Evidence for galaxy dynamics tracing cosmological evolution

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van Putten 2017 ApJ 828 28
- 2017 ApJ 837 22
- 2016 ApJ 824 43
- 2015 MNRAS, 450, L48

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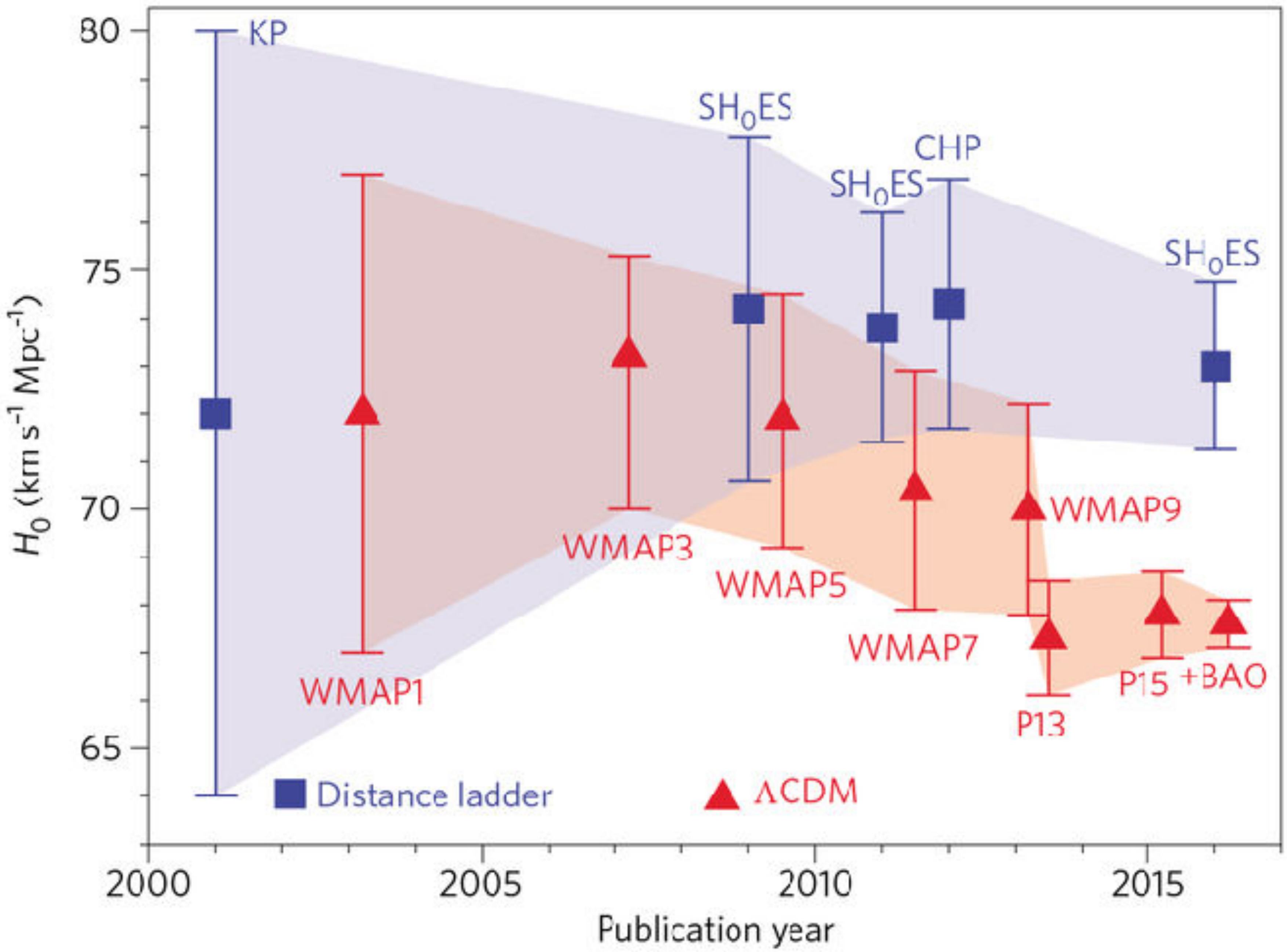
H_0-tension problem



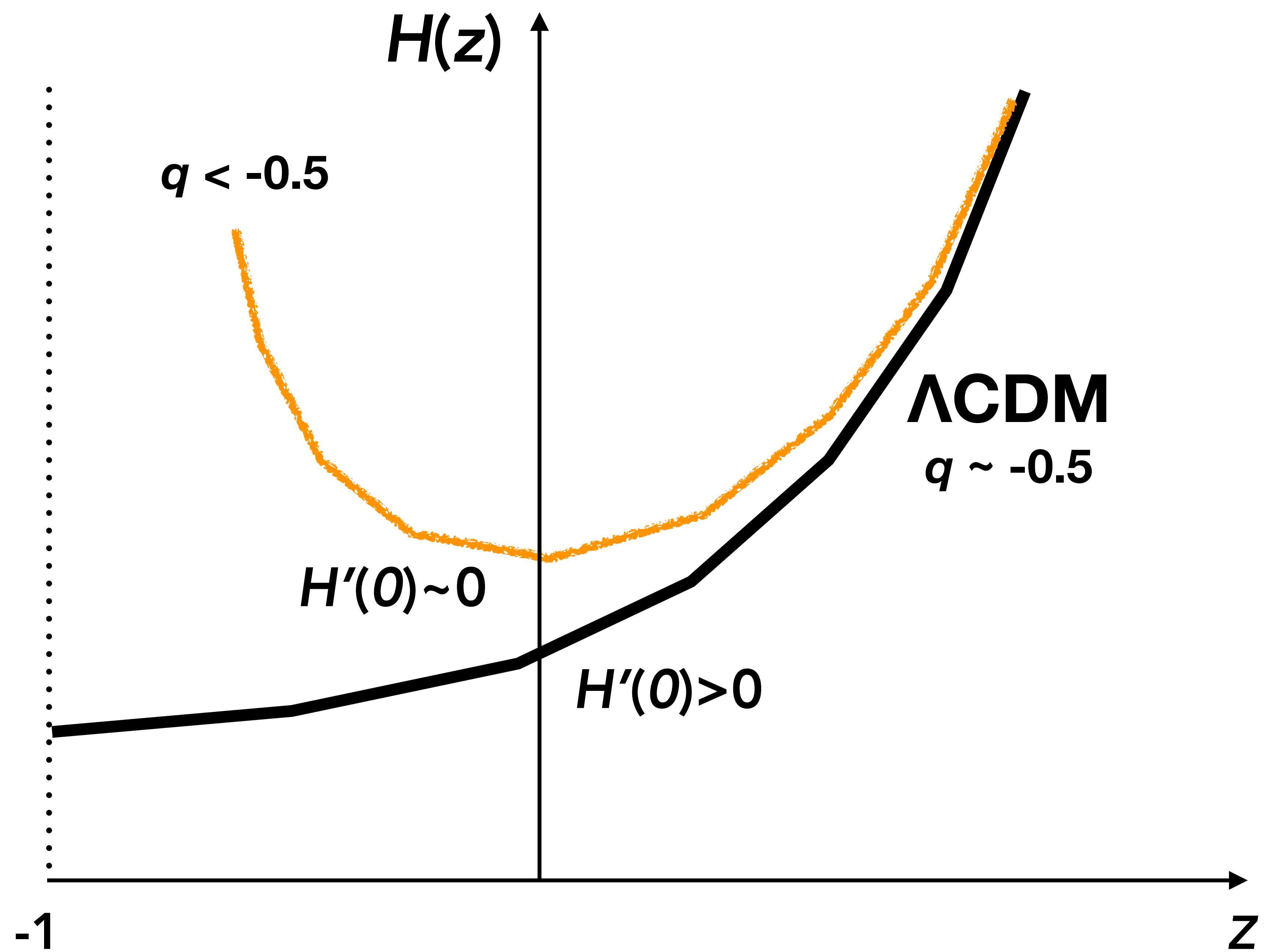
~10%

H_0 from surveys of the Local Universe (sans cosmological model)

H_0 from ΛCDM analysis of cosmological data (CMB, BAO, …)

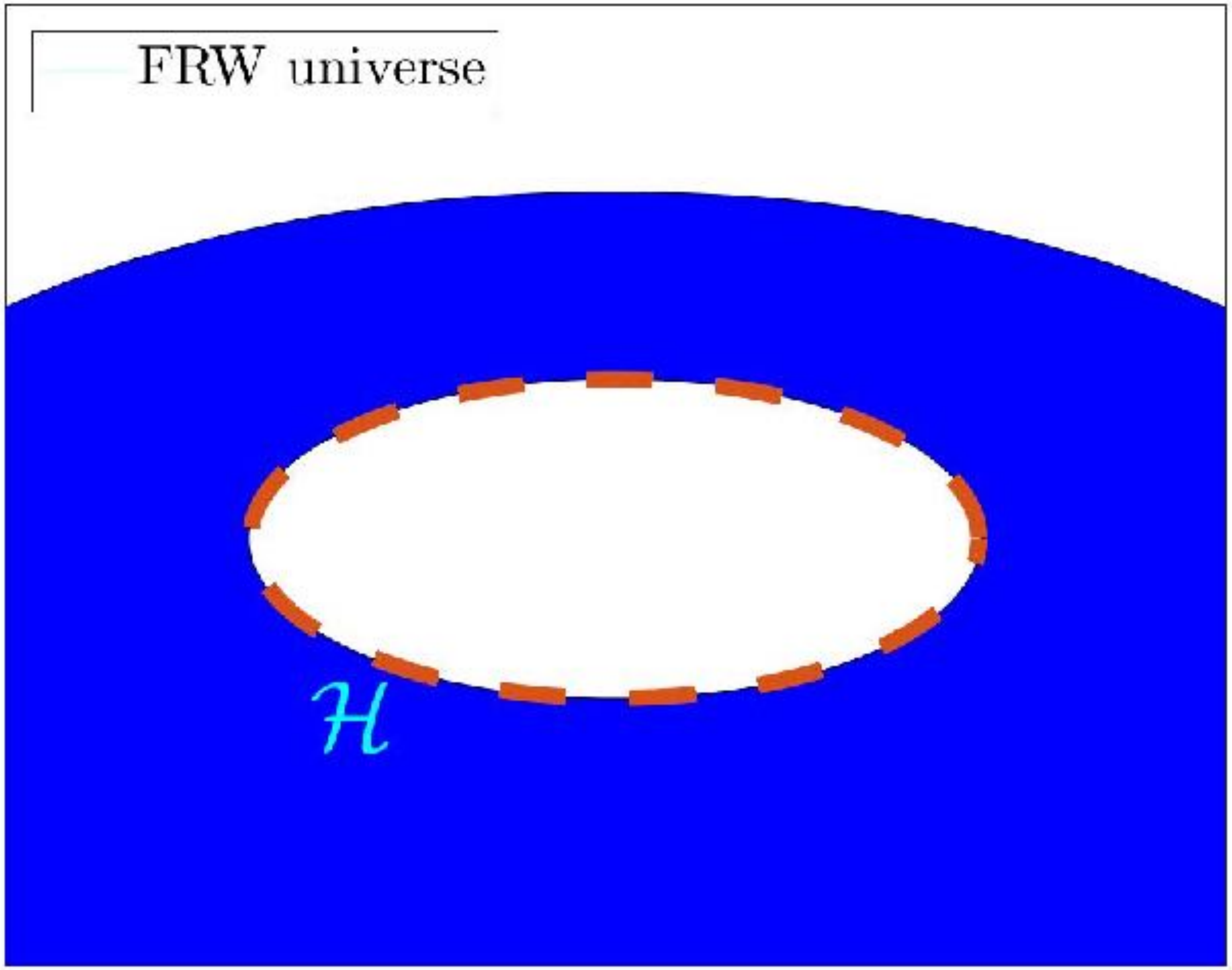
W. L. Freedman, 2017, Nat. Astron., 1, 0169

Fast versus *stiff* evolution



General relativity on a classical vacuum: $$q = \frac{1}{2}\Omega_m - \Omega_\Lambda$$

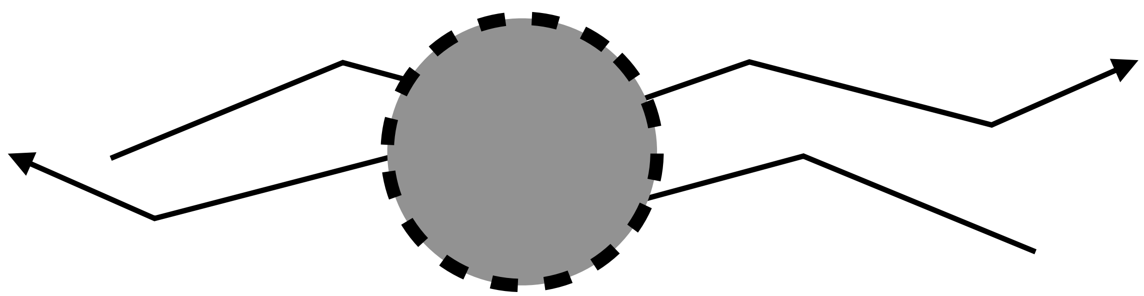
Cosmological horizon



Apparent horizon surface defined in geometric optics limit

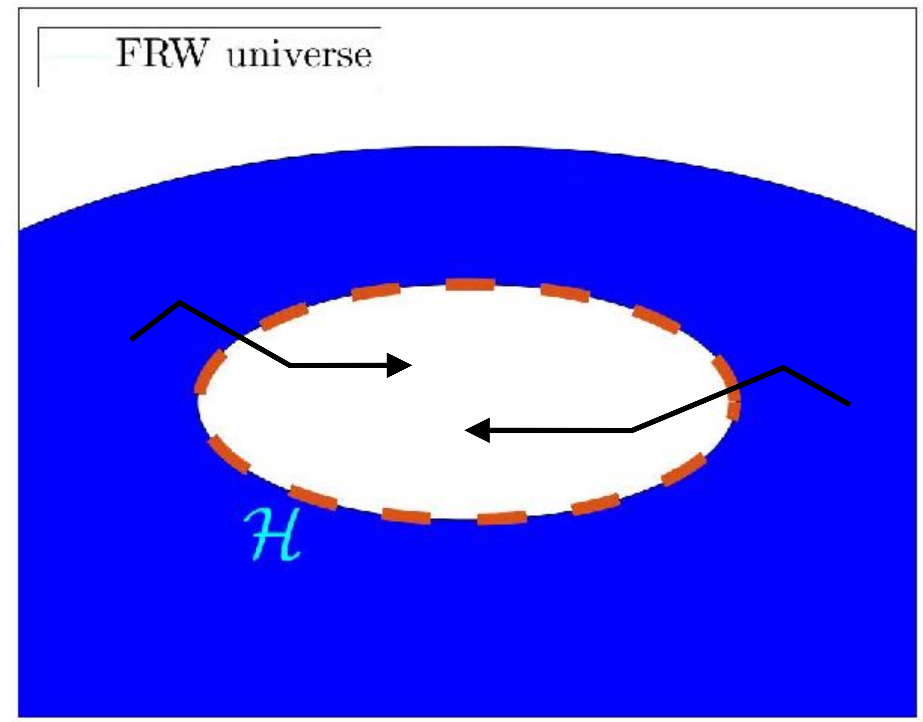
Natural tension $\mathcal{H}$ with wave mechanics

Hawking radiation:
super-horizon scale modes leaking out



$$\omega = \frac{1}{2C_S}$$

$$C_S = 2\pi R_S$$

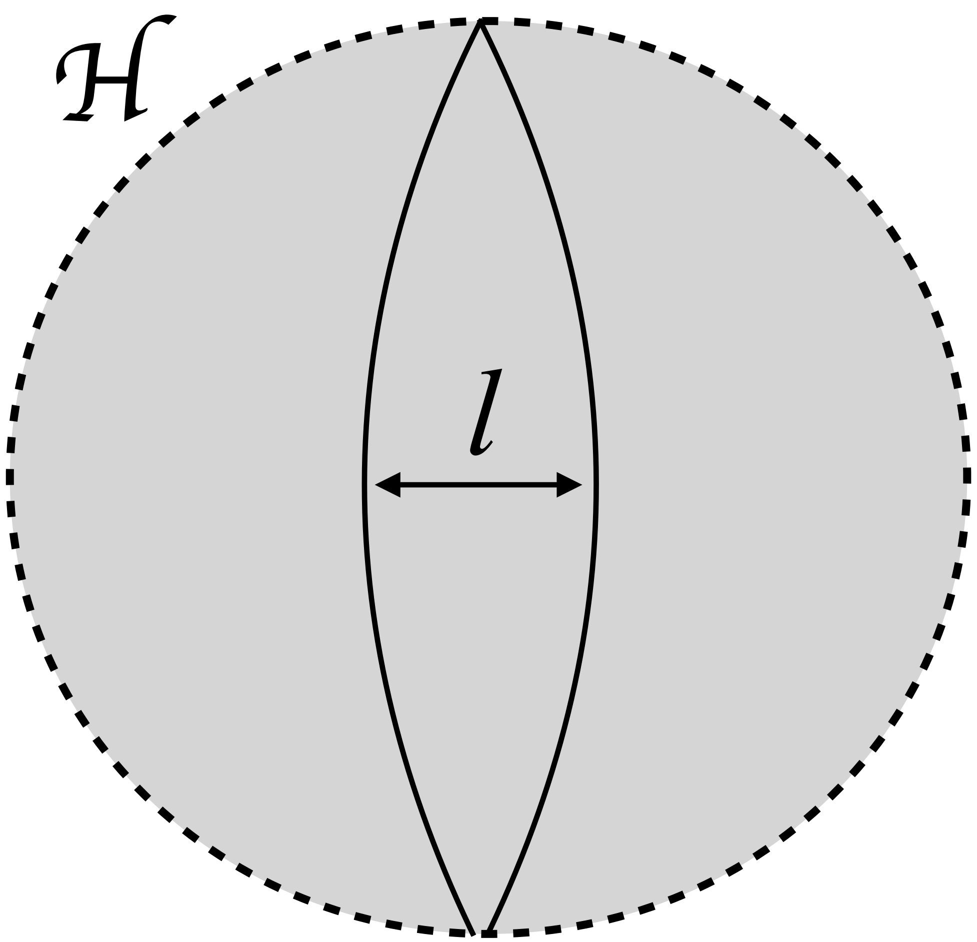


Super-horizon scale modes leaking in

$$\omega = ?$$

Fundamental frequency

van Putten 2017 ApJ 837 22



$\mathcal{H}$ is compact

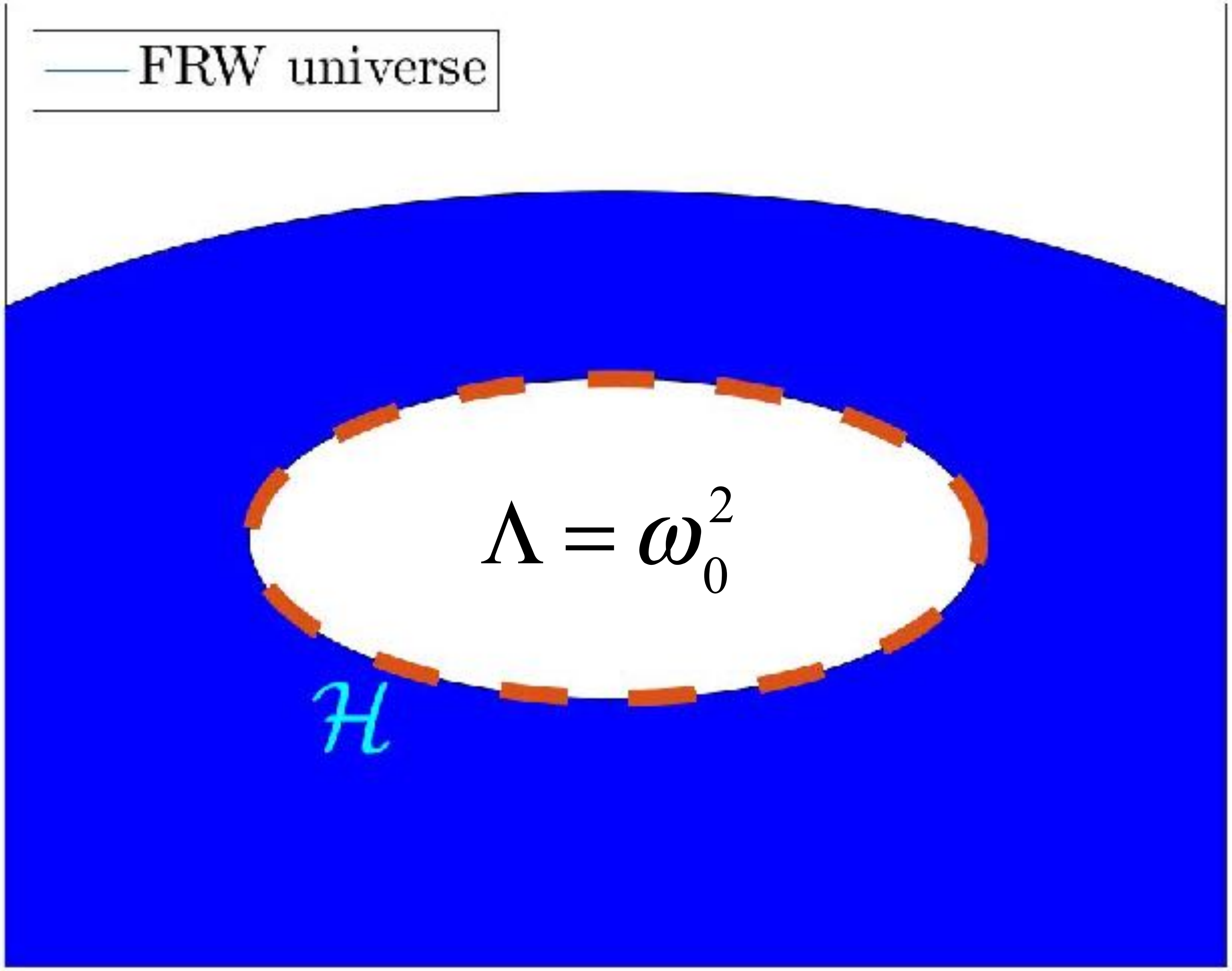
Equations of geodesic separation:

$$\omega_0 = \sqrt{1-q}\,H$$

By Gauss-Bonnet, consequences for spacetime within:

$$\omega = \sqrt{\omega_0^2 + k^2}: \quad \Lambda = \omega_0^2$$

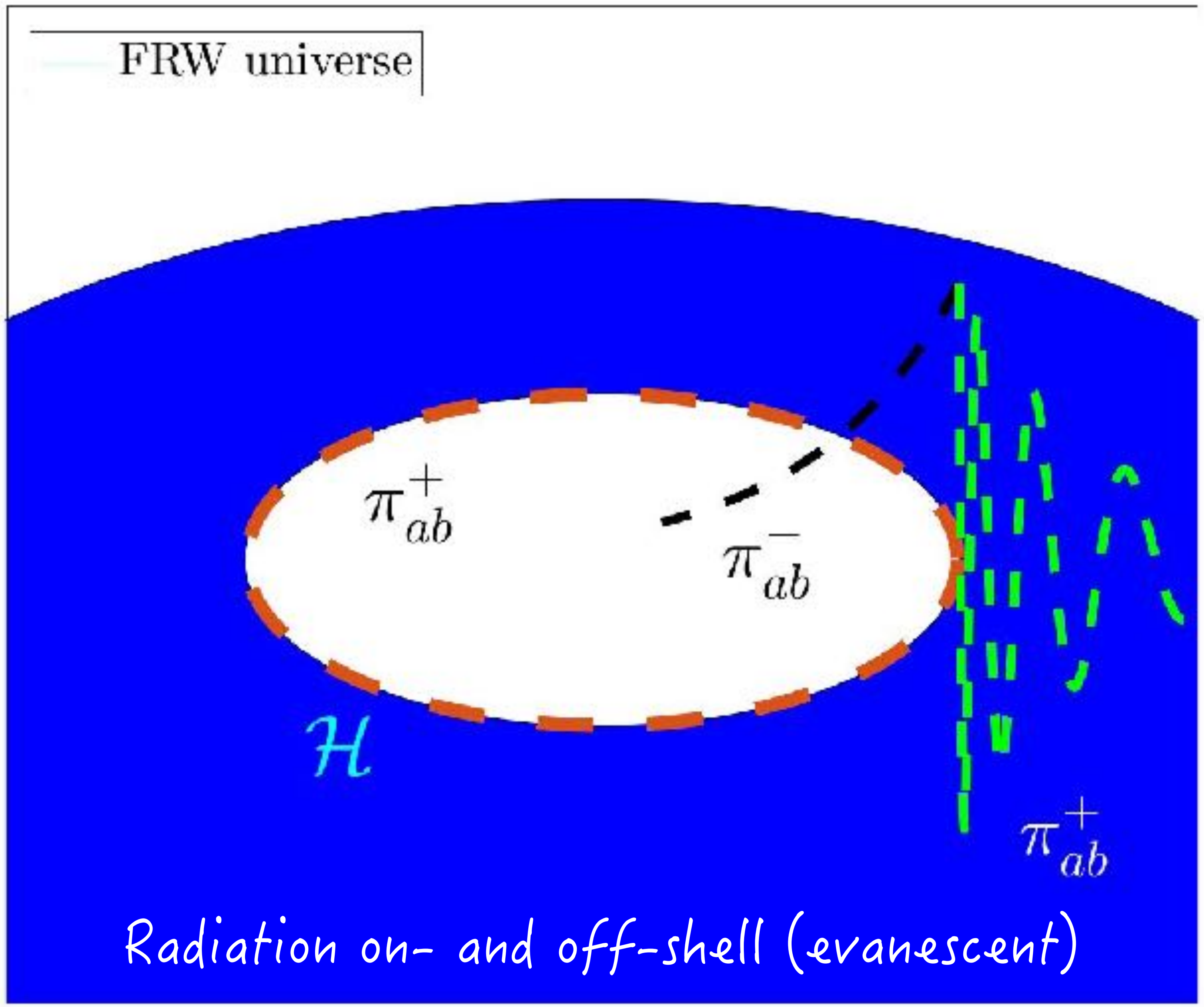
Cosmological vacuum



$$T_{ab} = (\rho + p)u_a u_b + p g_{ab} - \omega_0^2 g_{ab}$$

Evanescent DE and DM

Pick up nonzero trace by imaginary wave numbers at super-horizon scale wave lengths



$$T_{ab} = \rho_c \left[(1-q)\pi_{ab}^{-} + q\pi_{ab}^{+} \right] \qquad \pi_{ab}^{\pm} = \mathrm{dia}(1, \pm\tfrac{1}{3}, \pm\tfrac{1}{3}, \pm\tfrac{1}{3})$$

Canonical states of cosmology

q	**State**	$\rho_c^{-1} T_{ab}$
1	Radiation dominated	π^+_{ab}
1/2	Matter dominated	$u_a u_b$
0	Zero Hubble flow	π^-_{ab}
-1	de Sitter	$-g_{ab}$

Exact solution

$$H(z) = H_0\sqrt{1+\omega_m\left(6z+12z^2+12z^3+6z^4+\frac{6}{5}z^5\right)}\left(1+z\right)^{-1}$$

van Putten, 2017, ApJ, 848, 28

$$H_0 = H(0), \quad \omega_m = \Omega_m(0)$$

$$H'(0) = (3\omega_m - 1)H_0 \cong 0$$

$$q(z) = -1 + (1+z)H^{-1}(z)H'(z), \quad q_0 = q(0)$$

$$Q(z) = \frac{dq(z)}{dz}, \quad Q_0 = Q(0) = 3\omega_m\left(5-6\omega_m\right) \cong 2.8$$

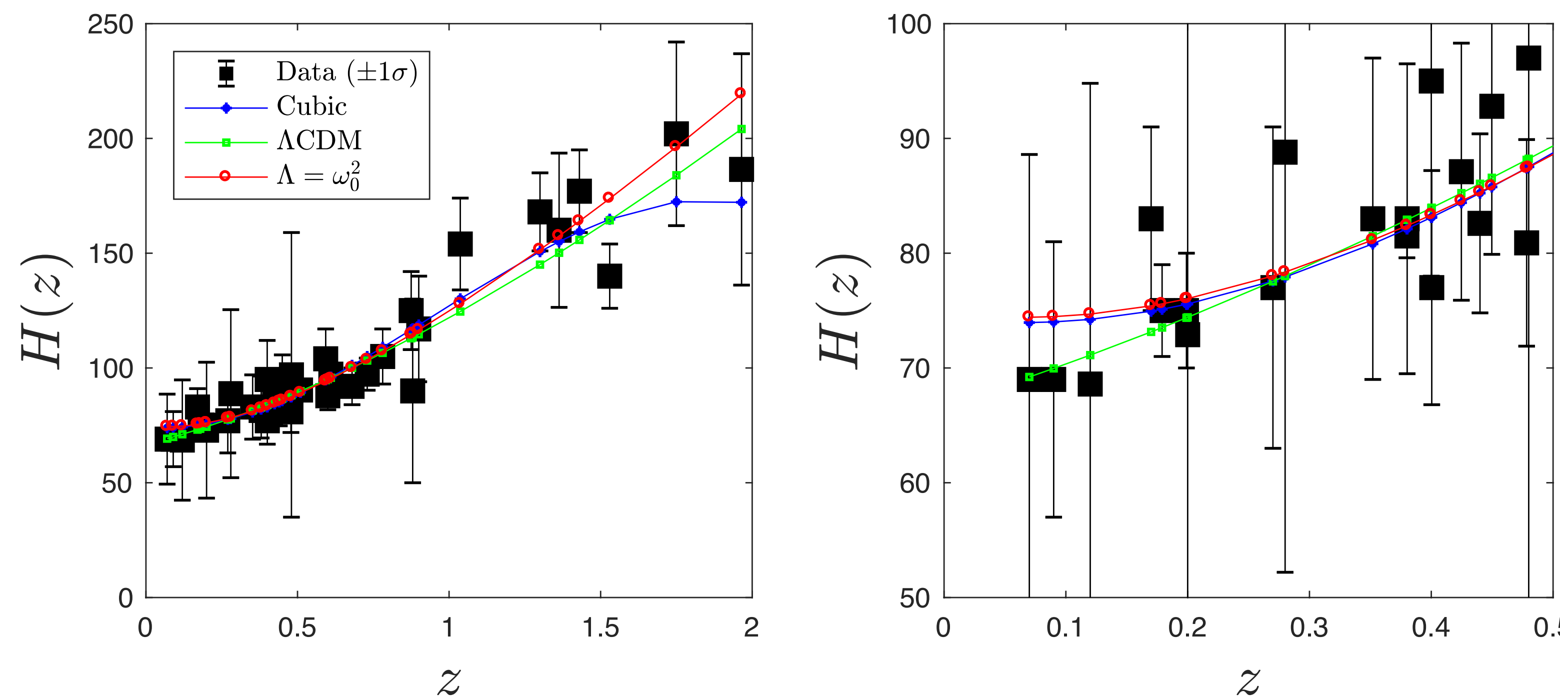
de Sitter state (q=-1) is unstable

Confrontation with data

Hubble Parameter vs. Redshift Data

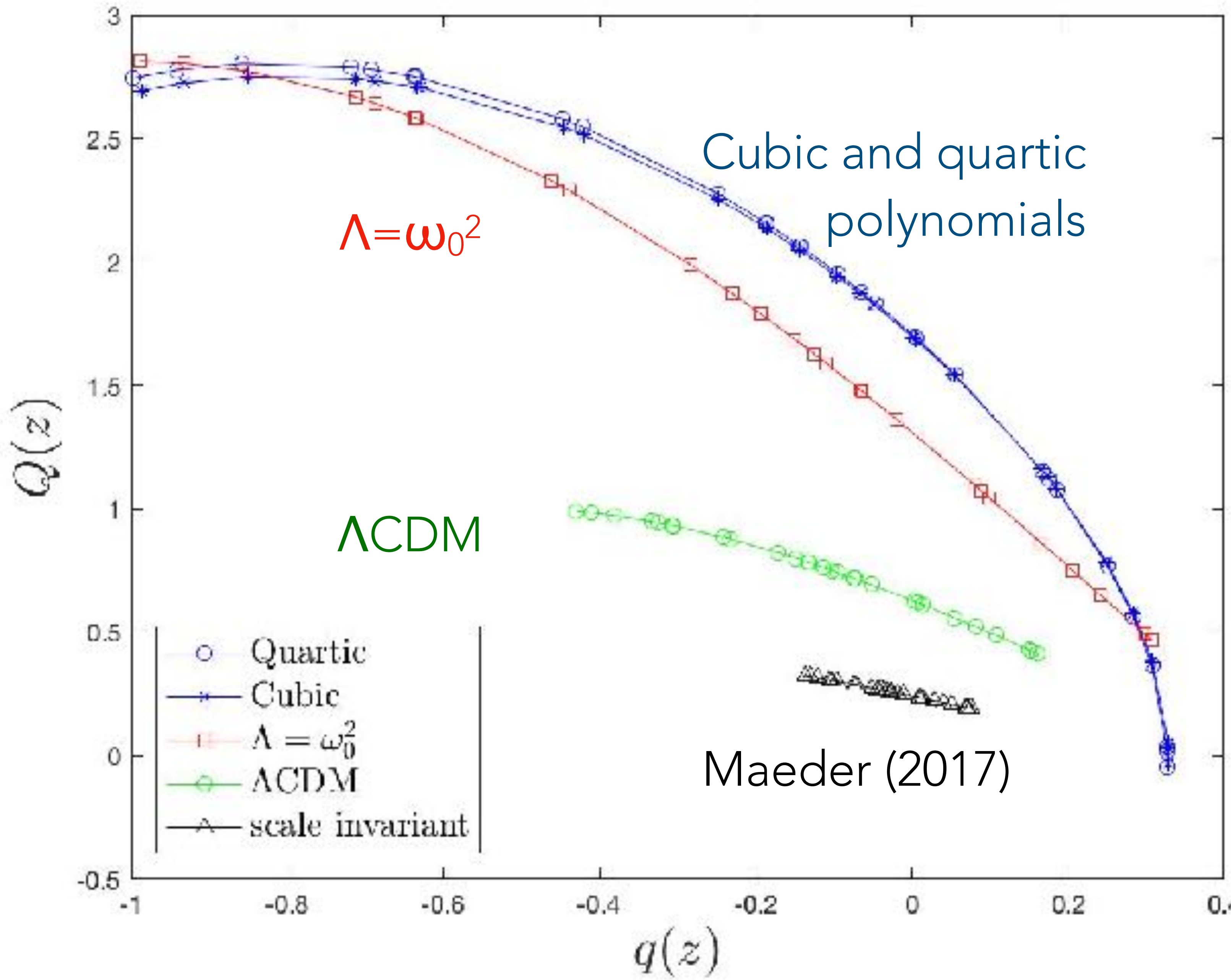
z	$H(z)$ (km s^{-1} Mpc^{-1})	σ_H (km s^{-1} Mpc^{-1})	Reference
0.070	69	19.6	5
0.090	69	12	1
0.120	68.6	26.2	5
0.170	83	8	1
0.179	75	4	3
0.199	75	5	3
0.200	72.9	29.6	5
0.270	77	14	1
0.280	88.8	36.6	5
0.352	83	14	3
0.380	81.5	1.9	10
0.3802	83	13.5	9
0.400	95	17	1
0.4004	77	10.2	9
0.4247	87.1	11.2	9
0.440	82.6	7.8	4
0.4497	92.8	12.9	9
0.4783	80.9	9	9
0.480	97	62	2
0.510	90.4	1.9	10
0.593	104	13	3
0.600	87.9	6.1	4
0.610	97.3	2.1	10
0.680	92	8	3
0.730	97.3	7	4
0.781	105	12	3
0.875	125	17	3
0.880	90	40	2
0.900	117	23	1
1.037	154	20	3
1.300	168	17	1
1.363	160	33.6	8
1.430	177	18	1
1.530	140	14	1
1.750	202	40	1
1.965	186.5	50.4	8
2.340	222	7	7
2.360	226	8	6

References. (1) Simon et al. 2005; (2) Stern et al. 2010; (3) Moresco et al. 2012; (4) Blake et al. 2012; (5) Zhang et al. 2012; (6) Font-Ribera et al. 2014; (7) Delubac et al. 2015; (8) Moresco 2015; (9) Moresco et al. 2016; (10) Alam et al. 2016.



Unbinned data compiled by Farooq et al. 2017

qQ-diagram

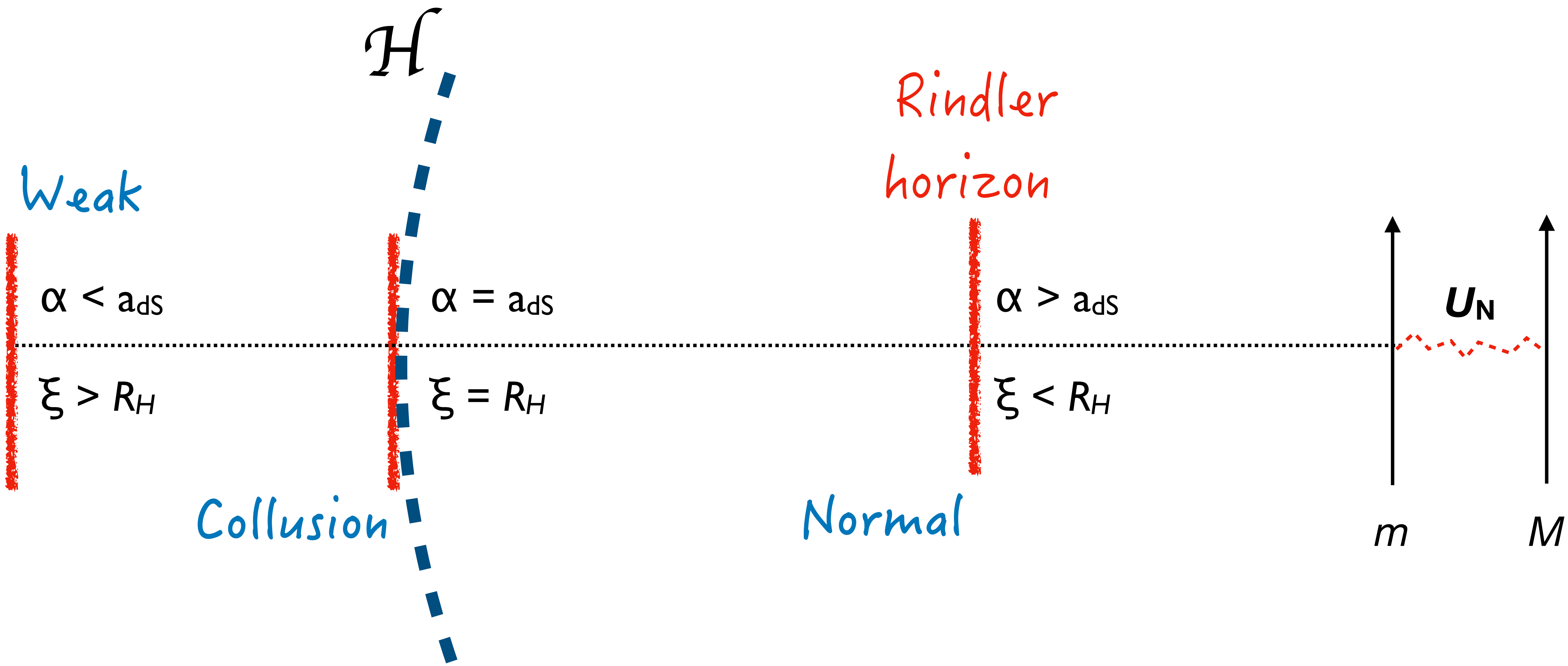


$\left[H_0\right] = \text{km s}^{-1}\ \text{Mpc}^{-1}$

$\Lambda=\omega_0^2$:	74.29 ± 2.6
Anderson & Riess (2017):	73.06 ± 1.76
GW17087 (Guidorzi et al. 2017):	$75.5 \pm (11.6 / 9.6)$

Dynamics in FRW cosmology

$a_{dS} = cH$



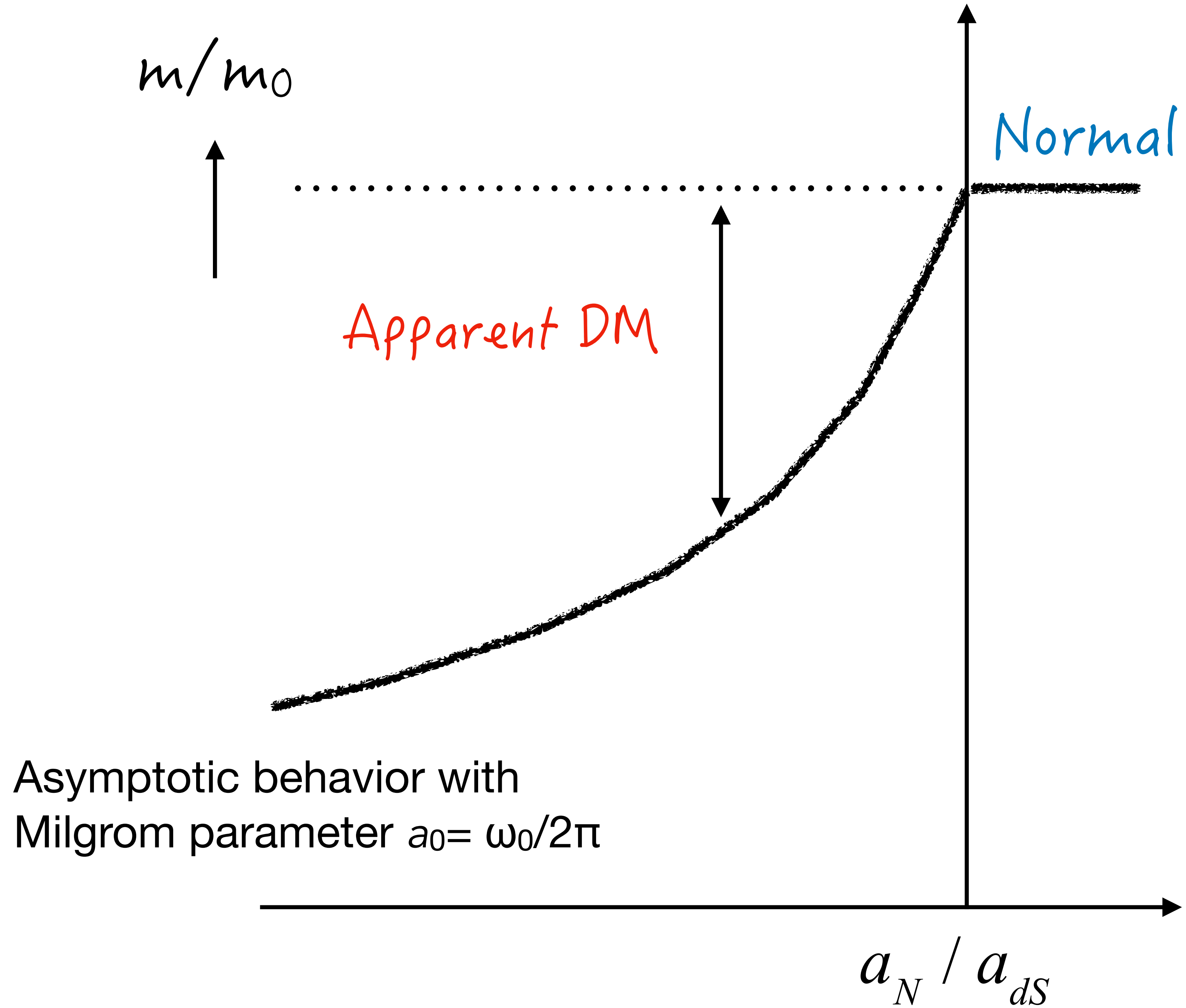
Entanglement entropy I = 2πϕ$_C$ in unitary holography: $U = -\int_0^\xi T_U \, dI = mc^2 \quad \left(\xi = \frac{c^2}{\alpha}, \xi \geq R_H \right)$

Inertial mass-energy $U=mc^2$: gravitational binding energy to Rindler horizon or $\mathcal{H}$ - whichever is more nearby

C^0 galaxy dynamics

$$m\alpha = F_N = m_0 a_N$$

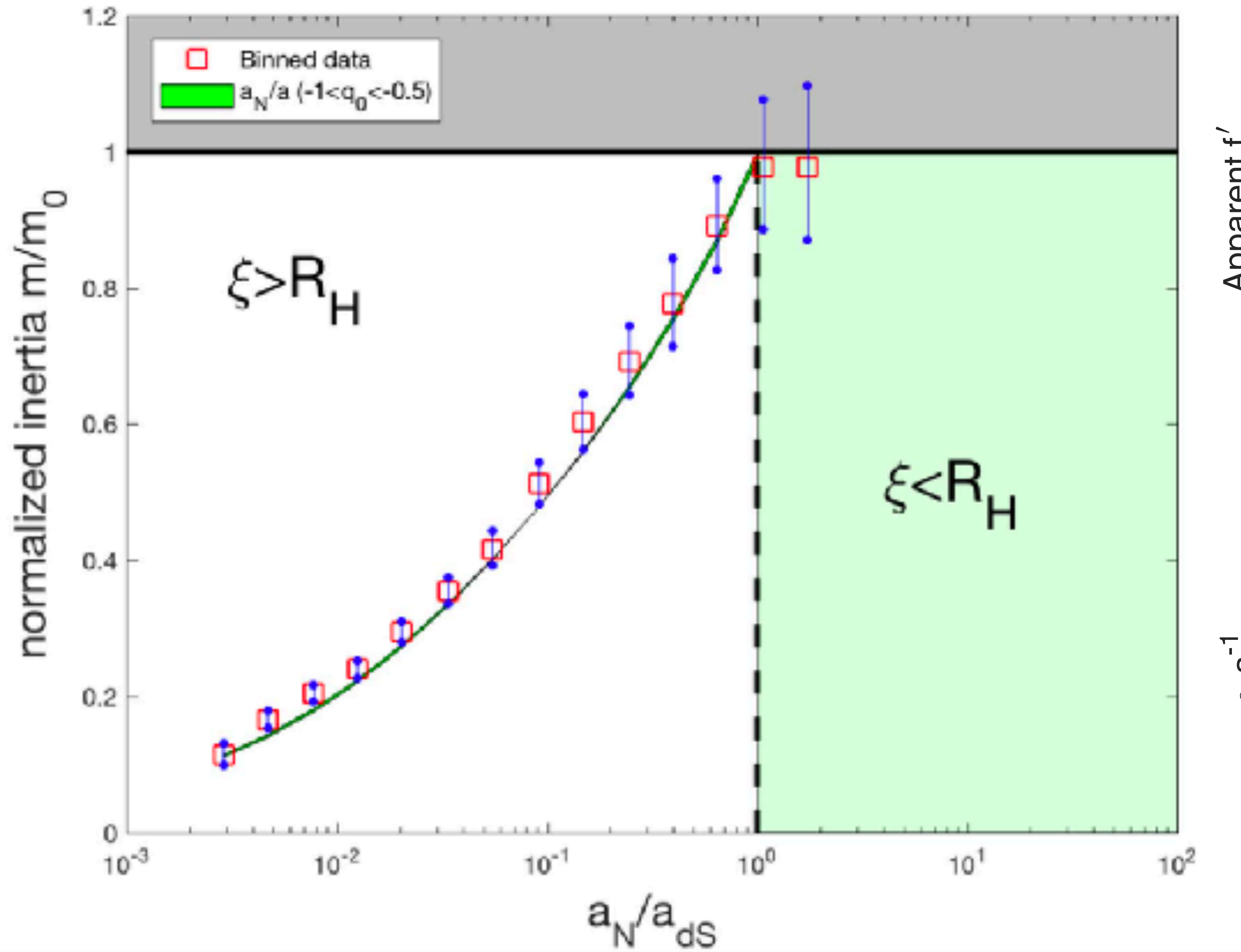
$$\frac{m}{m_0} = \frac{a_N}{\alpha} = \frac{V_b^2 / r}{V_c^2 / r}$$



Same E_k and U_N: invariant Lagrangian and Hamiltonian

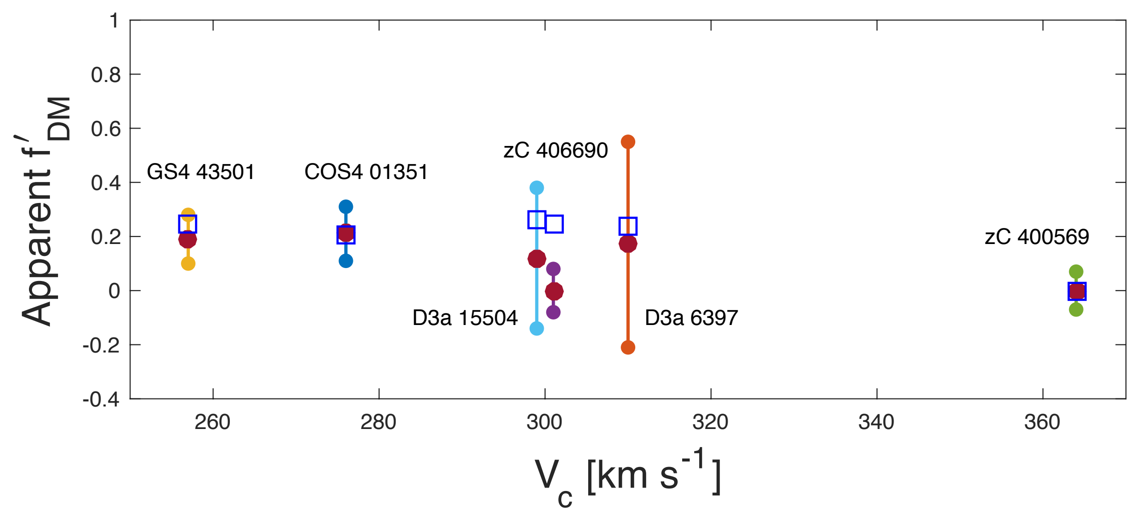
… over 0 < z < 2

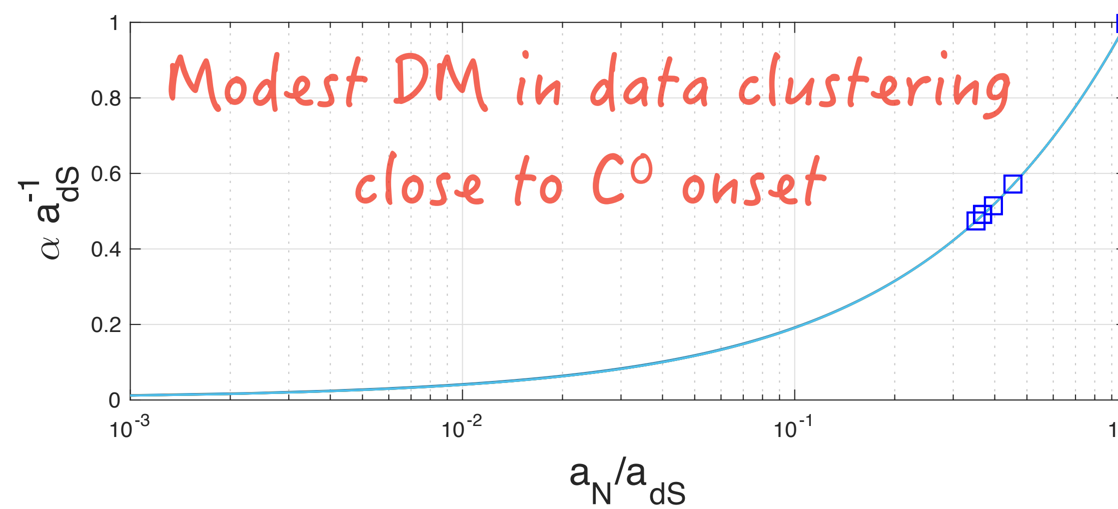
C^0 onset in data



z~0 galaxies (Lellie et al. 2016)

Apparent DM fraction





z~2 galaxies (Genzel et al. 2017)

Conclusions and Outlook

Evanescent DE and DM: super-horizon scale fluctuations ~ ω_0:

- Tension-free H_0 = 74.29 (2.6) km s^{-1} Mpc^{-1}
- Observational consistency in qQ-diagram with polynomial fits to $H(z)$ data

C^0 galaxy dynamics: reduced inertia at accelerations below a_{dS}:

- Apparent DM depend on distance to C^0 onset
- Observational agreement with galaxies over $0 < z < 2$

Left with DM concentrations in galaxy clusters with $m_{DM} < 10^{-30}$ eV