Isaac Tutusaus

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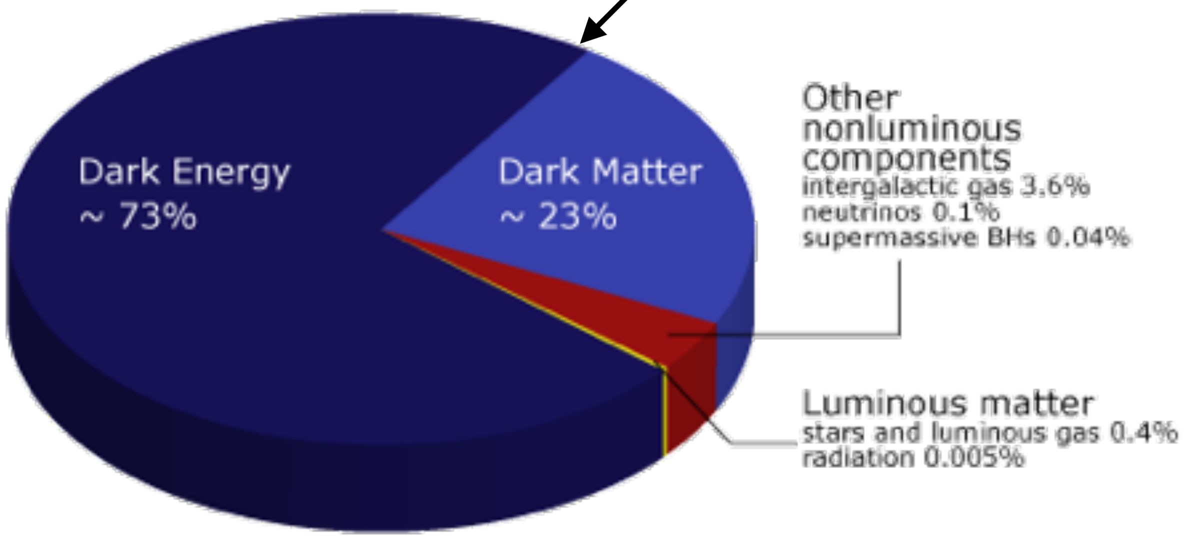
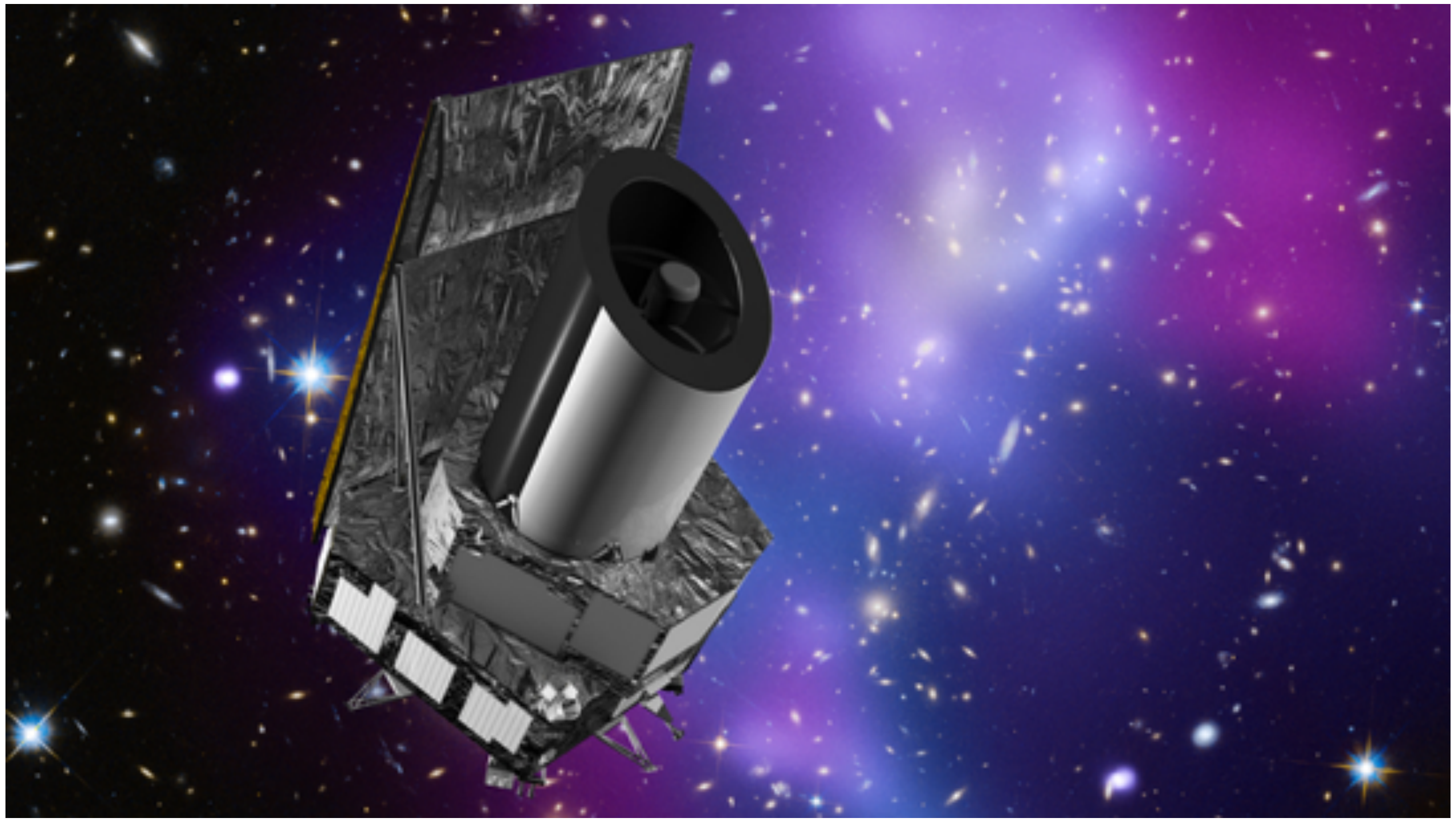
Study of the dark components of the Universe with the Euclid mission





Credit: ESA/C. Carreau

Dark sectors of the Universe: A Euclid survey approach (I. Tutusaus *et al.* 2016b)

Do we really know the nature of the so-called dark matter?

- Dark matter beyond CDM have been investigated within specific models:
  - Mass, decay rate and annihilation cross section for DM particles.
  - Interactions of DM with Standard Model particles (photons, neutrinos,…)
  - Interaction of DM with dark radiation.
  - Axions, collisionless WDM, collisionless massive neutrinos,…

- Or in a generalized parameterization of the ideal CDM simple pressureless fluid:
  - Three parameters are introduced: the equation of state parameter, the sound speed and the viscosity

$$\epsilon(\eta) = \frac{P_{GDM}(\eta)}{\rho_{GDM}(\eta)} \qquad c_s^2(\eta, \vec{x}) \qquad c_{vis}^2(\eta, \vec{x})$$

What happens with dark energy if we relax the pressureless hypothesis of dark matter?

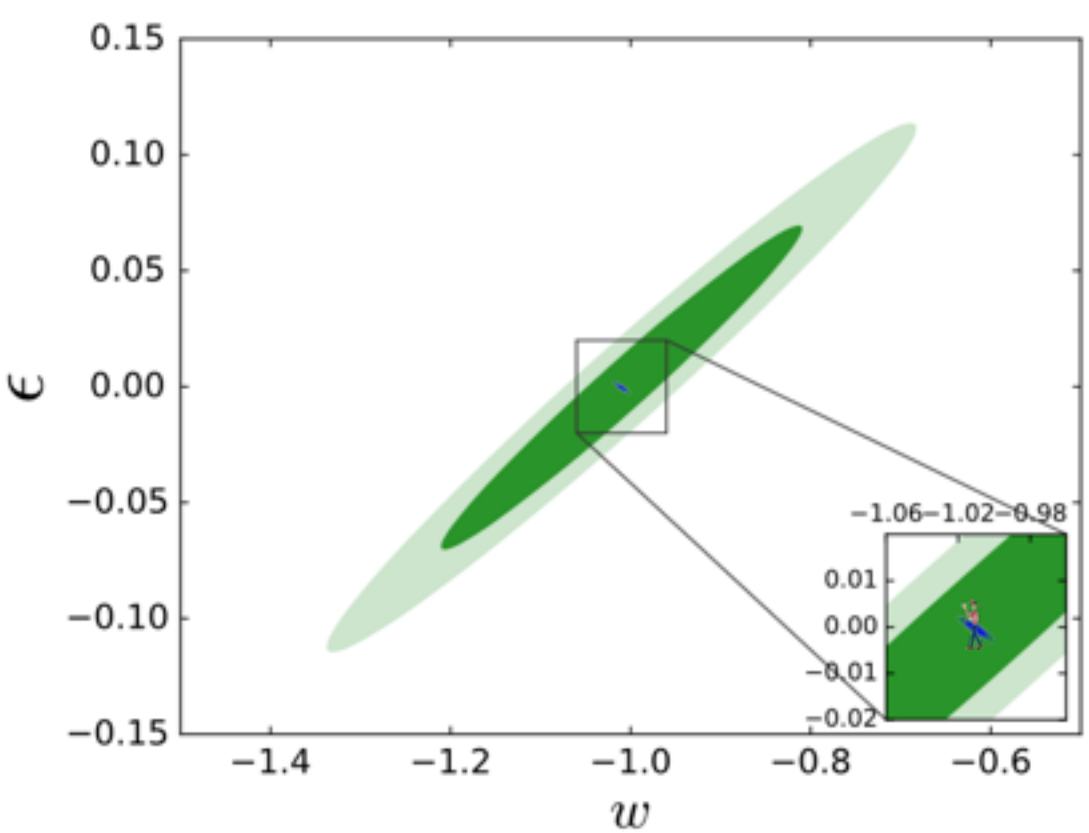
- We consider a simple generalized dark matter model with nonvanishing constant equation of state parameter, but keeping the sound speed and the viscosity equal to zero.
- We allow for a constant equation of state parameter for dark energy.

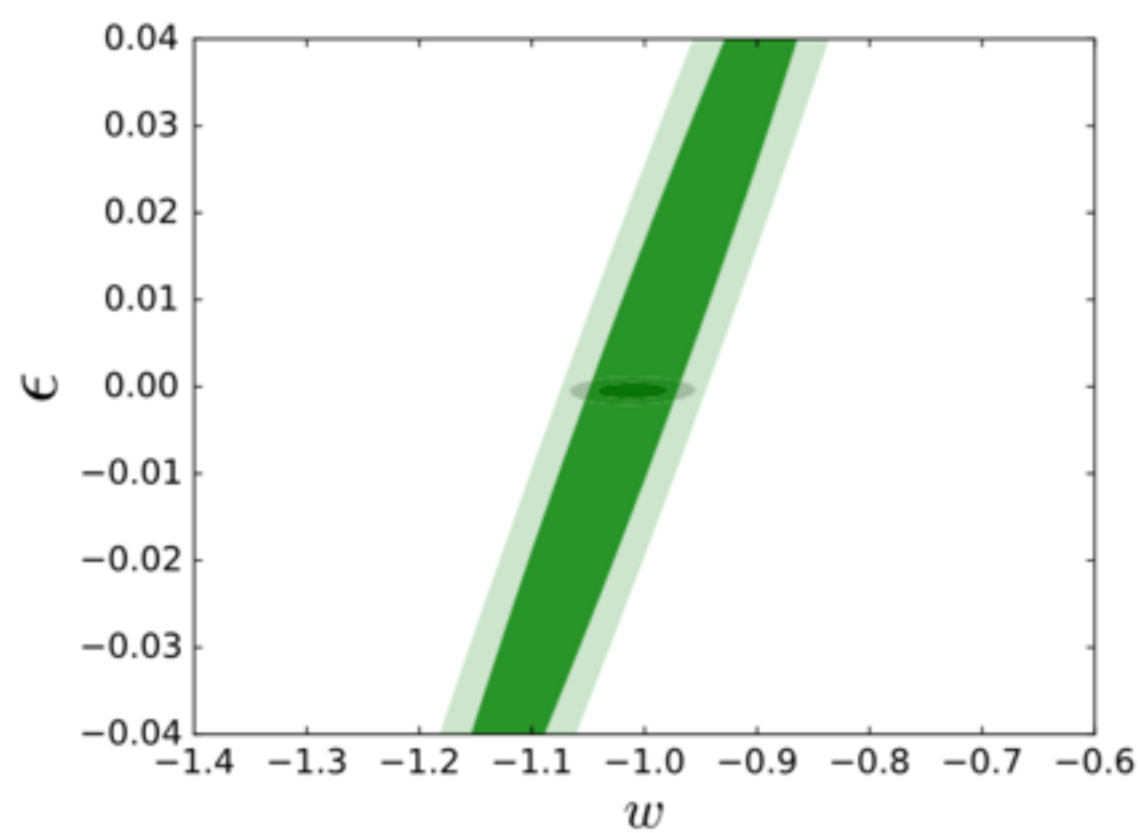
Dark sectors of the Universe: A Euclid survey approach (I. Tutusaus *et al.* 2016b)

What happens if we relax the pressureless hypothesis of dark matter?

Conclusions:

- Present-day low-redshift data constraints are strongly degraded, showing a degeneracy between the equation of state parameters of the dark components.
- The addition of CMB data restores the expected precision on DE thanks to its constraint on ϵ.
- The Euclid redshift galaxy survey is expected to break the above degeneracy, although the high accuracy on DE equation of state parameter is lost.
- Combining Euclid with the CMB restores the expected exquisite precision of the Euclid survey on DE, even allowing for a nonpressureless dark matter component.

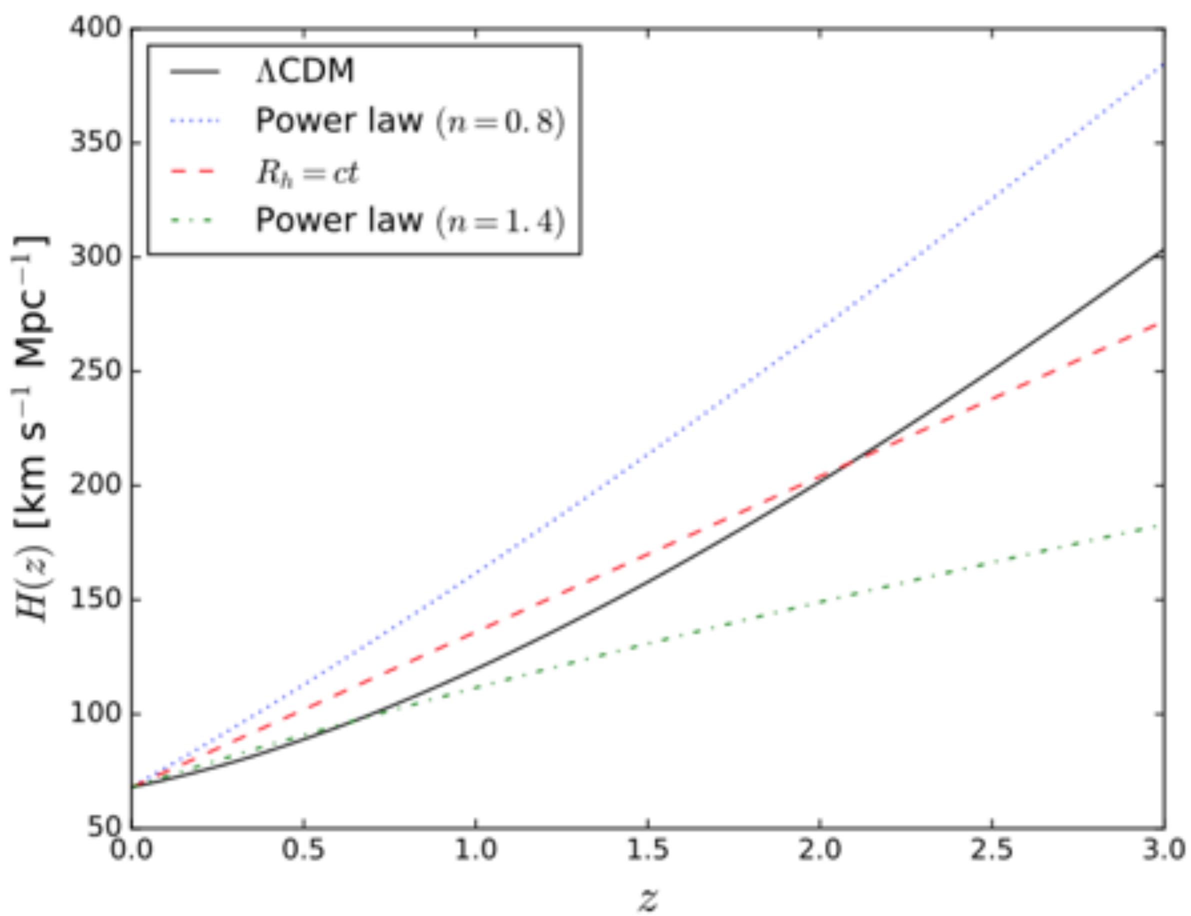




Power law cosmology model comparison with CMB scale information (I. Tutusaus *et al.* 2016a)

Do we really need to distinguish between the dark sectors of the Universe?

- The power law expansion of the Universe scale radius, $R(t) \propto t^n$, and the $R_h = ct$ Melià model have been proposed as alternative frameworks to the standard ΛCDM model.
  - They predict a power law and a nonaccelerated expansion of the Universe, respectively, without distinguishing the dark components.
- Only low-redshift data have been used to test these models.
- We have included information coming from the CMB in a model independent way.

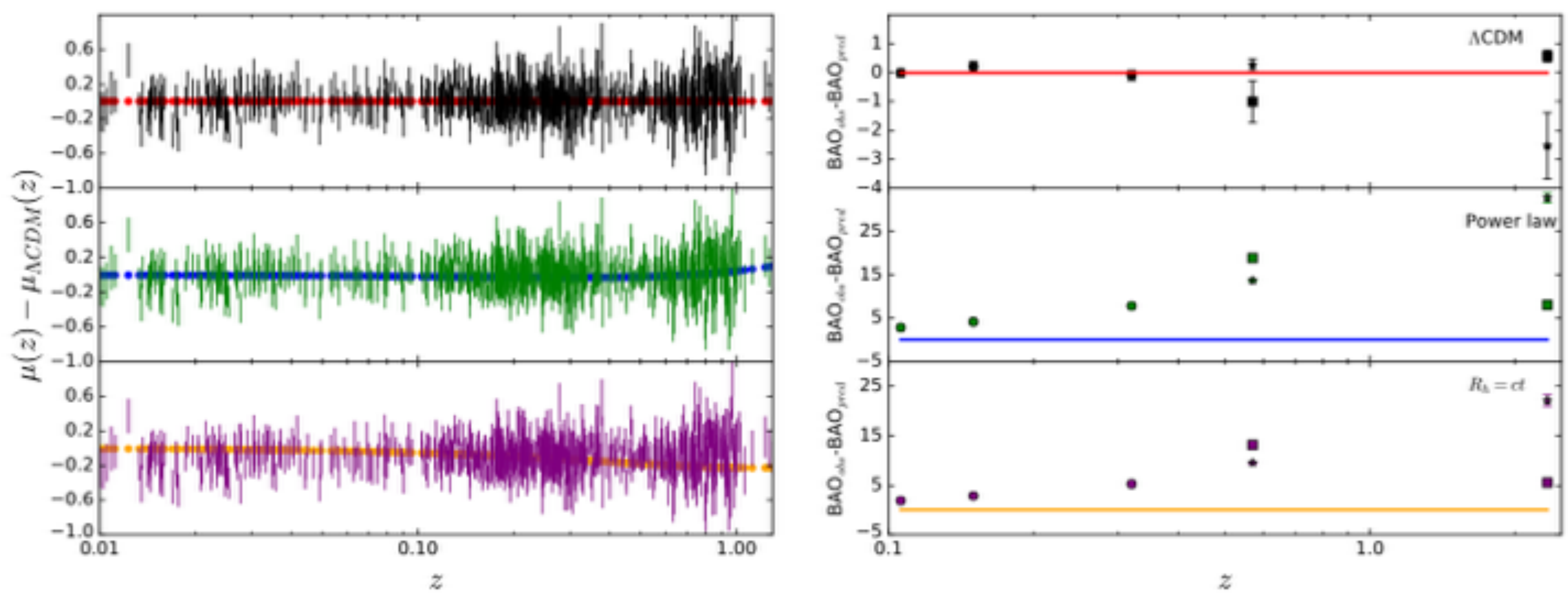


Power law cosmology model comparison with CMB scale information (I. Tutusaus *et al.* 2016a)

Do we really need to distinguish between the dark sectors of the Universe?

Conclusions:

- A power law expansion can predict the SNIa observations either alone or combined with BAO data, but the $R_h = ct$ is clearly disfavored with respect to ΛCDM.
- When adding CMB data we find that the power law and the $R_h = ct$ models cannot account for both low-redshift and CMB data.
- Both models are ruled out when considering all the expansion history of the Universe.



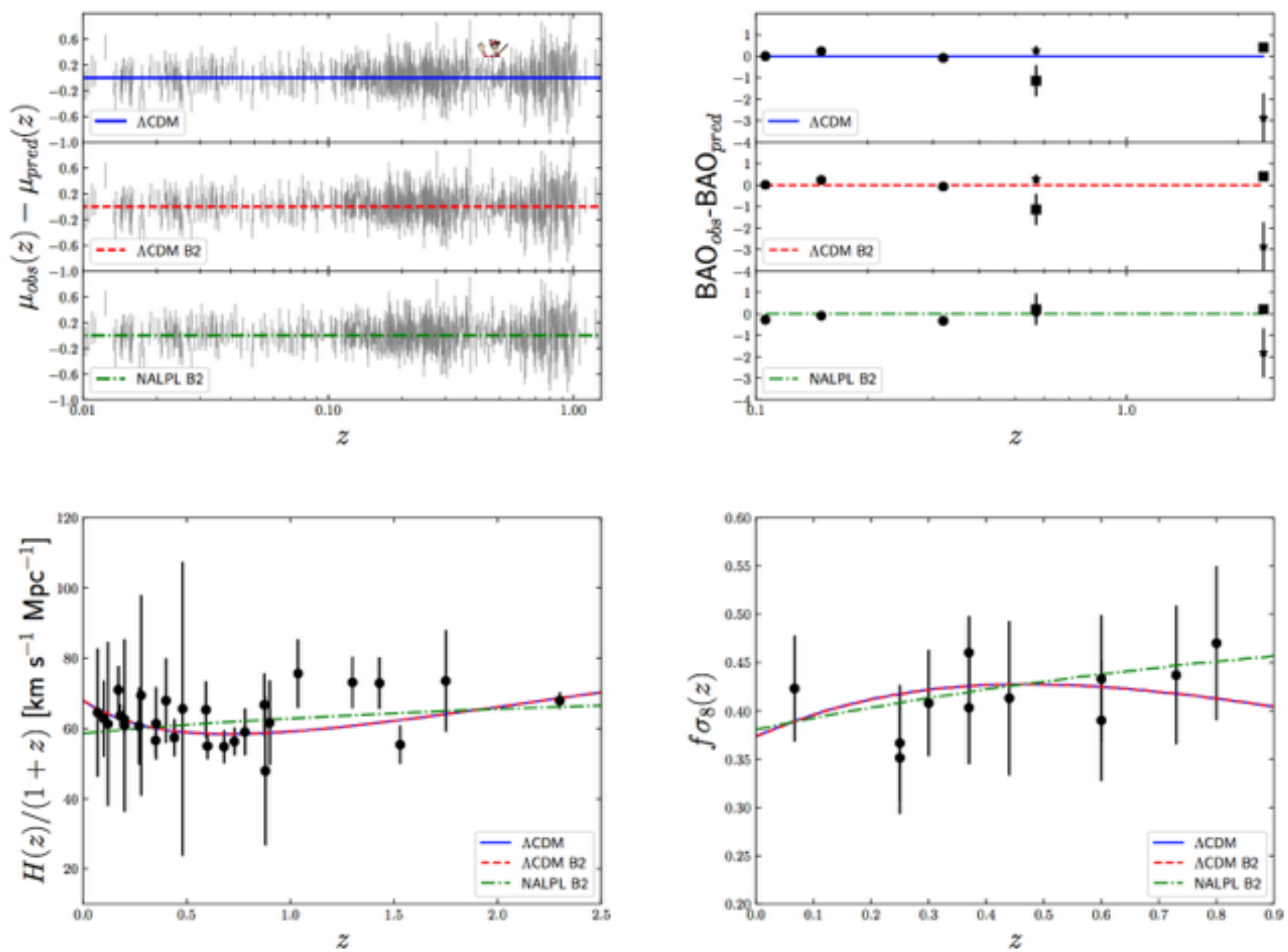
Is cosmic acceleration proven by local cosmological probes? (I. Tutusaus *et al.* 2017)

The accelerated expansion of the Universe is based on the SNIa Hubble diagram and the SNIa standard candles assumption. Several effects have been added into the SNIa standardization in the past 20 years. So:

- We test again the accelerated expansion of the Universe NOT assuming that SNIa intrinsic luminosity is independent of the redshift.
- We use the main cosmological probes: SNIa, BAO, Hubble parameter, linear growth of structures.

Conclusions:

- Low-redshift probes are completely consistent with a nonaccelerated universe.
- The SNIa standard candles assumption is needed today to claim an accelerated expansion from local cosmological probes.



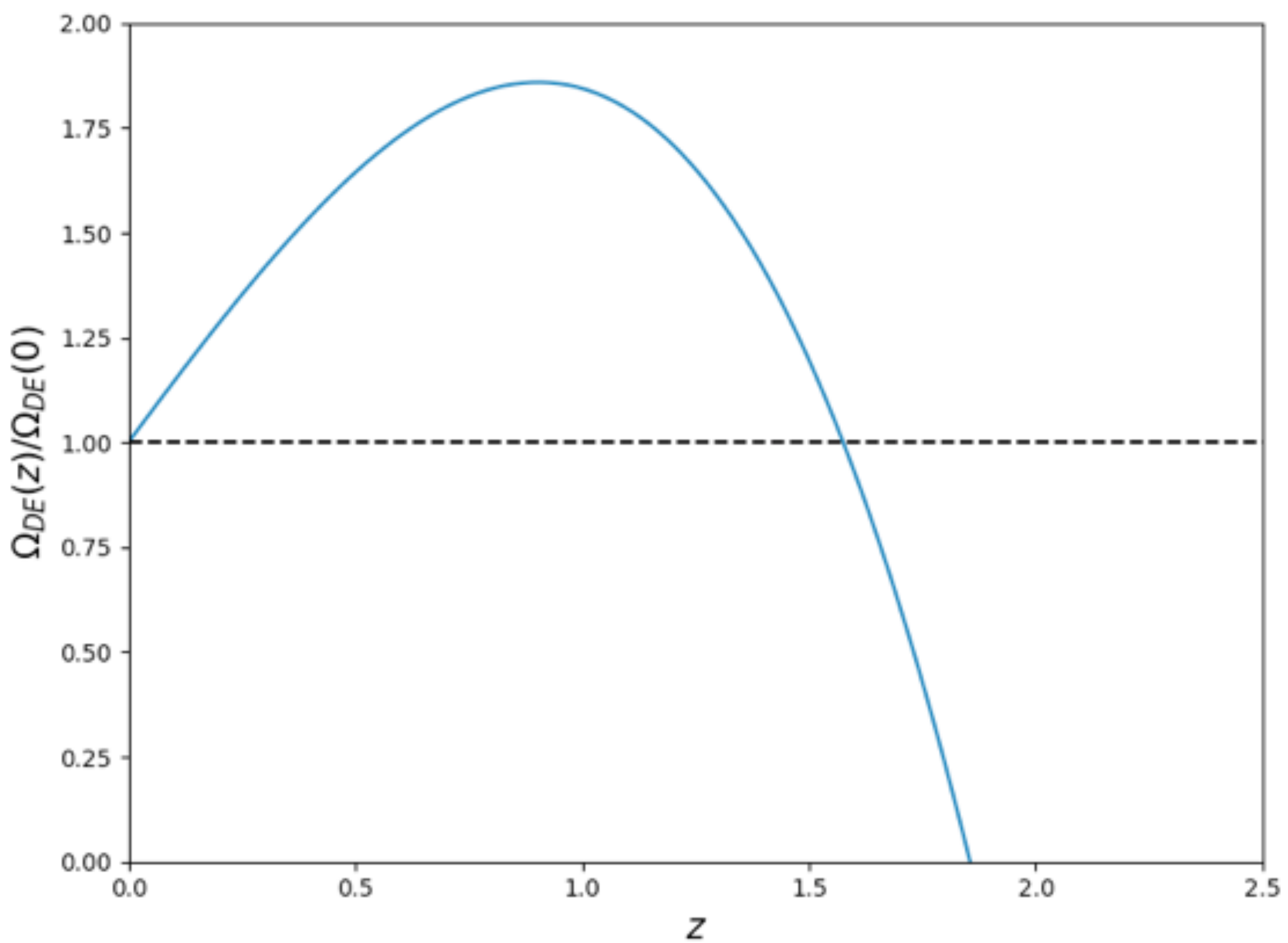
Lack of evidence for cosmic acceleration from the main cosmological probes? (I. Tutusaus *et al.* in prep.)

Even assuming the SNIa intrinsic luminosity to be redshift independent, does the addition of the CMB proof the accelerated expansion of the Universe?

- We consider a $R_h = ct$ model forcing the dark energy density to be always positive. In practice:

Conclusions:

- This nonaccelerated model is perfectly compatible with the main cosmological probes.
- The SNIa standard candles assumption is needed today to claim an accelerated expansion from **the main** cosmological probes.
- Future spectroscopic surveys (like DESI) together with measurements of the Hubble constant will provide definite proof of the accelerated expansion in a model independent way.



Work in progres…

Coming back to more realistic and theoretically motivated models, may we predict the full power of Euclid in putting constraints on their cosmological parameters?

- We consider again the Generalized Dark Matter models, but including now parameters beyond the equation of state, studying the interaction between GDM and dark energy, and performing more robust analysis: