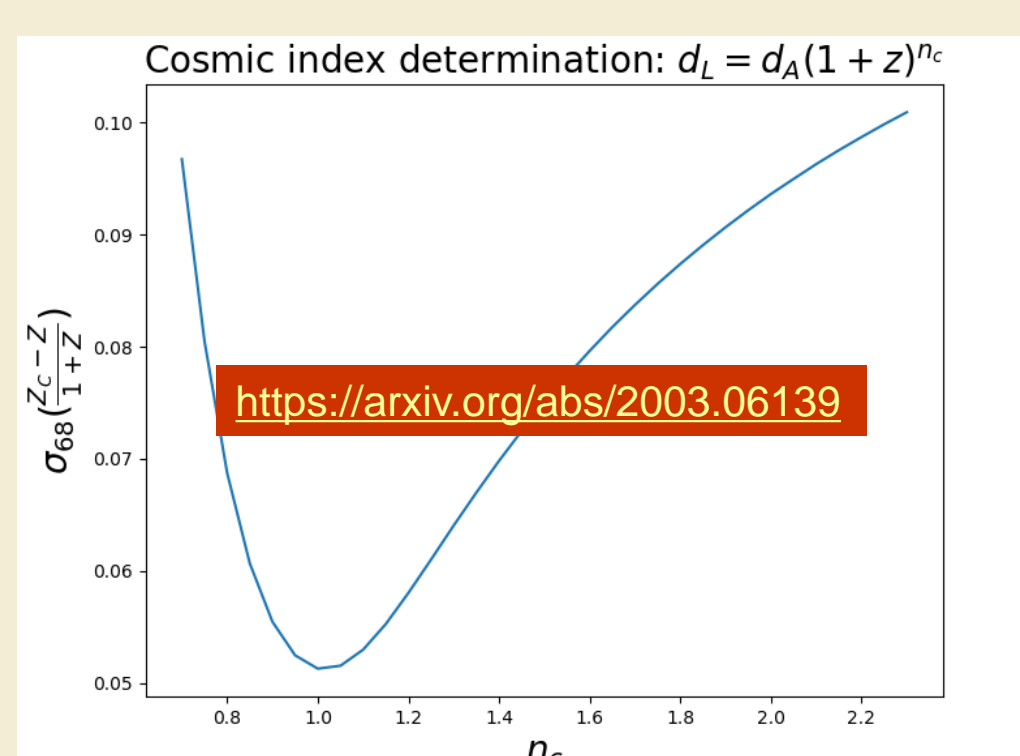
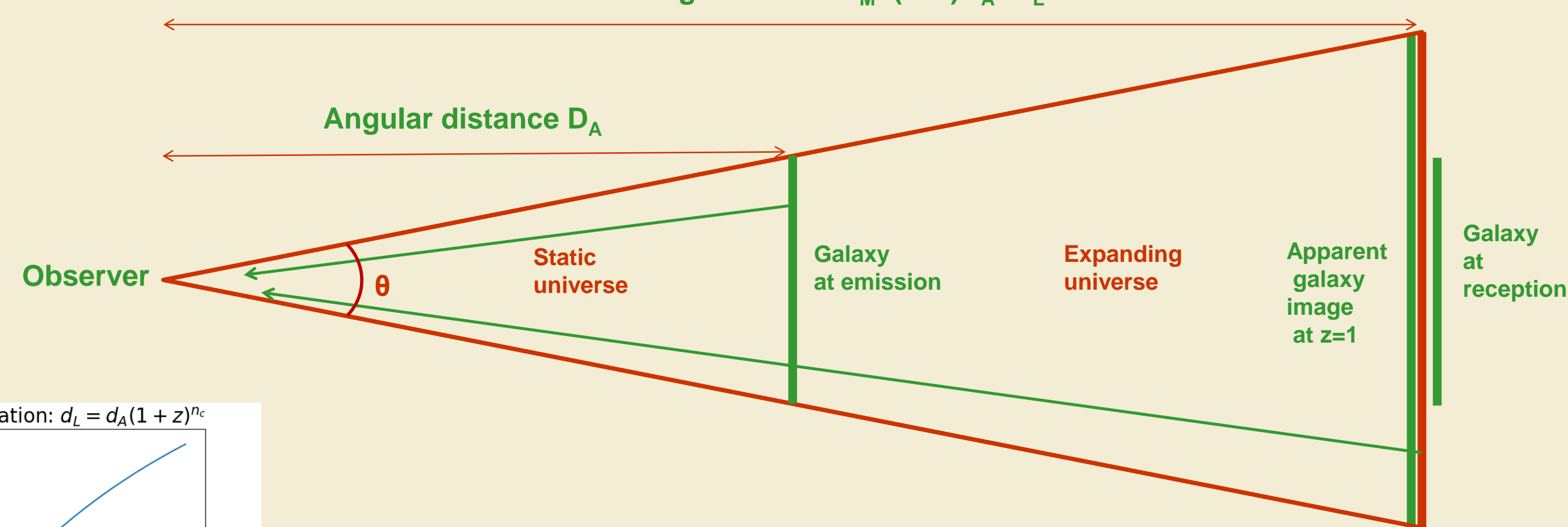
Agrees with SH0ES  $H_0$  measure

## Expansion Lensing -- deduced from FLRW metric

$D_A = S/\theta$  defines the angular distance for both static and expanding universes

- $D_A$  is the same for both universes since corresponds to the distance at time of emission
- $S$  (size of the object) is also the same in static and expanding universes
  - $\Rightarrow \theta$  (the subtended angle by the image of a galaxy) is the same in both universes
  - $\Rightarrow$  there is not flux dispersion in an expanding universe
  - $\Rightarrow$  the flux dilution comes uniquely from light rays path elongation (that delays the photons and hence dilute the flux) and from the wavelength increment
  - $\Rightarrow$  both phenomena are explained by an unique  $(1+z)$  factor

Comoving distance  $D_M = (1+z)D_A = D_L$



### Redshift relations

$$\lambda' = \lambda/(1+z) \quad \text{and} \quad d\lambda' = d\lambda/(1+z)$$

### K-correction

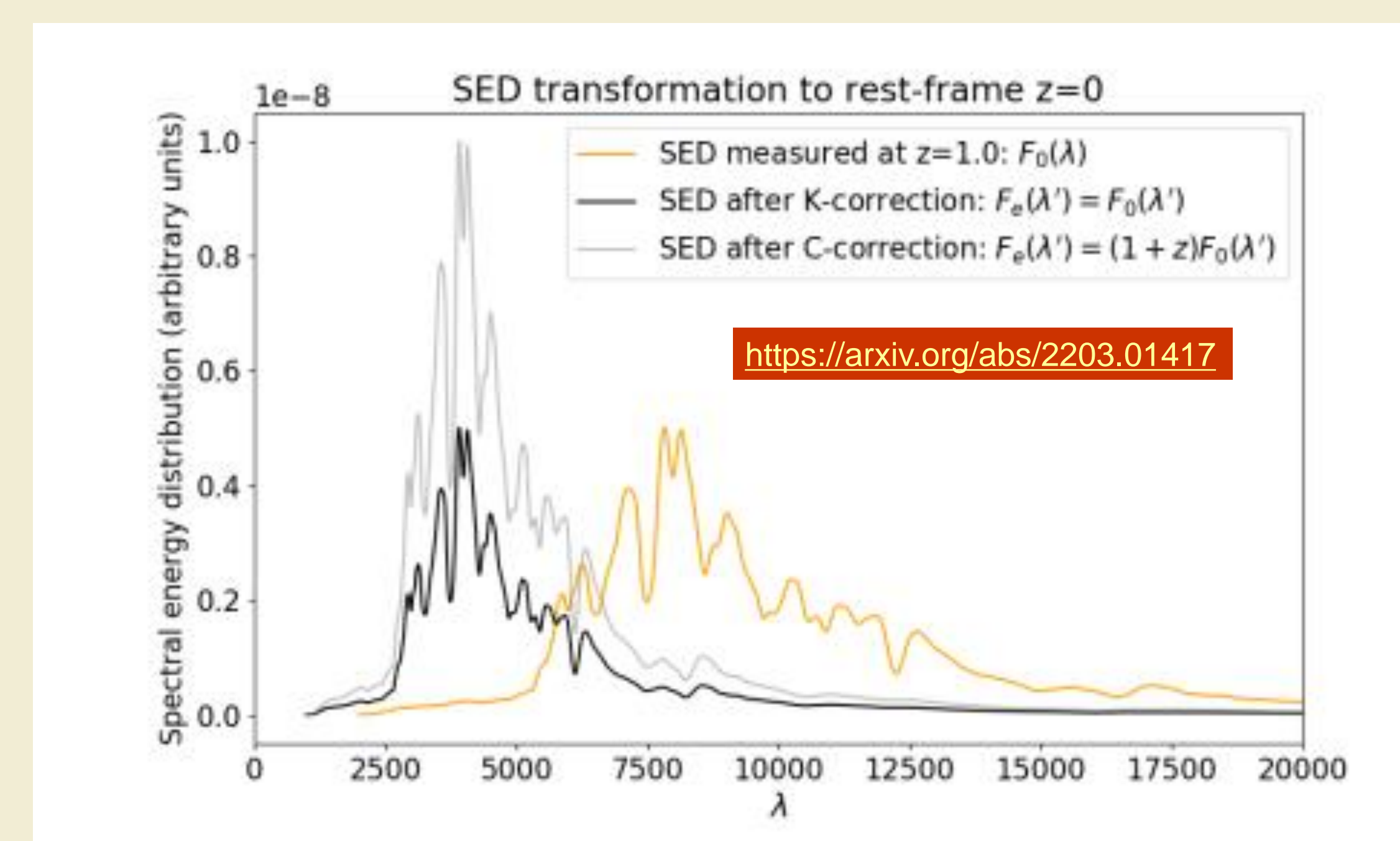
$$\int F(\lambda)d\lambda = \int F(\lambda')d\lambda'$$

Improperly accomplished change of variable (downgrades de actual flux measured)

### C-correction

$$\int F(\lambda)d\lambda = \int F(\lambda')(1+z)d\lambda'$$

Rightly performed change of variable



## CONCLUSION

A misleading luminosity-angular distances relation has been transmitted along the last century in spite the proper equation was already formulated from General Relativity by Etherington at thirties. A detailed inspection of Friedmann-Lemaître-Robertson-Walker (FLRW) metric reveals the expansion lensing paradigm, and hence the right luminosity-angular distances equation. On the other side, an improperly accomplished change of variable on k-correction drives to downgrading the measured flux of Type Ia supernovae. Addressing both flaws in the JLA Supernovae sample drives to a  $\Lambda$ -Matter (baryonic) universe.

## REFERENCES

<https://arxiv.org/abs/2003.05307>

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<https://arxiv.org/abs/2203.01417>

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