DESIgning concordant cosmological distances in the age of precision cosmology

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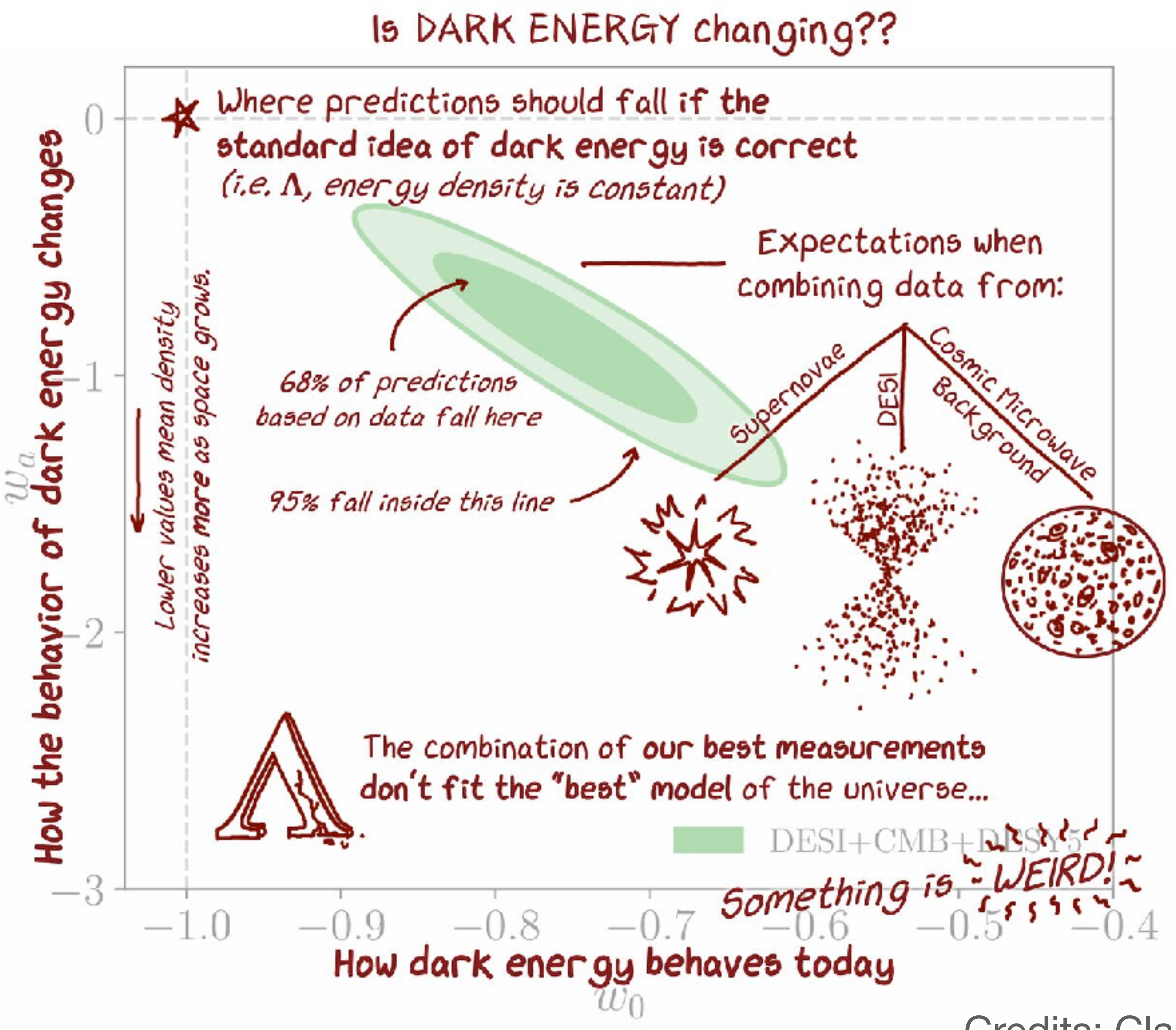
Non-standard features in observed distances



Credits: Claire Lamman/DESI collaboration

Summary

1. *Pitfalls of the CPL parametrization*

2. *Cosmological distances*

3. *Geometrical tests of the expansion rate*

The Chevallier-Polarski-Linder parametrization

Simple lineal expansion (Taylor expansion in z) leads to:

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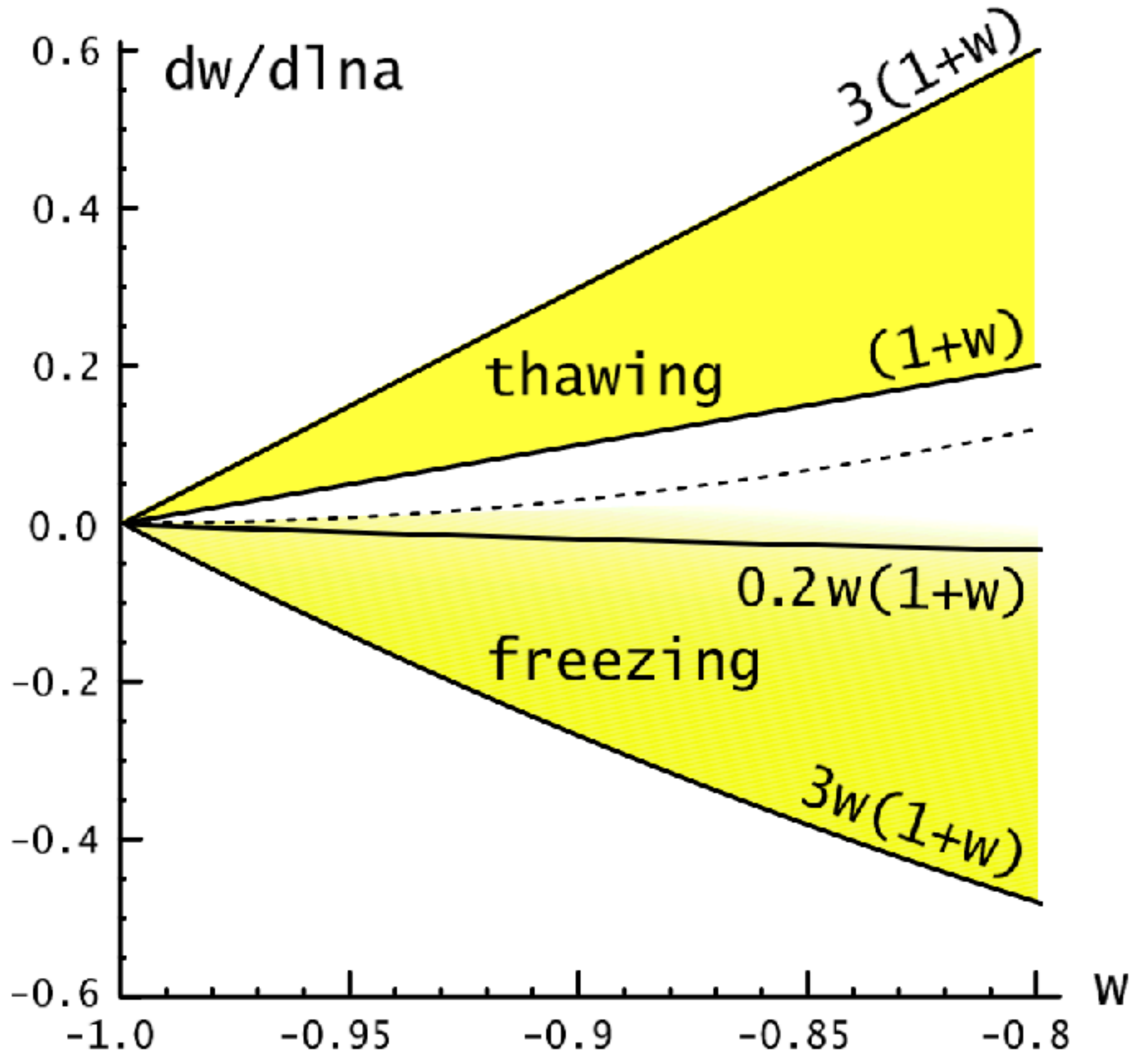
$w(z) \approx w_0 + w_a z$ for $z \ll 1$

$w(z) = w_0 + w_a$ for $z \to \infty$

CPL as Quintessence

Physical model consists of a minimally coupled canonical scalar field, can be classified as by how its EoS evolves with time.

$$\ddot{\varphi} + 3H\dot{\varphi} = -\,dV/d\varphi$$



Caldwell & Linder, arXiv:astro-ph/0505494

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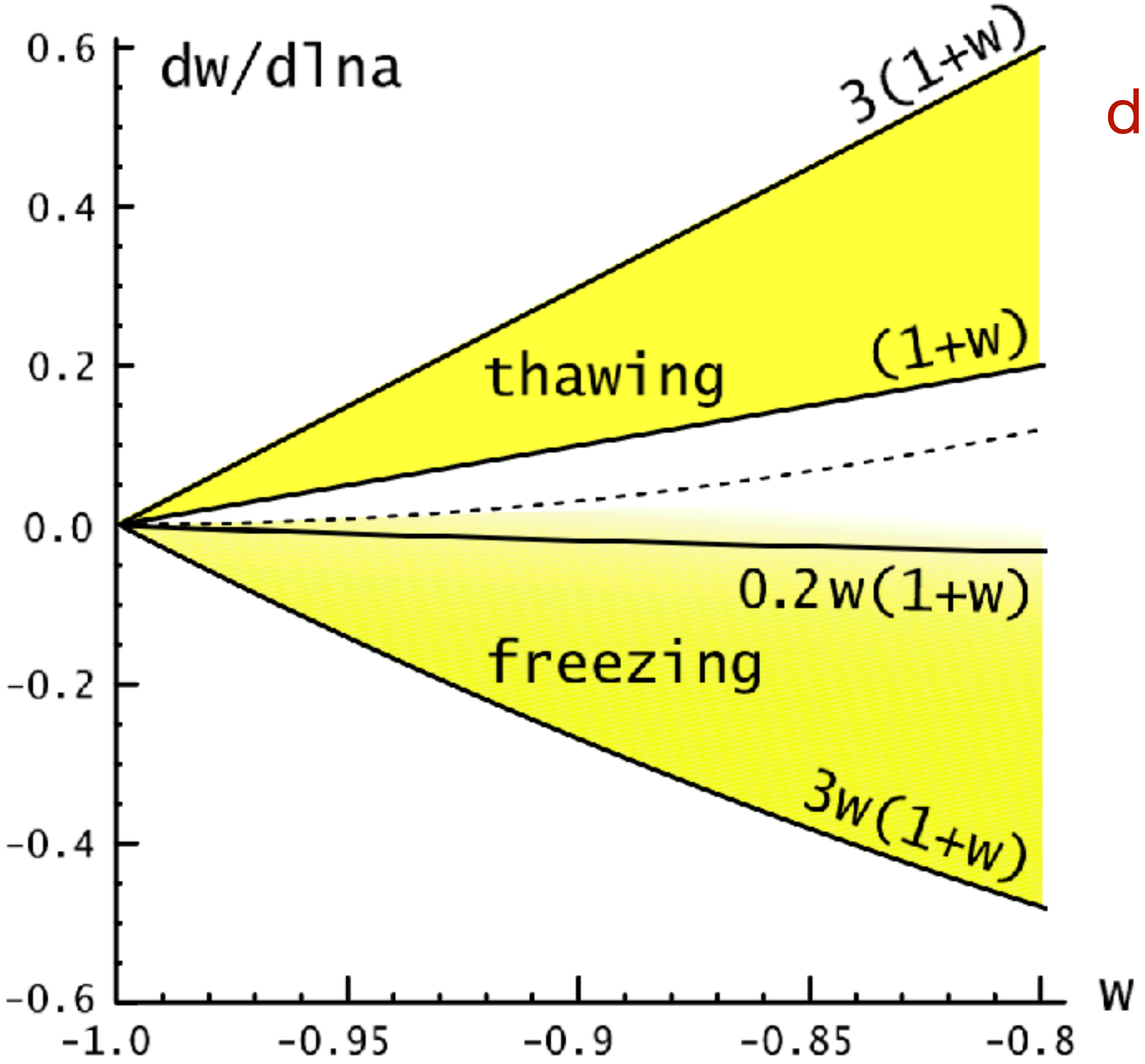

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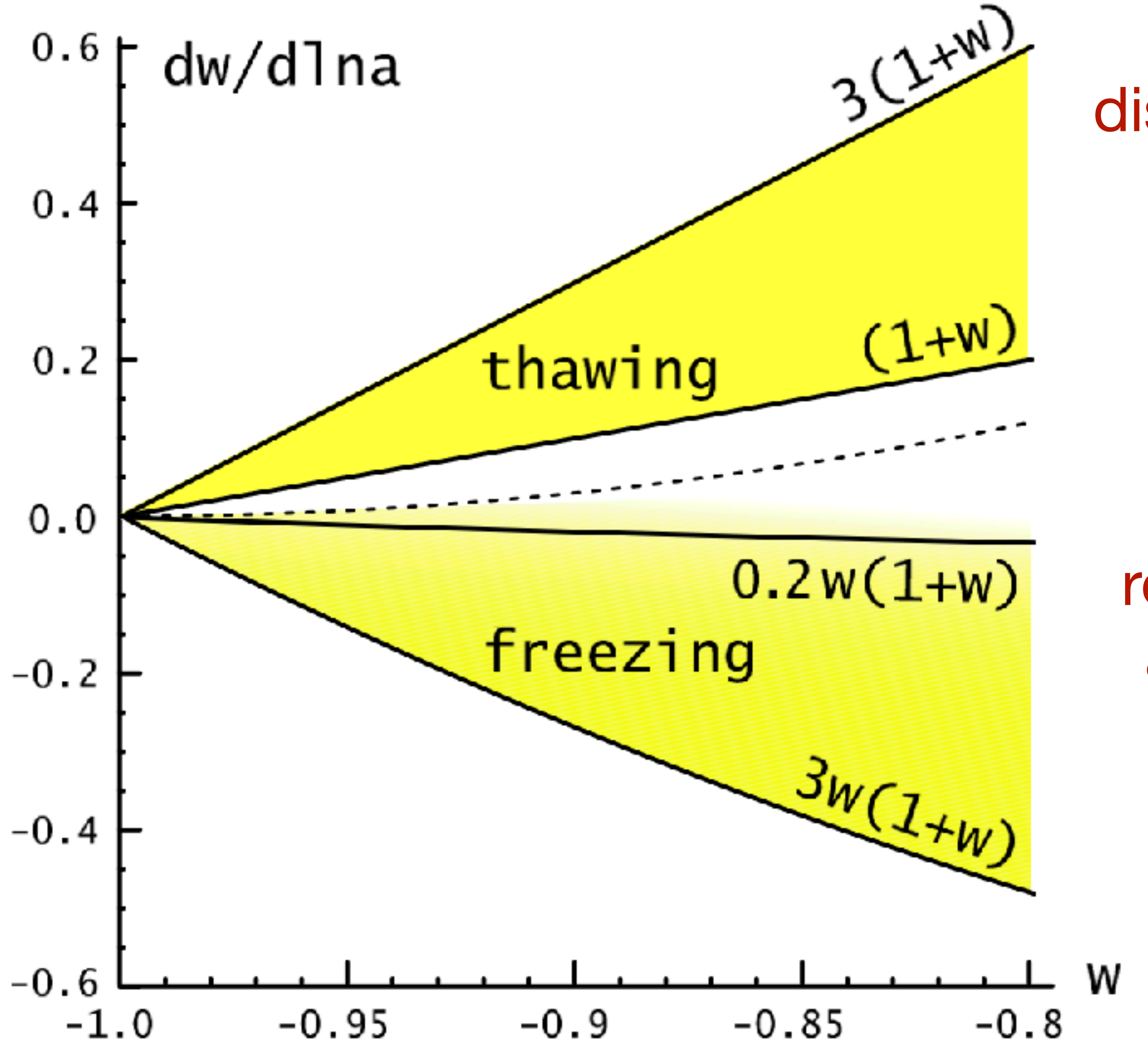

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The field which has been already rolling towards its potential minimum but which slows down and creeps to a halt as it comes to dominate the universe.

Initially, $w > -1$ and $dw/d\ln a < 0$.

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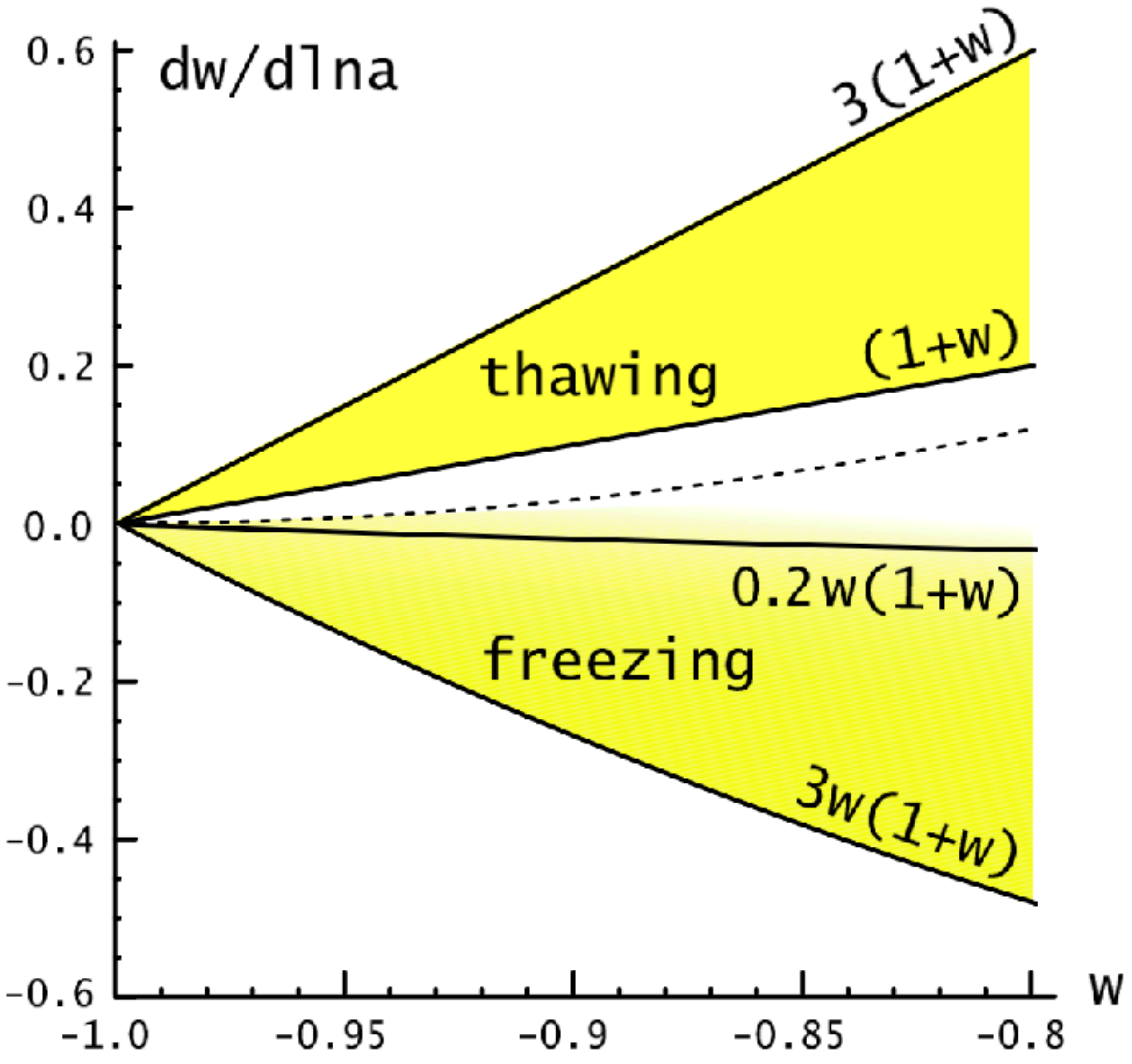

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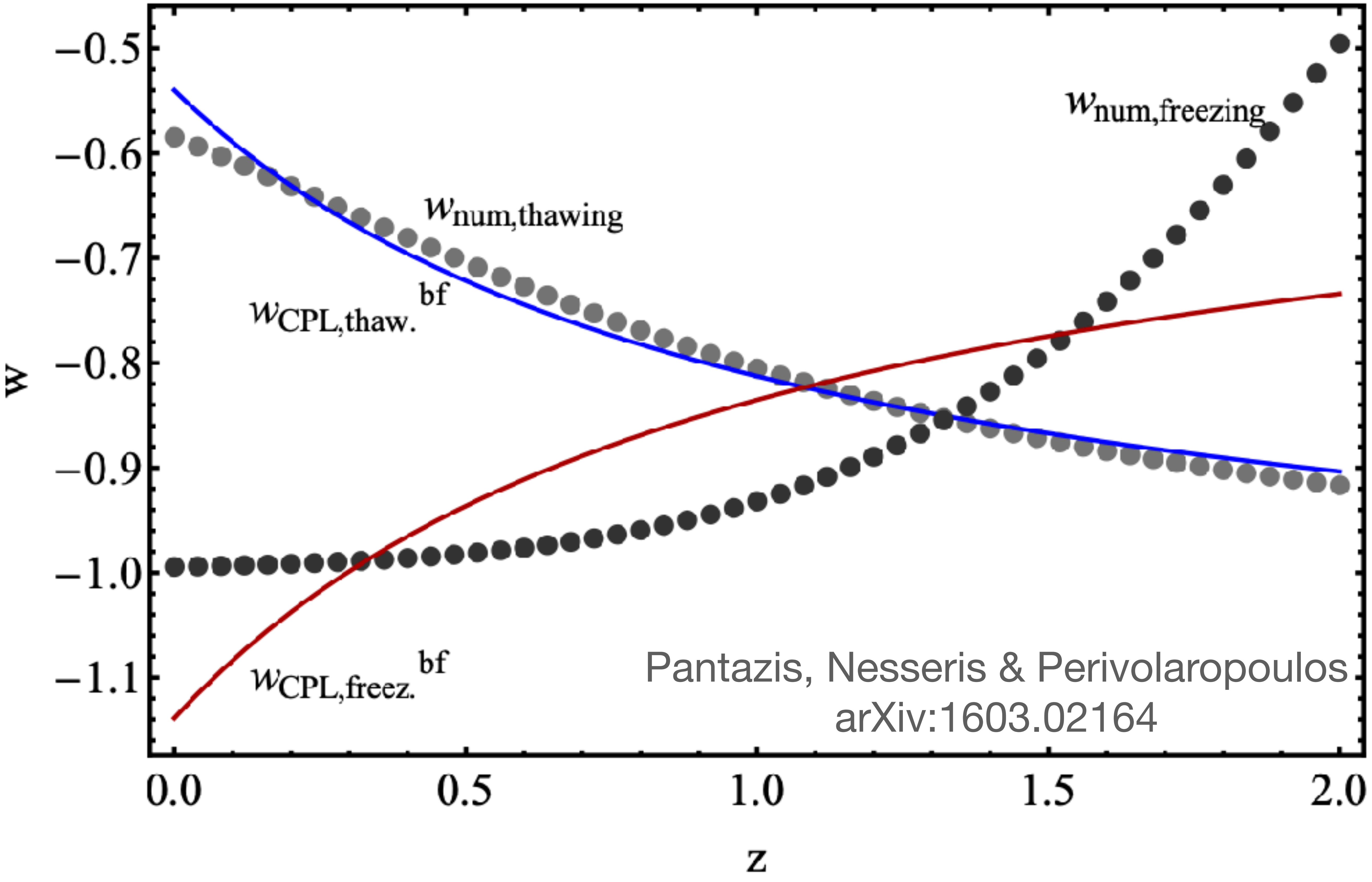
CPL model well thawing models, but fails to reproduce freezing scenarios.



Pantazis, Nesseris & Perivolaropoulos arXiv:1603.02164

CPL as Quintessence

Mapping the Chevallier-Polarski-Linder parametrization onto Physical Dark Energy Models

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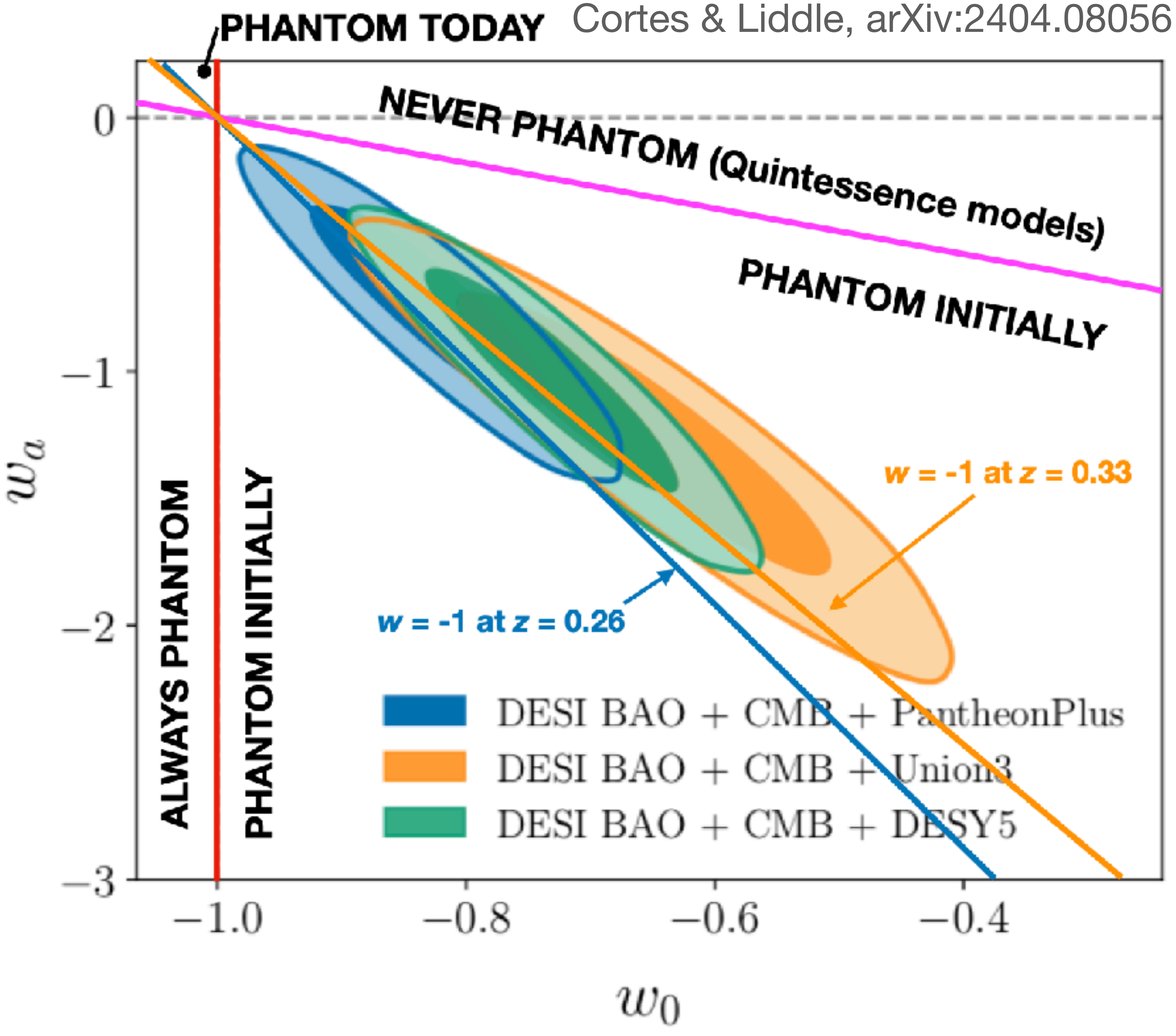
Department of Physics and Astronomy, Vanderbilt University, Nashville, TN 37235

Considered as a straightforward linear approximation for the equation of state parameter as a function of the expansion factor, the CPL parametrization is undeniably useful, particularly when attempting to detect deviations from the ΛCDM model. However, as a probe of physical models which might correspond to non-ΛCDM behavior (or at least the types of physical models considered here), the CPL parametrization is not optimal, and, at least for the case of quintessence, it seems more appropriate to move toward the kind of parametrization discussed in Ref. [33]. It would, of course, be useful to extend this study to some of the other classes of models for dark energy that have been proposed in the literature.

Although straightforward to use, CPL is not necessarily the optimal choice to model canonical Quintessence models!

Preference for phantom behavior



Cortes & Liddle, arXiv:2404.08056

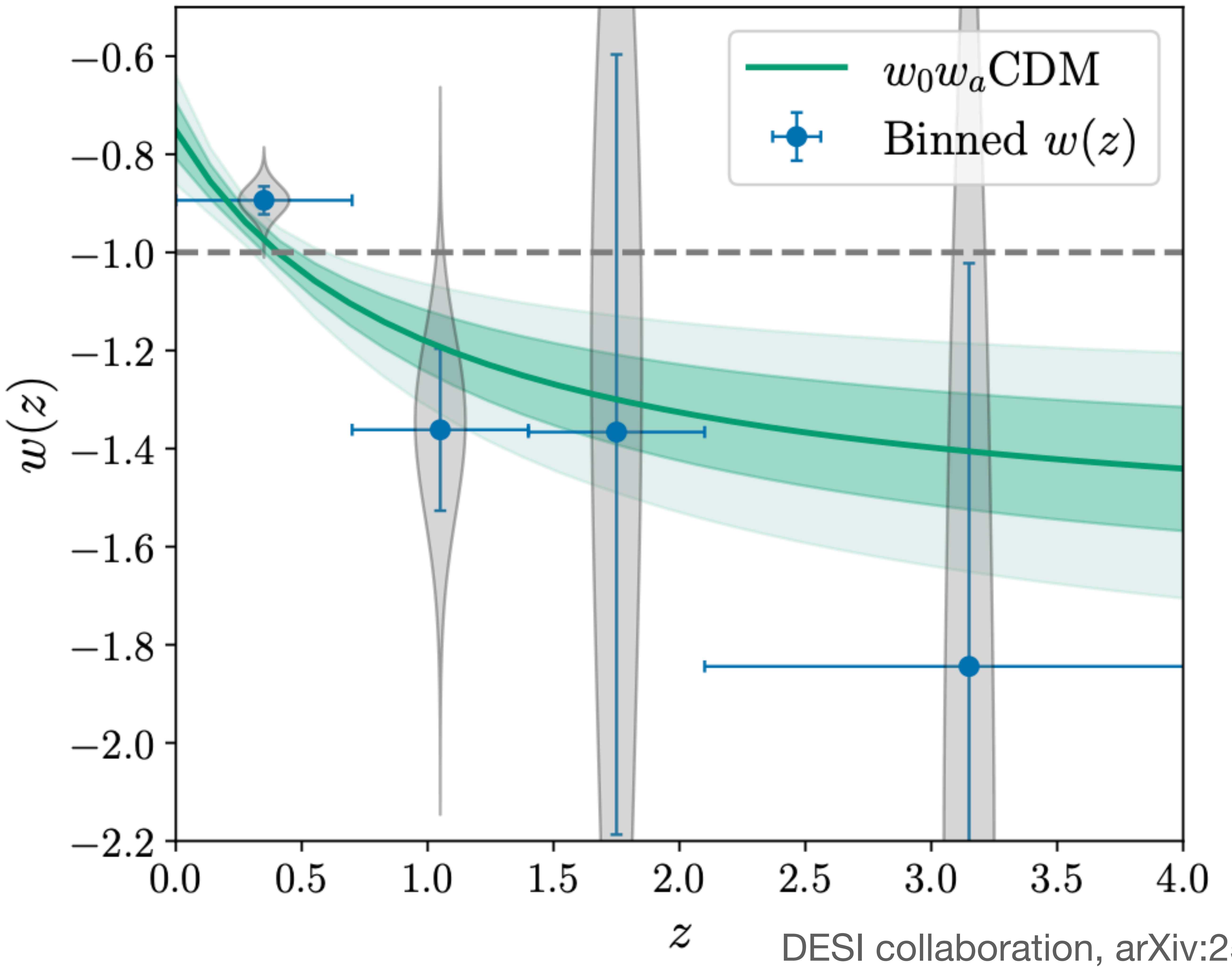
Constraints show a preference for phantom behavior ($w < -1$) at $z \gtrsim 0.4$

$w < -1$ are unphysical within the GR framework.

ρ_{de} till $z \approx 0.4$ with the expansion of the Universe!

Preference for phantom behavior

Phantom EoS are preferred regardless of the used parametrization!



DESI collaboration, arXiv:2503.14738

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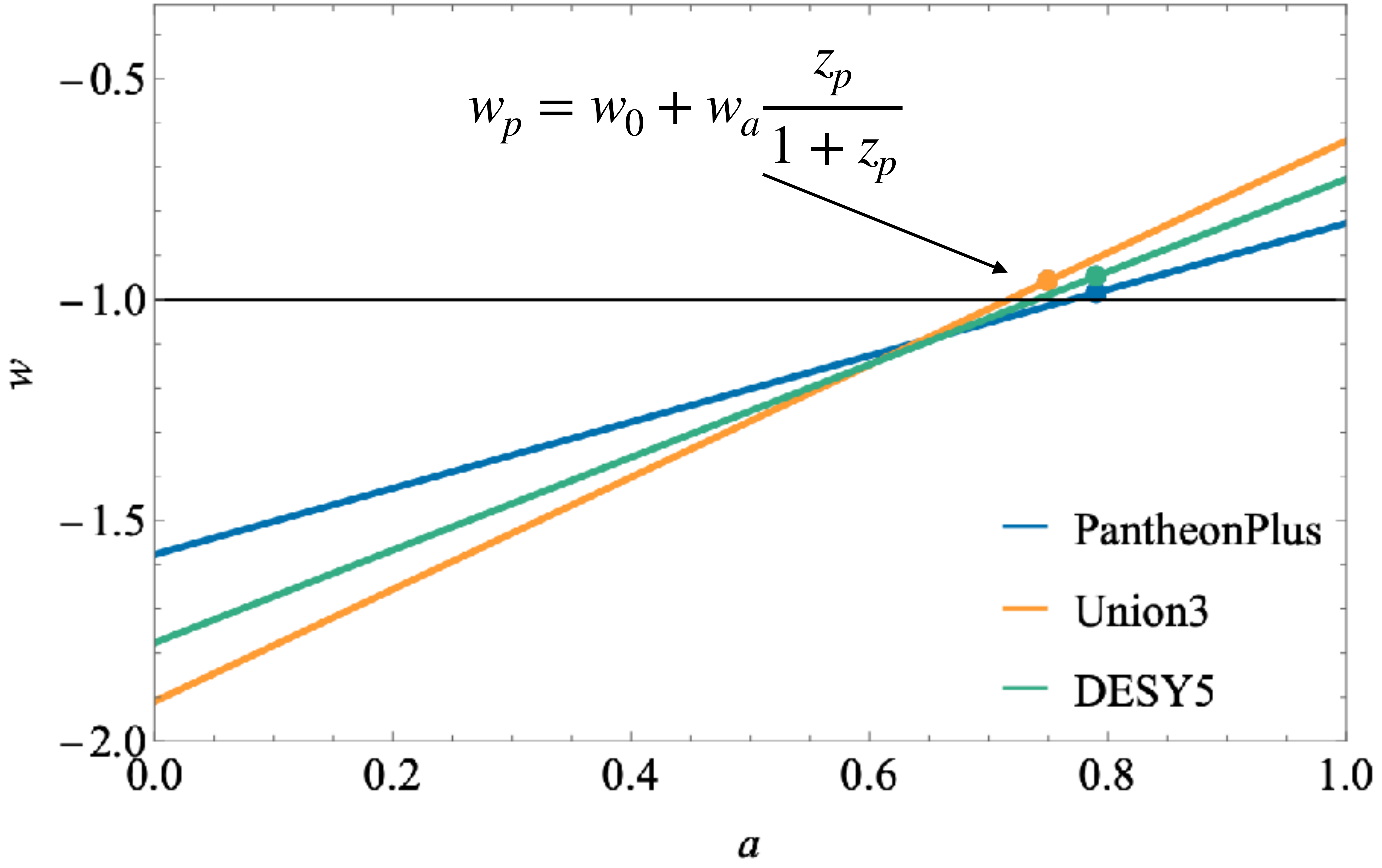

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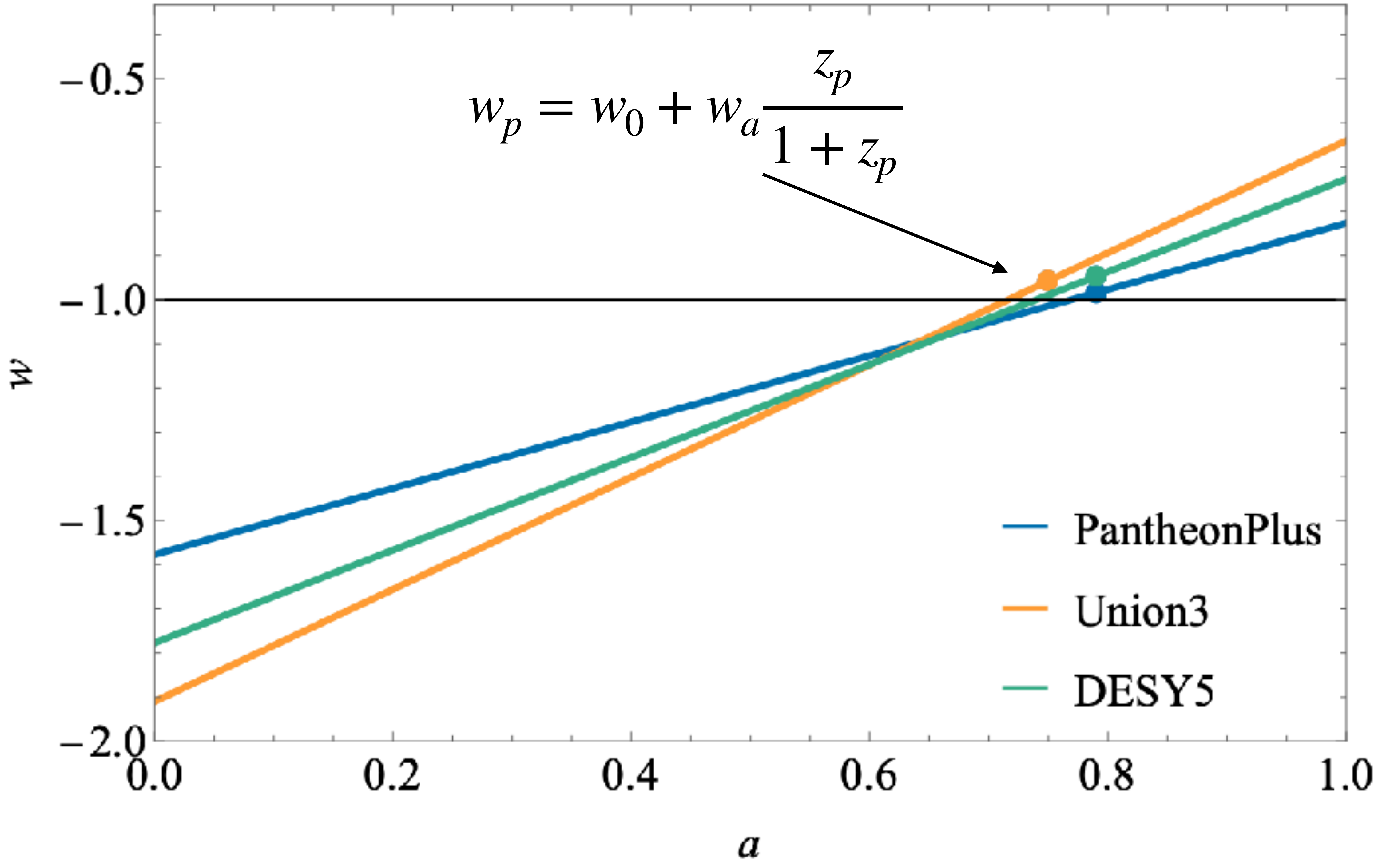

DESI+CMB: w_p = -1.024 ± 0.043

DESI+CMB+DESY5: w_p = -0.954 ± 0.024

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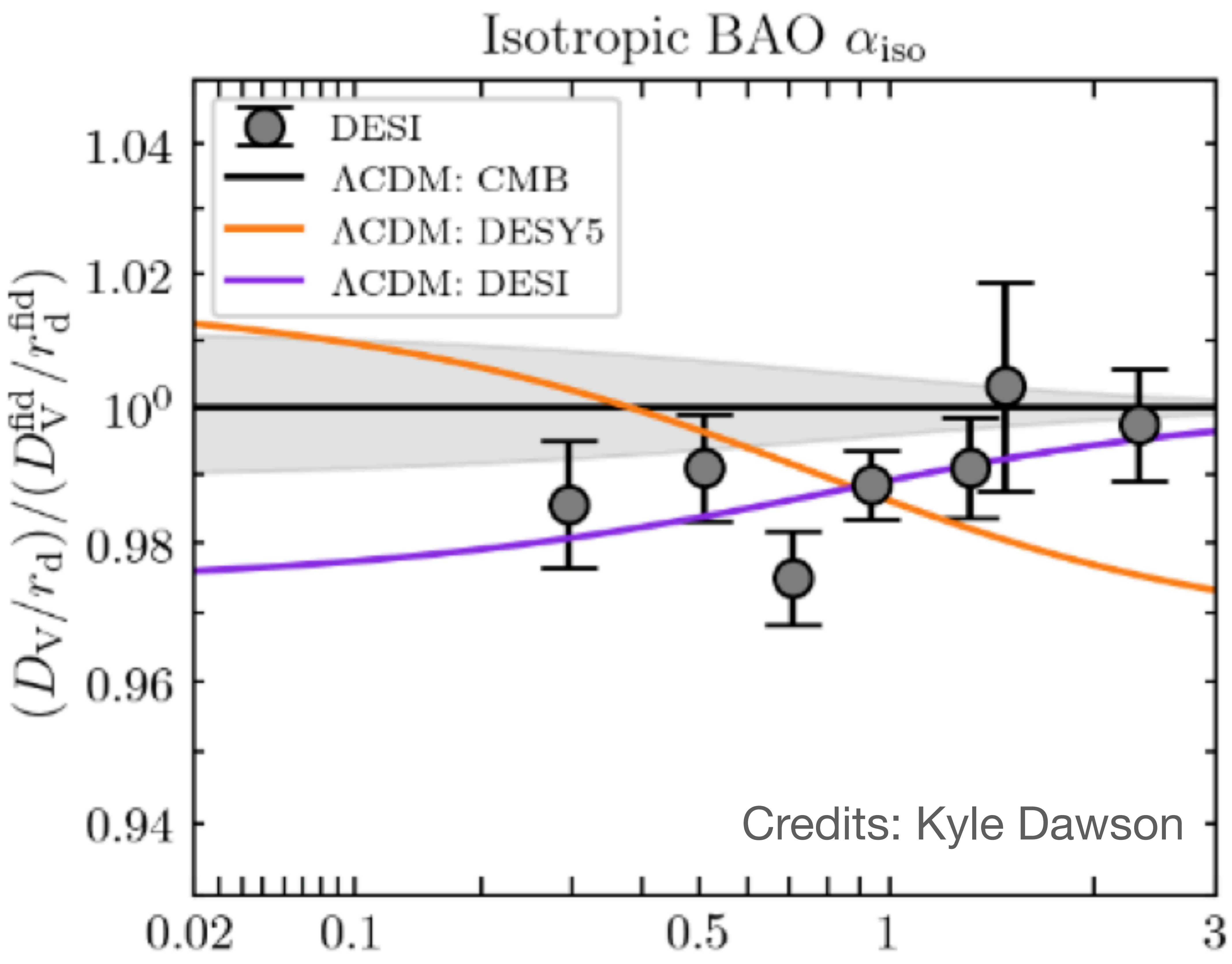
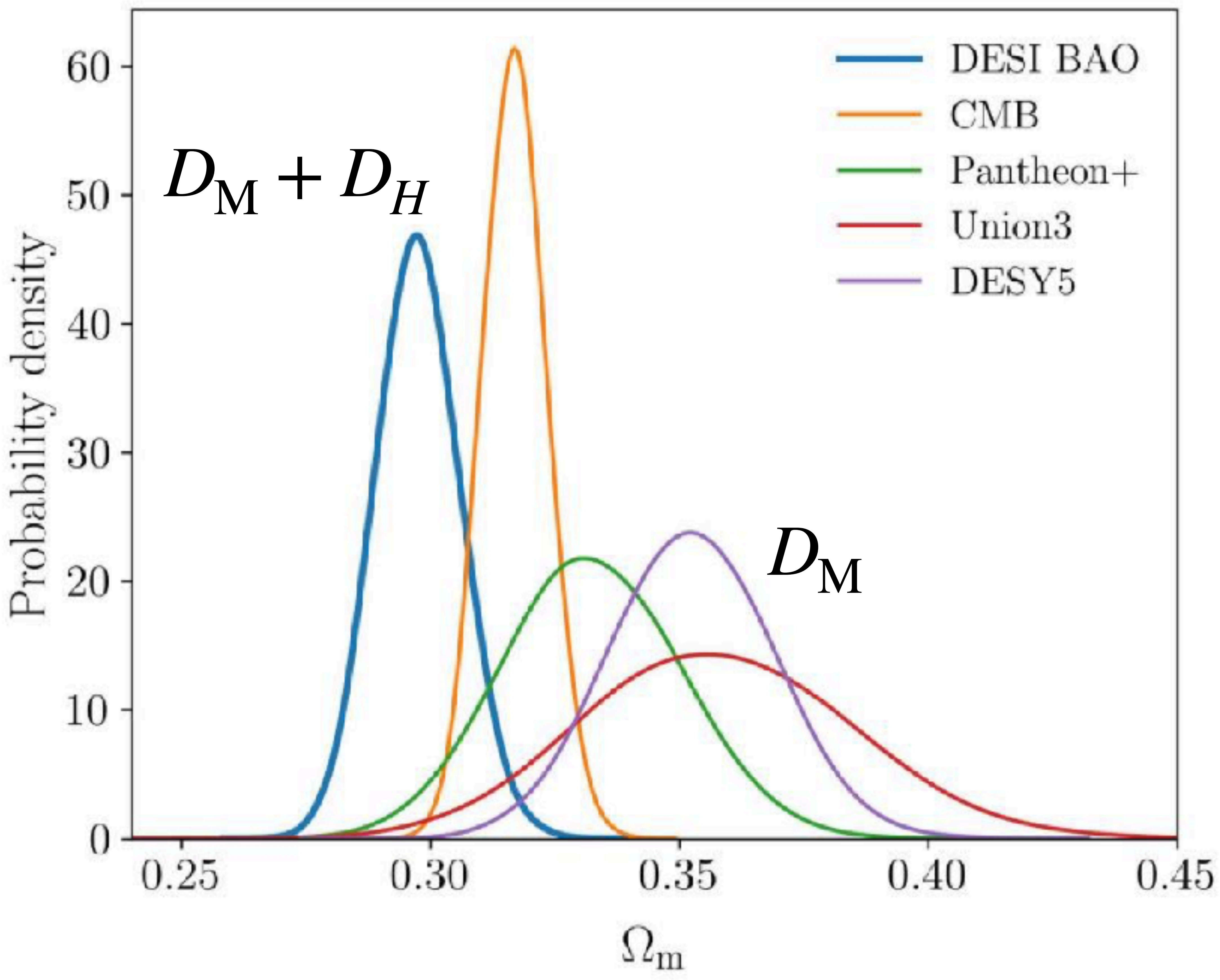
BAO not only complement SNe data, but also provide further geometric information!

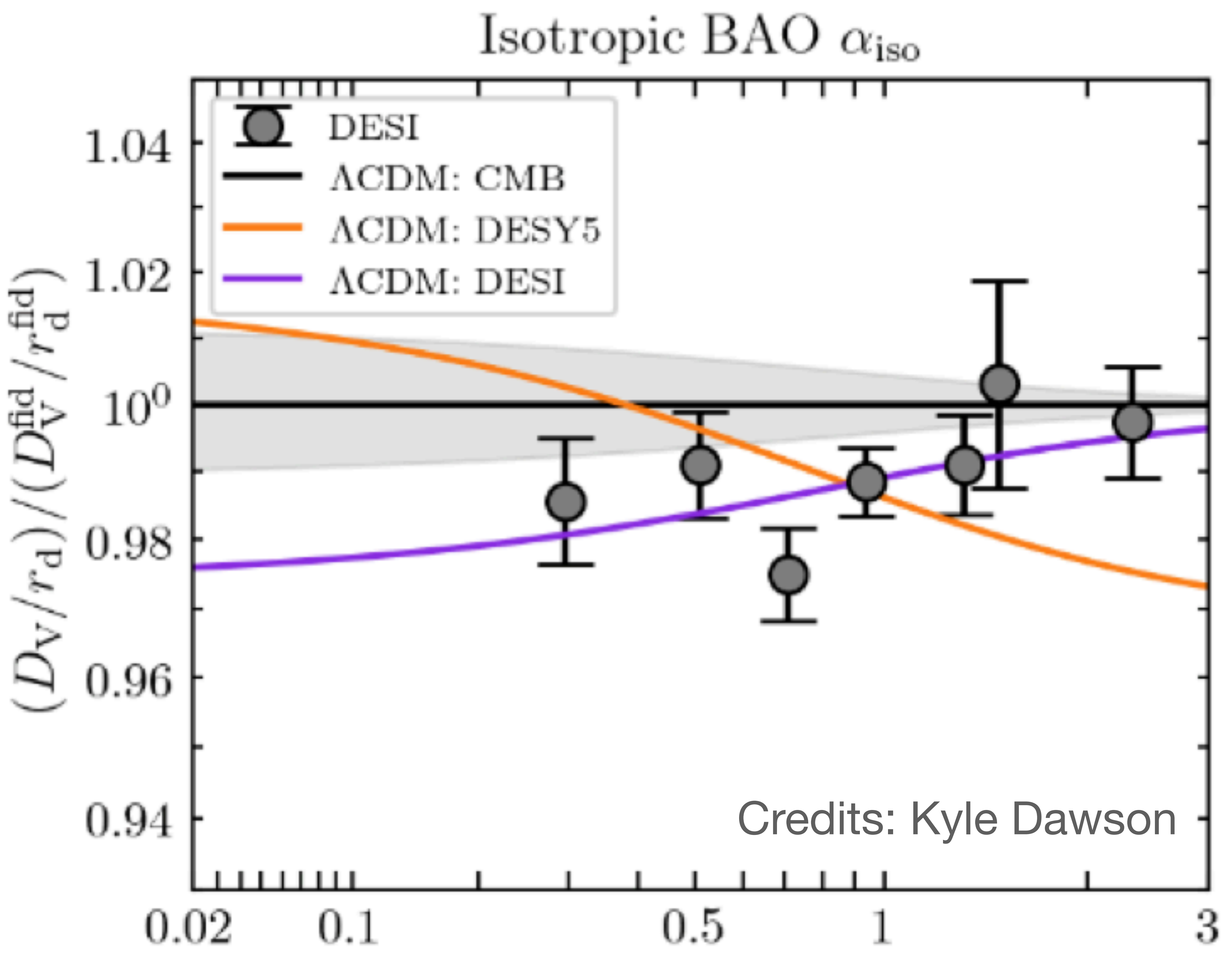
DESI vs Supernovae

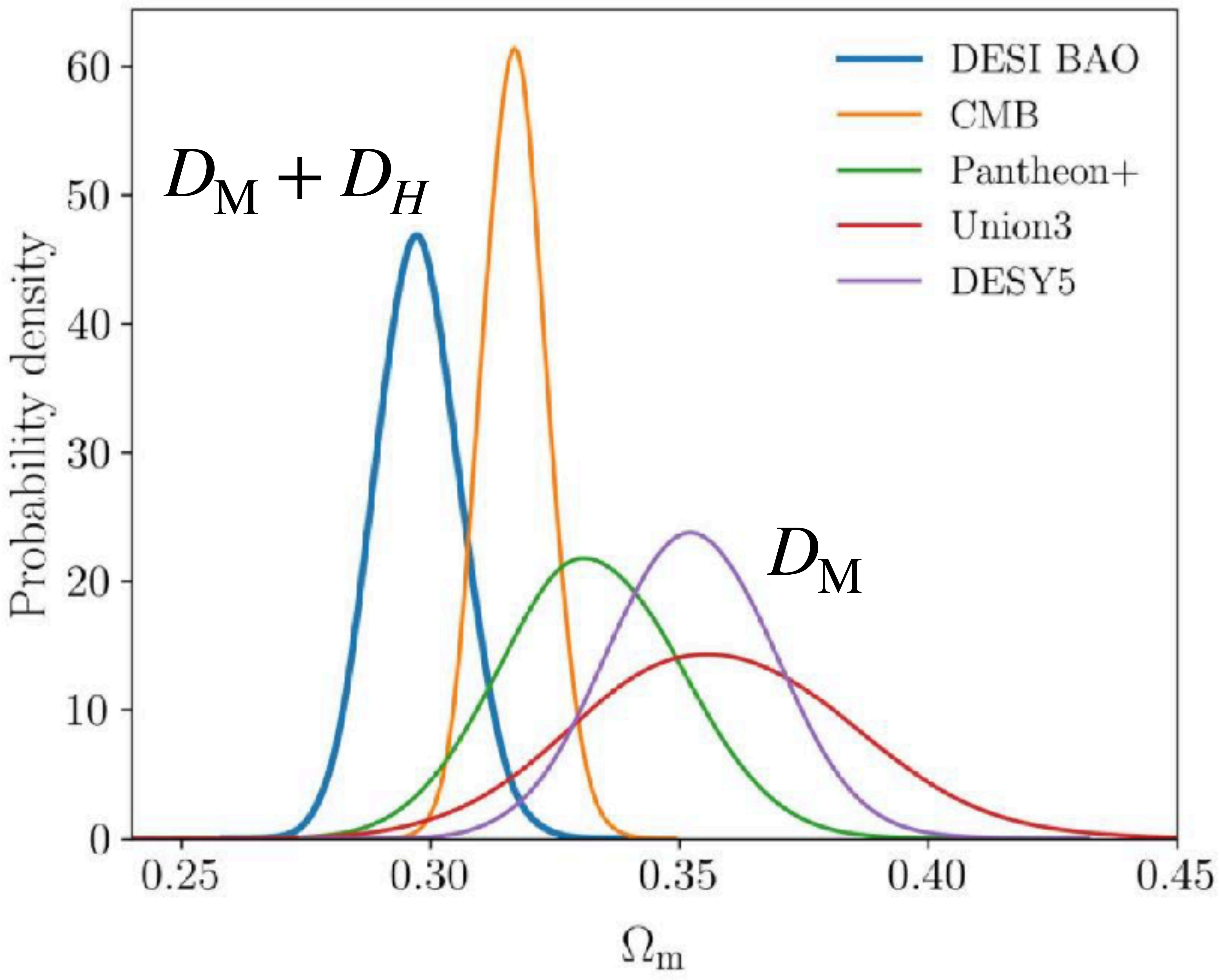




DESI vs Supernovae

ΛCDM fails to simultaneously fit BAO and SNe distances!





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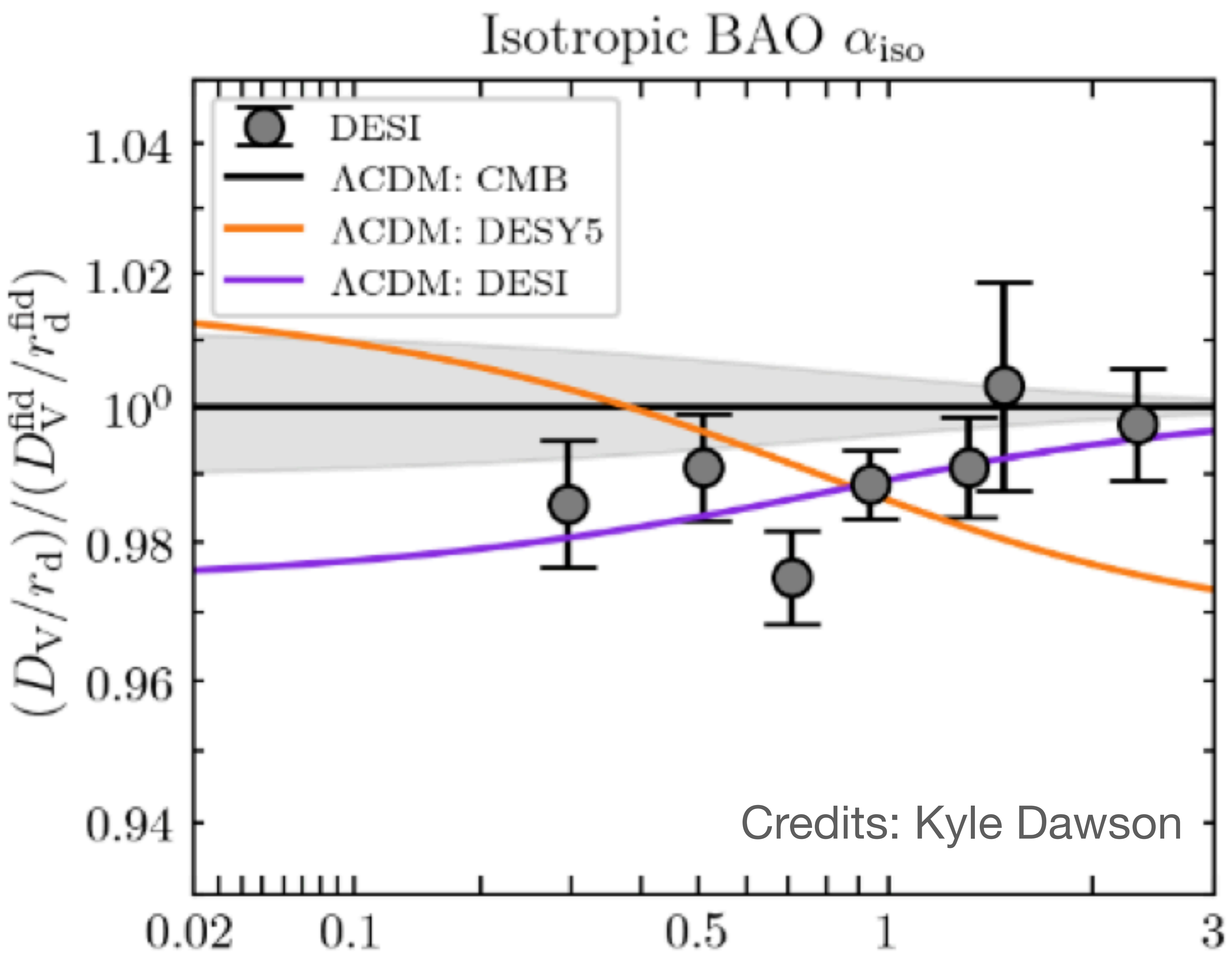
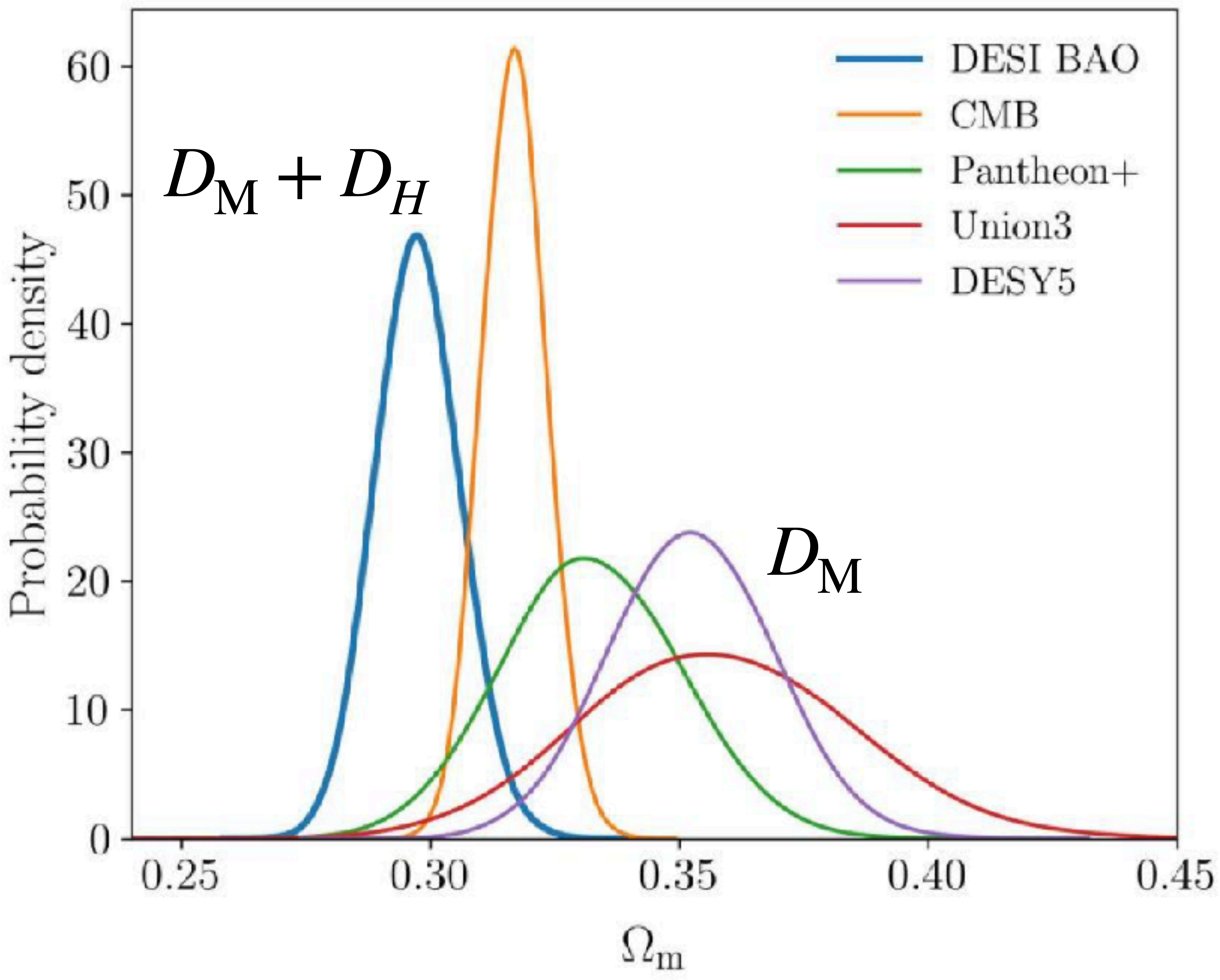
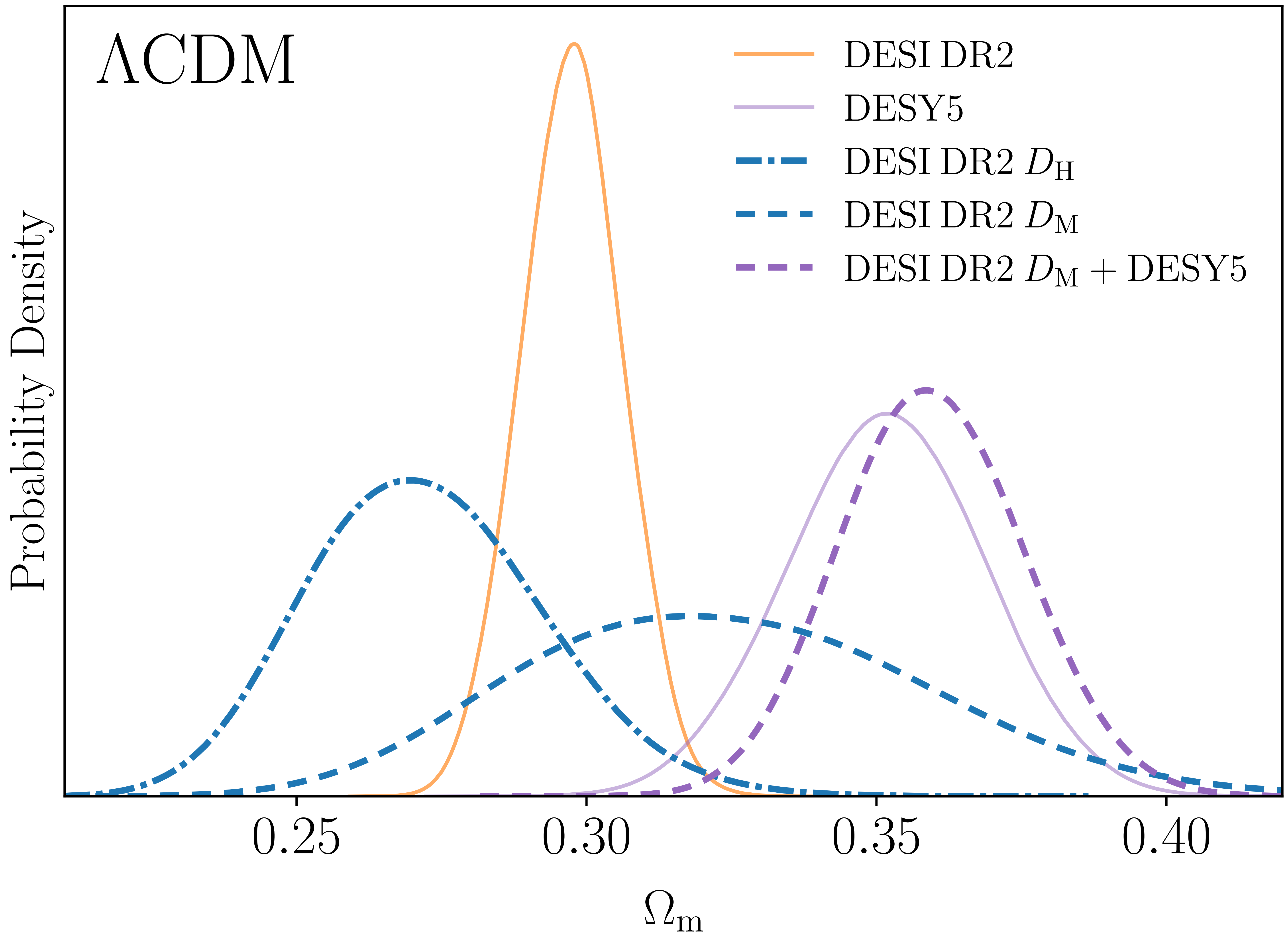




Are D_M from SNe consistent with D_M from BAO? What about D_H?

Geometrical test for ΛCDM



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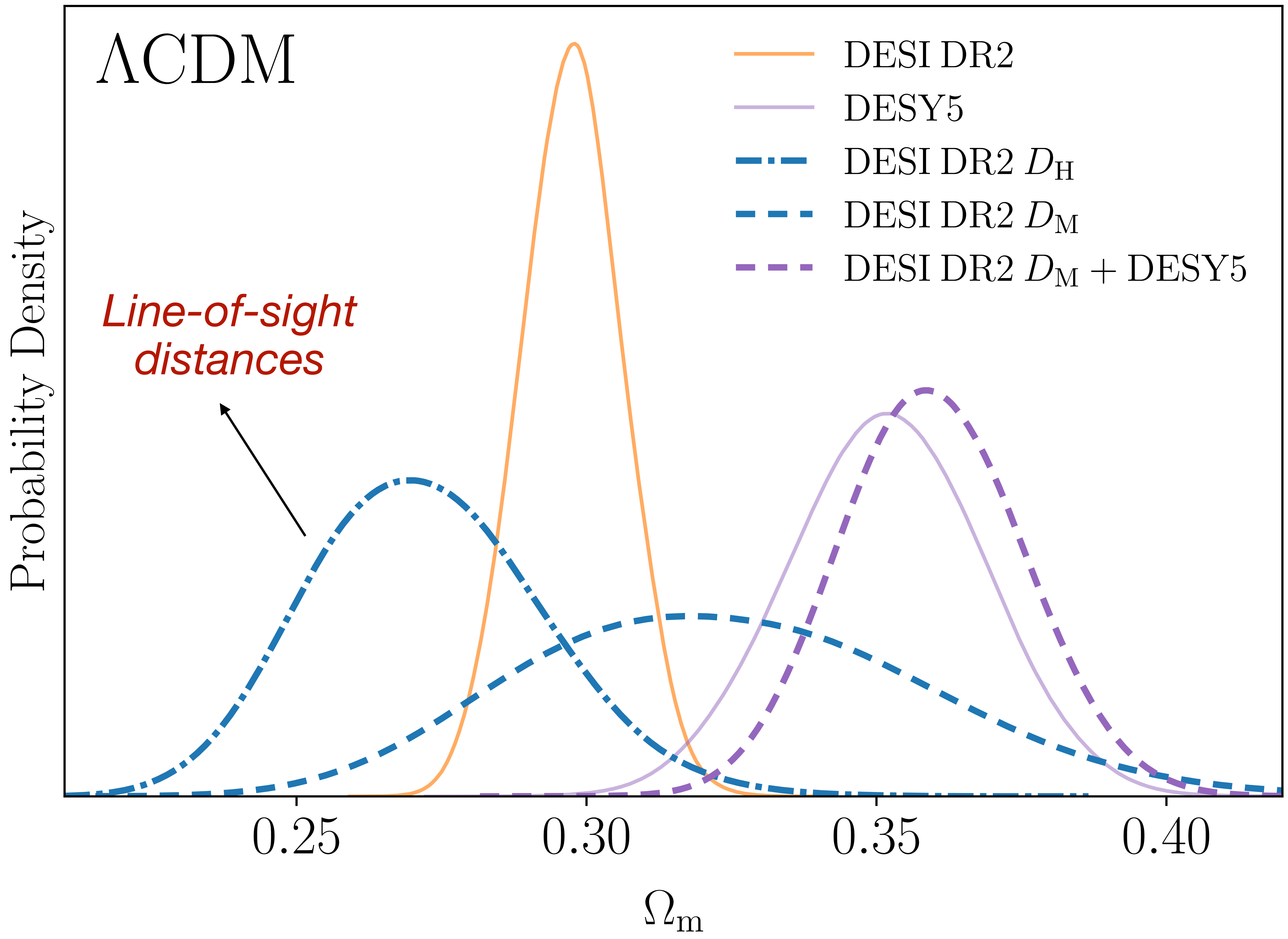

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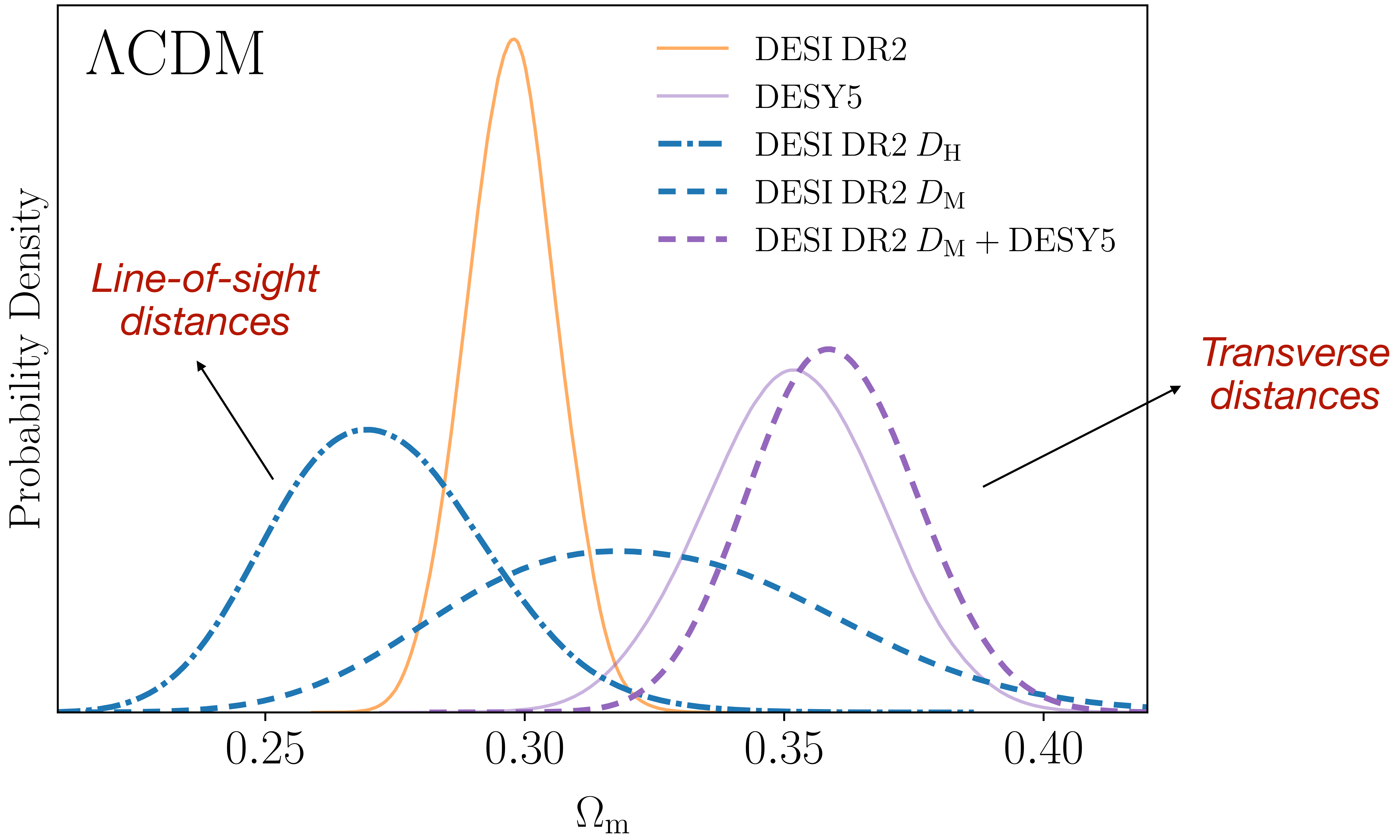
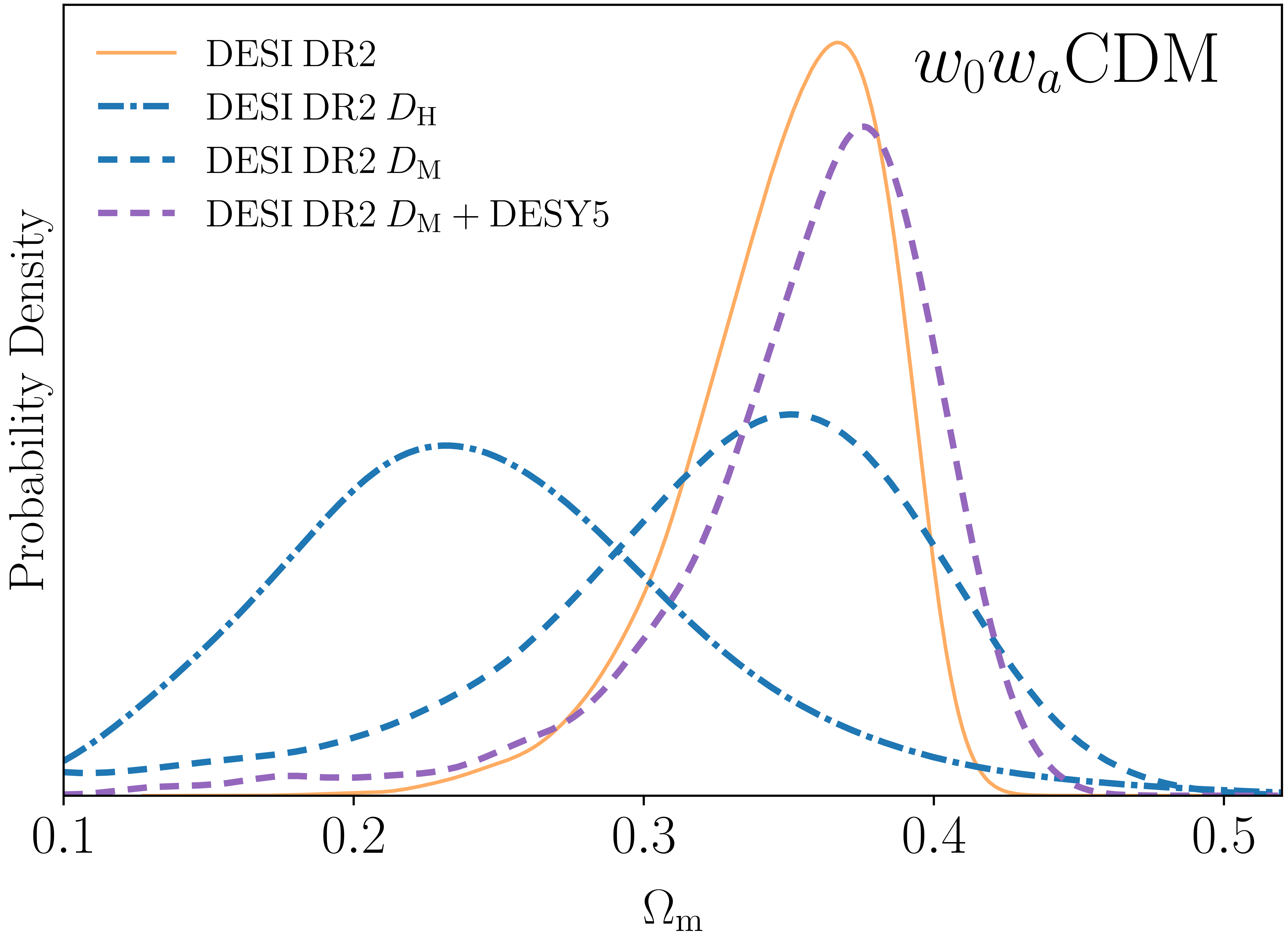


Geometrical test for w_0w_aCDM



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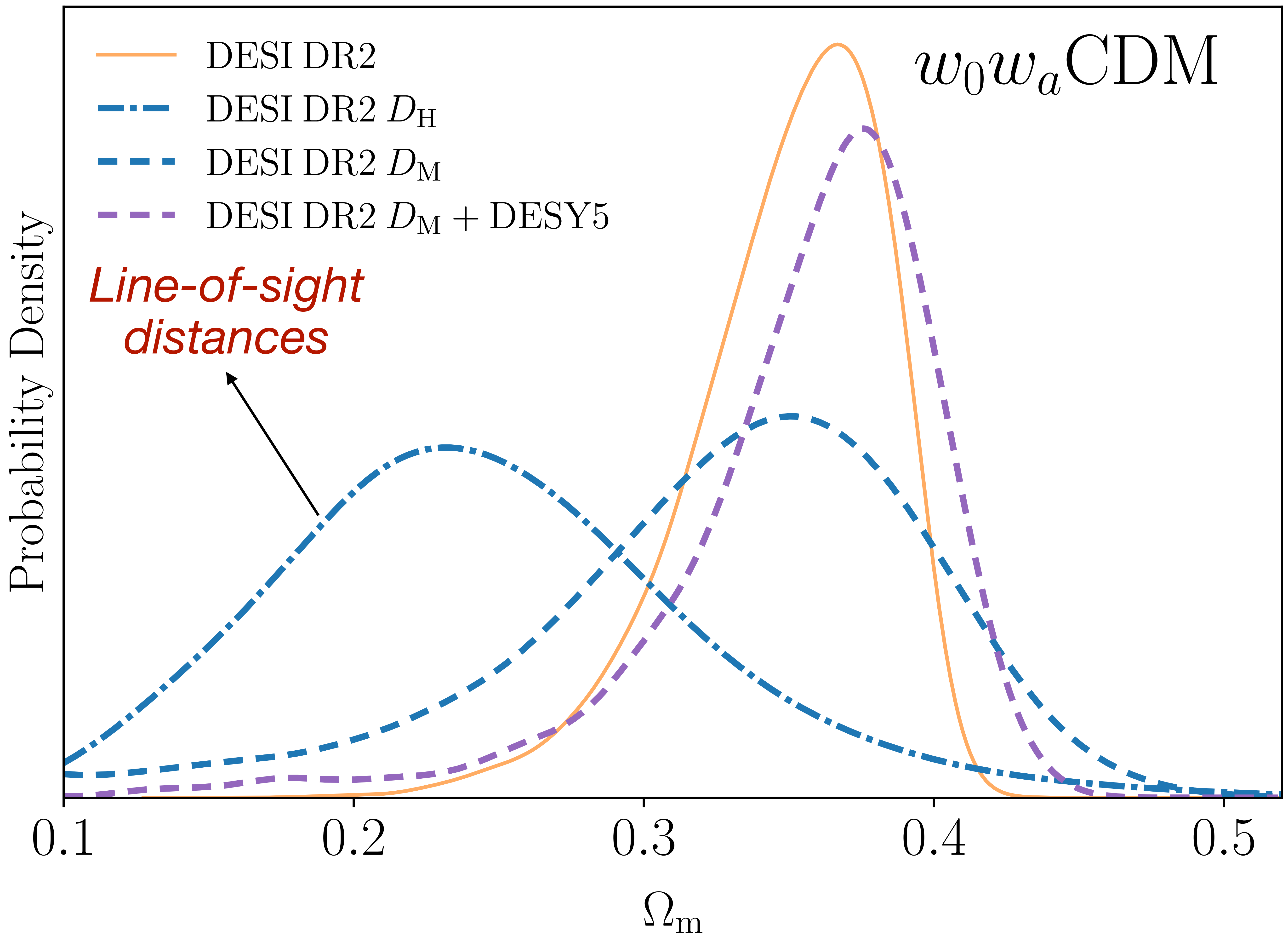
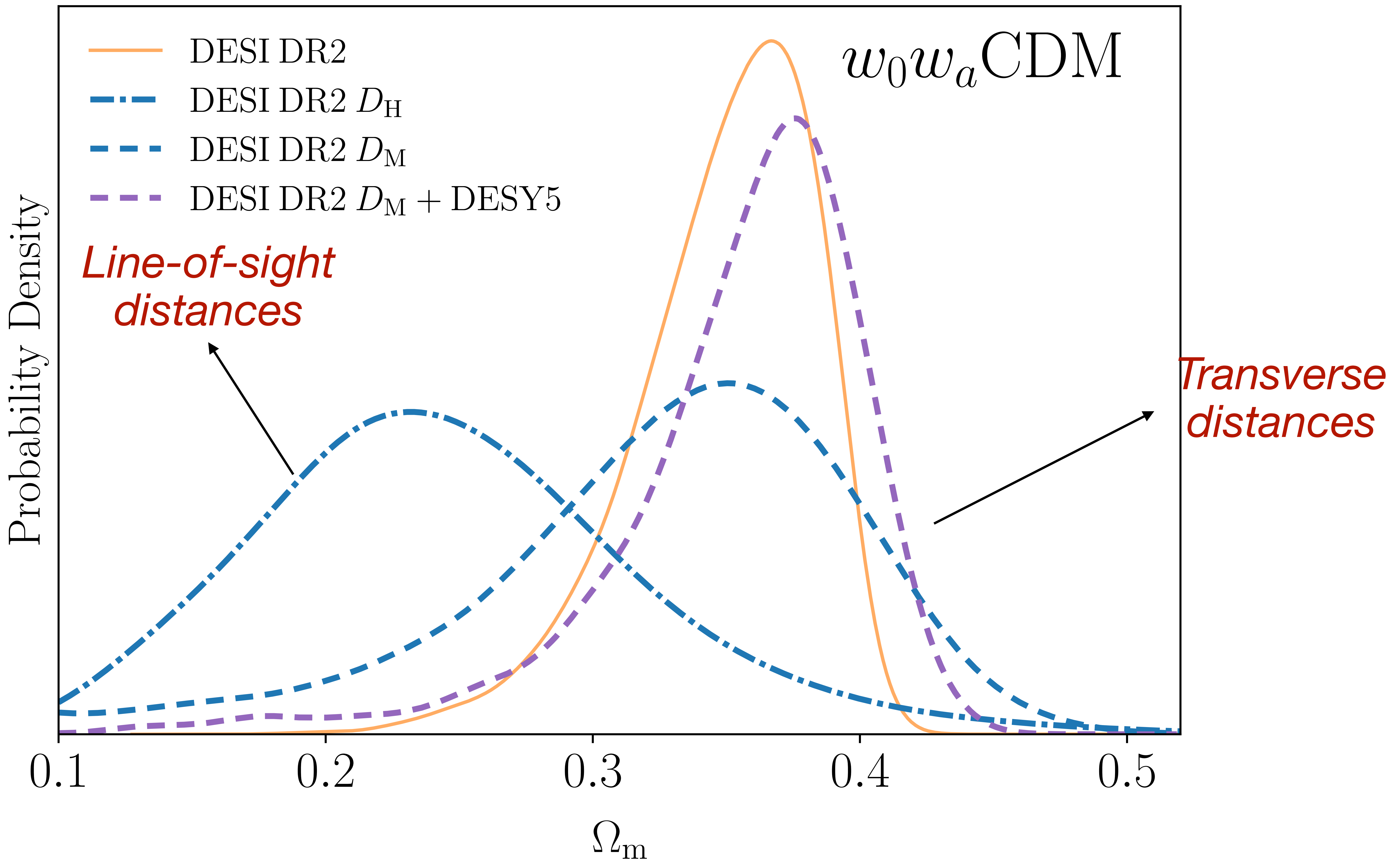


Geometrical test for $w_0 w_a$CDM



Conclusions

- *Early hints of an anisotropic expansion: there is a systematic preference for lower values of Ω_m when analyzing D_H distances, compared to constraints with D_M.*
- *Non-FLRW feature regardless of DE nature: fluctuations in Ω_m determinations for ΛCDM and $w_0 w_a$CDM*
- *Motivate the study of non-FLRW models.*