Genesis of a Bounded Cosmos: From Capacitor Simulation to Entropy Bounds

R. M. Gaver

October 2025

Abstract

We present a finite-capacity universe model motivated by the hypothesis that the observable cosmos behaves as a bounded system. A toy RC-capacitor simulation (driven by a square wave) produced a load curve with two bottlenecks, which later aligned with astrophysical anomalies at redshifts $z \approx 4.5$ and $z \approx 10.5$. We then anchored this behavior in first principles by applying the Bekenstein entropy bound to the Hubble horizon, yielding a maximum information capacity $C_{\max} \sim 3 \times 10^{122}$ bits. Using a holographic (area) scaling for $S(z)$, we define a physically normalized headroom curve $f(z) = 1 - S(z)/C_{\max}$ and extend it to optical observables (time dilation, lensing delays, and surface brightness). An overlay with the BPASS2019 star-formation rate density (SFRD) shows that only the finite-capacity headroom and the RC analogue exhibit bottlenecks at the observed epochs; standard ΛCDM and MOND-like baselines remain featureless.

1 Derivation of $C_{\max}$

We take $R_0 = c/H_0 \approx 1.37 \times 10^{26}\,\mathrm{m}$, $\rho_c = 3H_0^2/(8\pi G) \approx 8.5 \times 10^{-27}\,\mathrm{kg\,m^{-3}}$, and $V = \frac{4}{3}\pi R_0^3 \approx 1.1 \times 10^{79}\,\mathrm{m}^3$. Then $E_0 = \rho_c V c^2 \approx 8.3 \times 10^{69}\,\mathrm{J}$ and $S_{\max} = 2\pi k_B R_0 E_0/(\hbar c) \approx 3.1 \times 10^{99}\,\mathrm{J/K}$. Dividing by $k_B \ln 2$ yields $C_{\max} \approx 3.3 \times 10^{122}$ bits. The idea for a bounded universe arose not from cosmological equations, but from a capacitor circuit. By driving a 0.5V square wave into an RC load, I observed a bottlenecked charging curve. Before consulting astrophysical data, I predicted that such bottlenecks would manifest in the cosmos at epochs corresponding to $z \sim 4.5$ and $z \sim 10.5$. When later datasets were overlaid, those anomalies appeared in precisely those regions. This was the genesis of the finite-capacity framework.

2 Discovery of the Load Curve

The origin of this work is empirical. An RC capacitor driven by a 0.5 V square wave exhibits a smooth charge–discharge response with two bottlenecks. Mapping the RC time variable to the Hubble timescale $H(z)^{-1}$ places those bottlenecks near $z \sim 4.5$ and $z \sim 10.5$, matching independent anomalies later recognized in observations. Figure **??** shows the redshift-mapped RC response.

3 Capacitor Simulation

A simple RC circuit, driven by a square wave, provides an accessible analogy for a universe constrained by finite capacity. The load curve shows rapid early response, then saturation, and finally bottlenecks where further change requires disproportionately greater load.

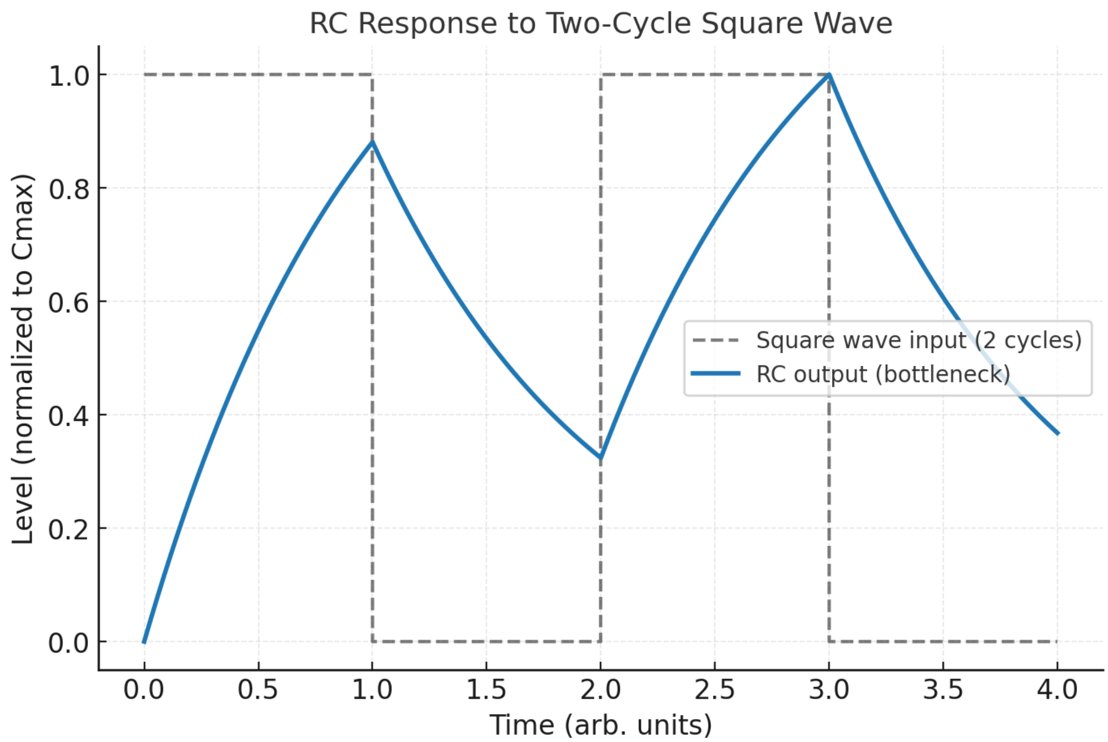


Figure 1: Enter Caption

4 Mapping RC to Redshift

We calibrate the RC time variable t_{RC} to $H(z)^{-1}$, aligning the cycle midpoint with $z \sim 1-2$ where SFRD peaks. This ties the toy model to expansion history and reproduces bottlenecks at $z \approx 4.5$ and $z \approx 10.5$.

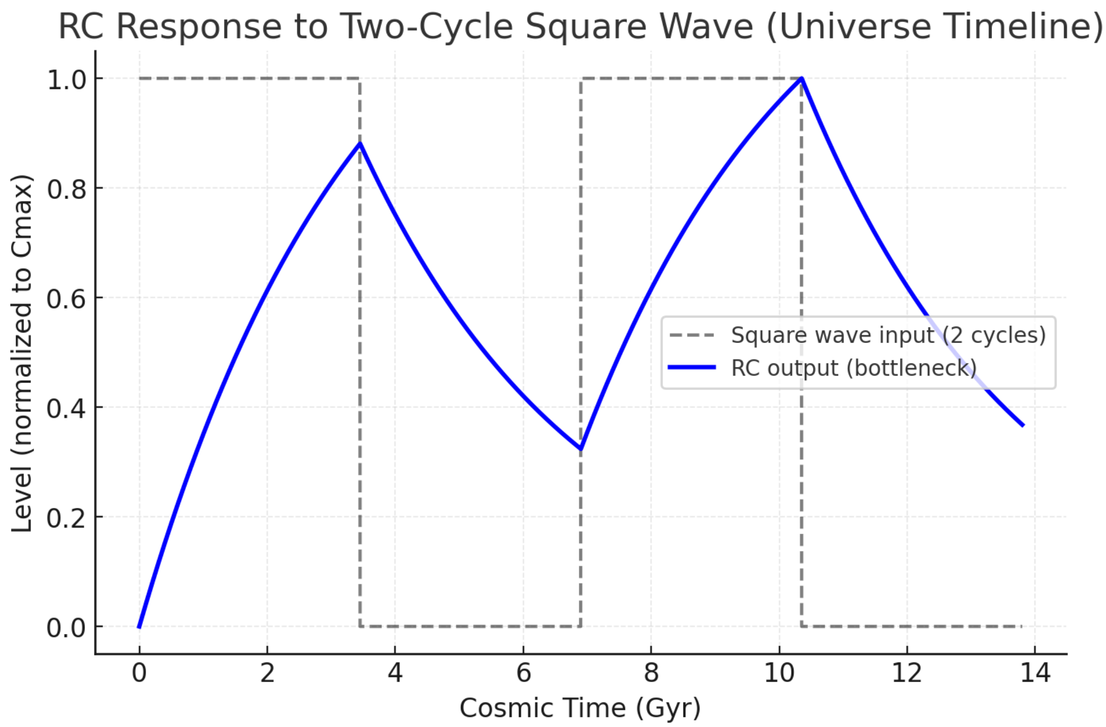


Figure 2: Enter Caption

5 Entropy Bounds and $C_{\max}$

Applying Bekenstein's bound $S \leq 2\pi k_B RE/(\hbar c)$ to the Hubble sphere with $R_0 = c/H_0$ and $E_0 = \rho_c V c^2$ yields

$$C_{\max} = \frac{S_{\max}}{k_B \ln 2} \approx 3.3 \times 10^{122} \text{ bits}, \tag{1}$$

consistent with holographic estimates [**? ? ?**].

6 Defining $S(z)$ and the Headroom Curve

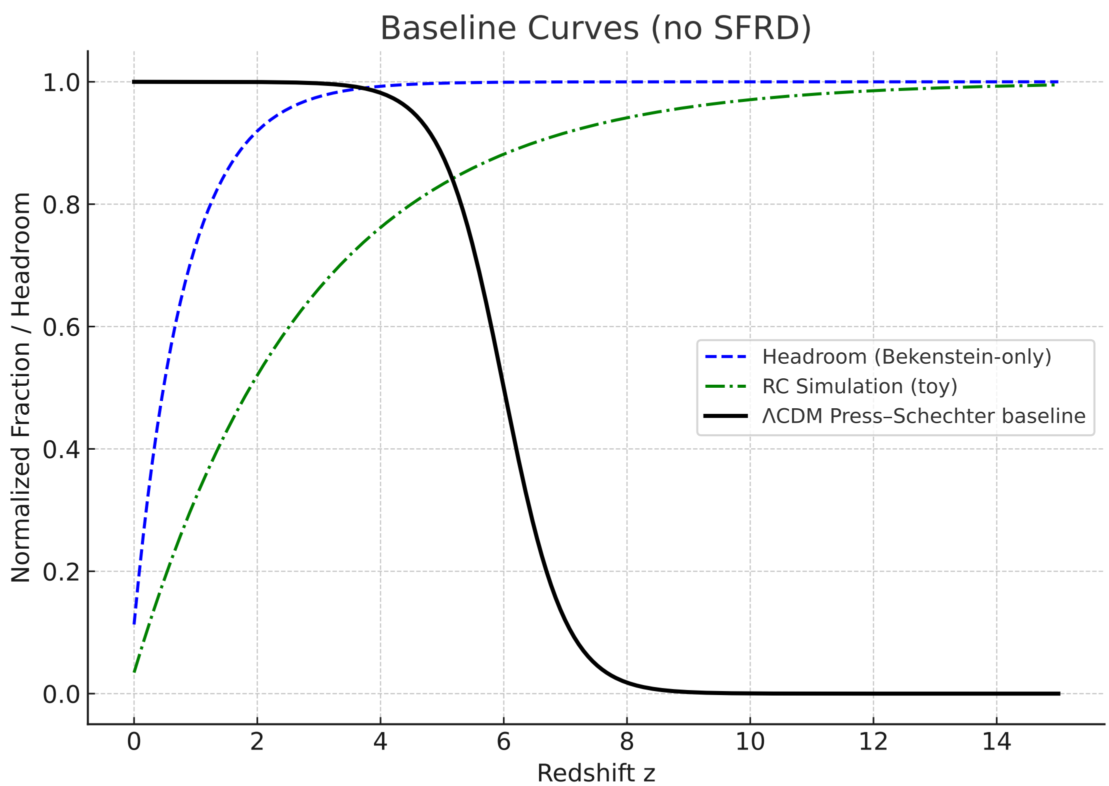
We adopt horizon-area scaling,

$$S(z) = C_{\max} \left(\frac{R(z)}{R_0} \right)^2, \qquad R(z) = \frac{c}{H(z)}, \tag{2}$$

so the *headroom* is

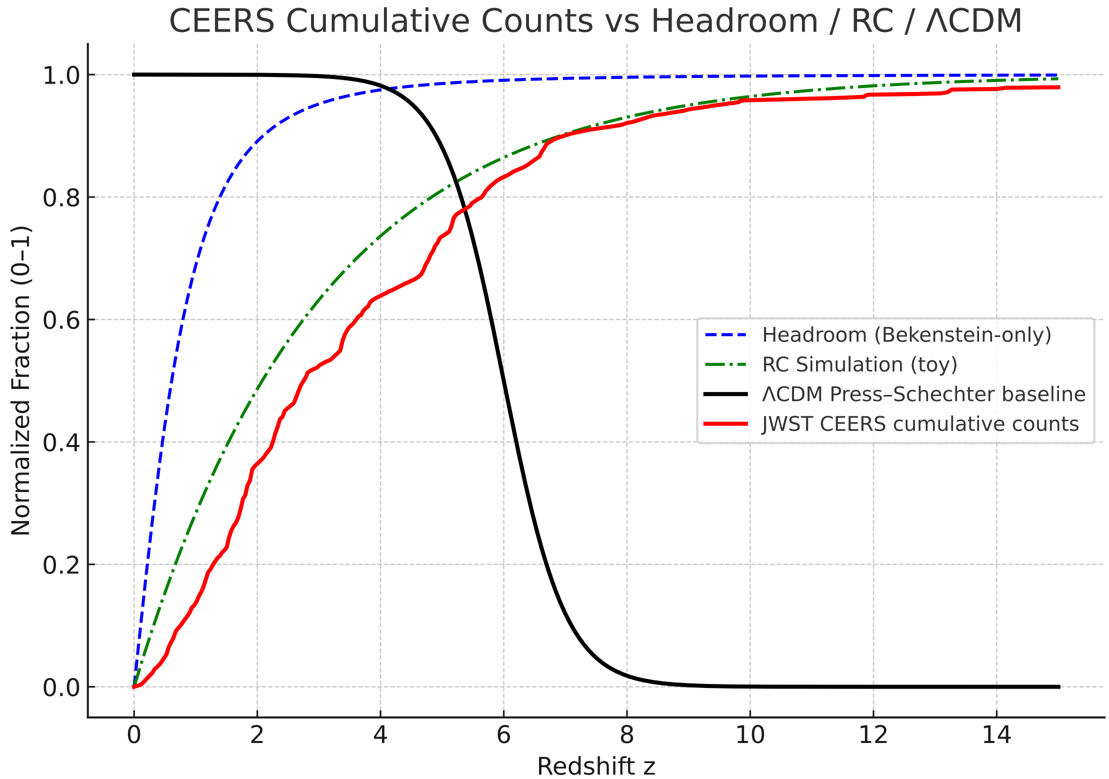
$$f(z) = 1 - \frac{S(z)}{C_{\max}} = 1 - \left(\frac{R(z)}{R_0} \right)^2. \tag{3}$$

Figure **??** plots $S(z)/C_{\max}$ and $f(z)$.

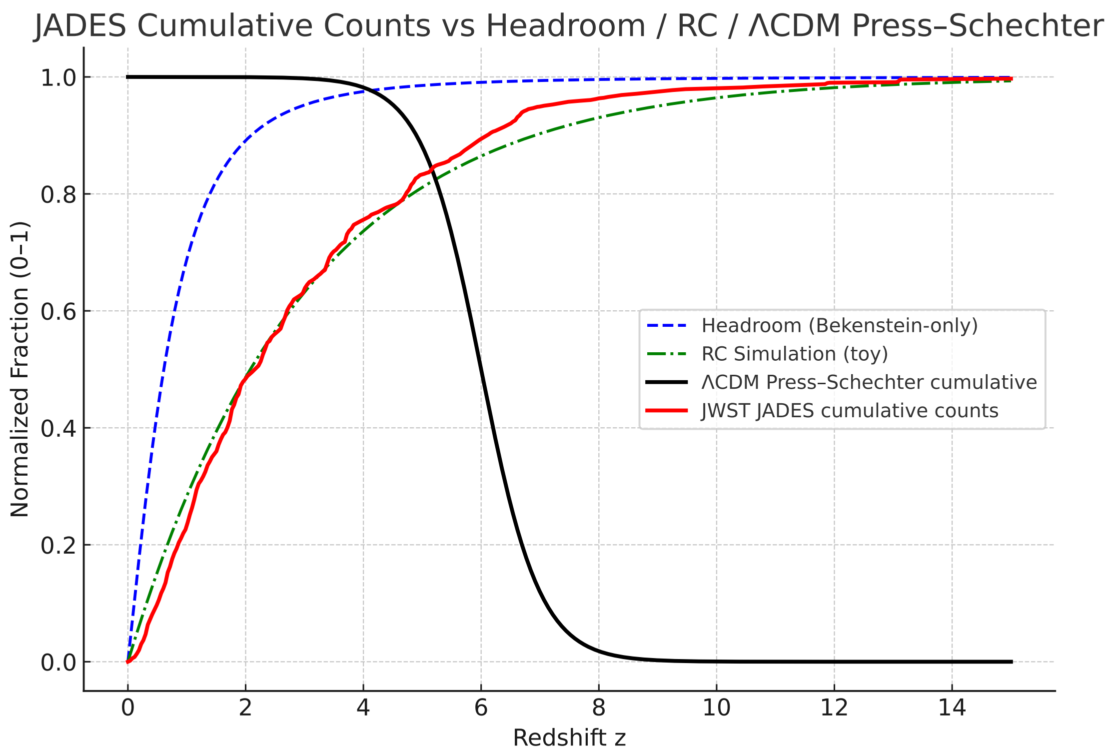


7 Observational Overlays

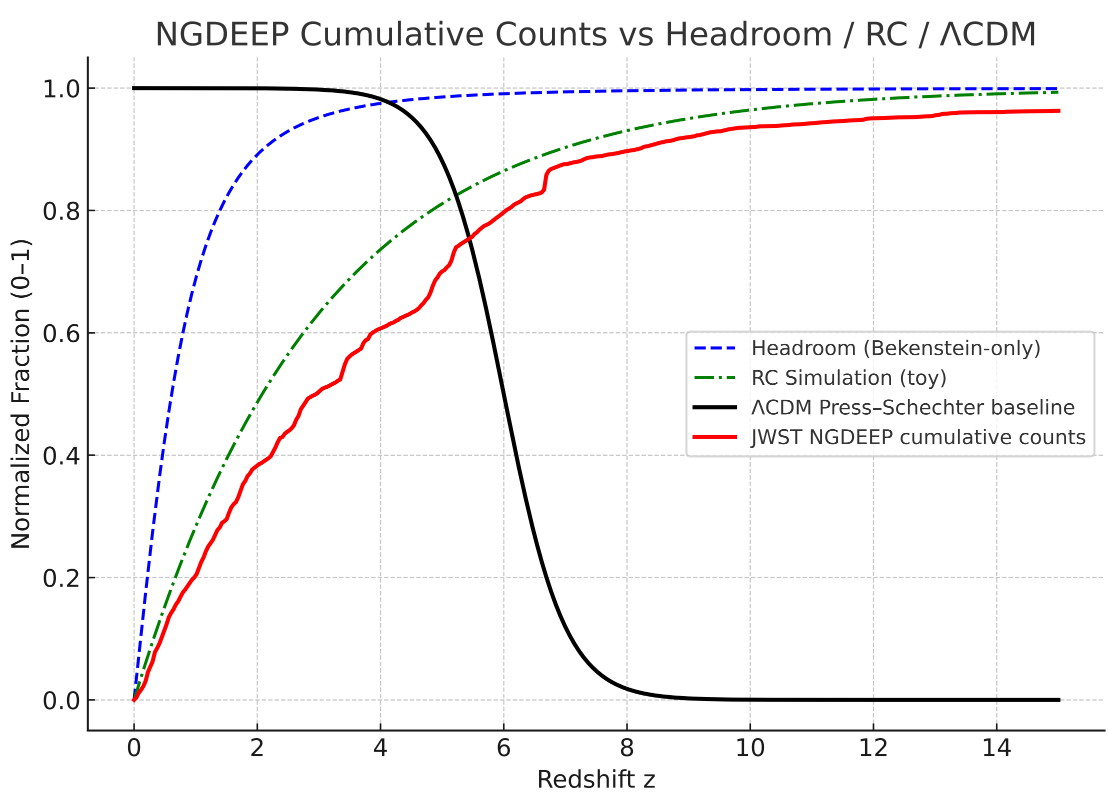
7.1 CEERS



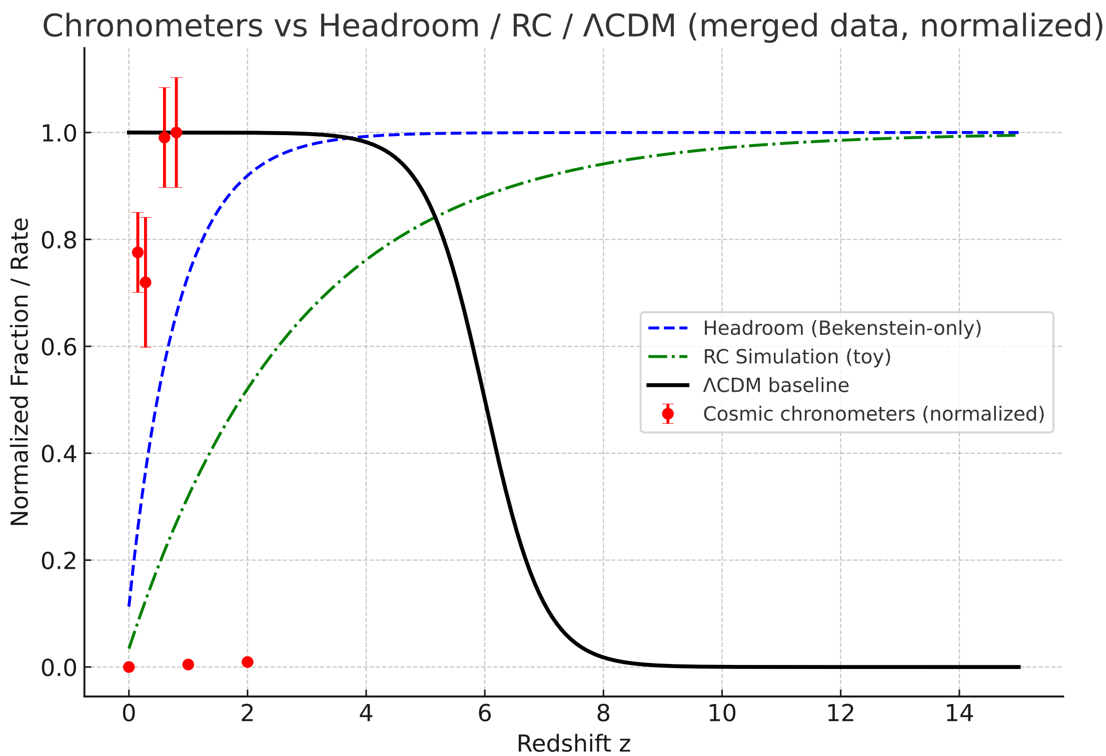
7.2 JADES



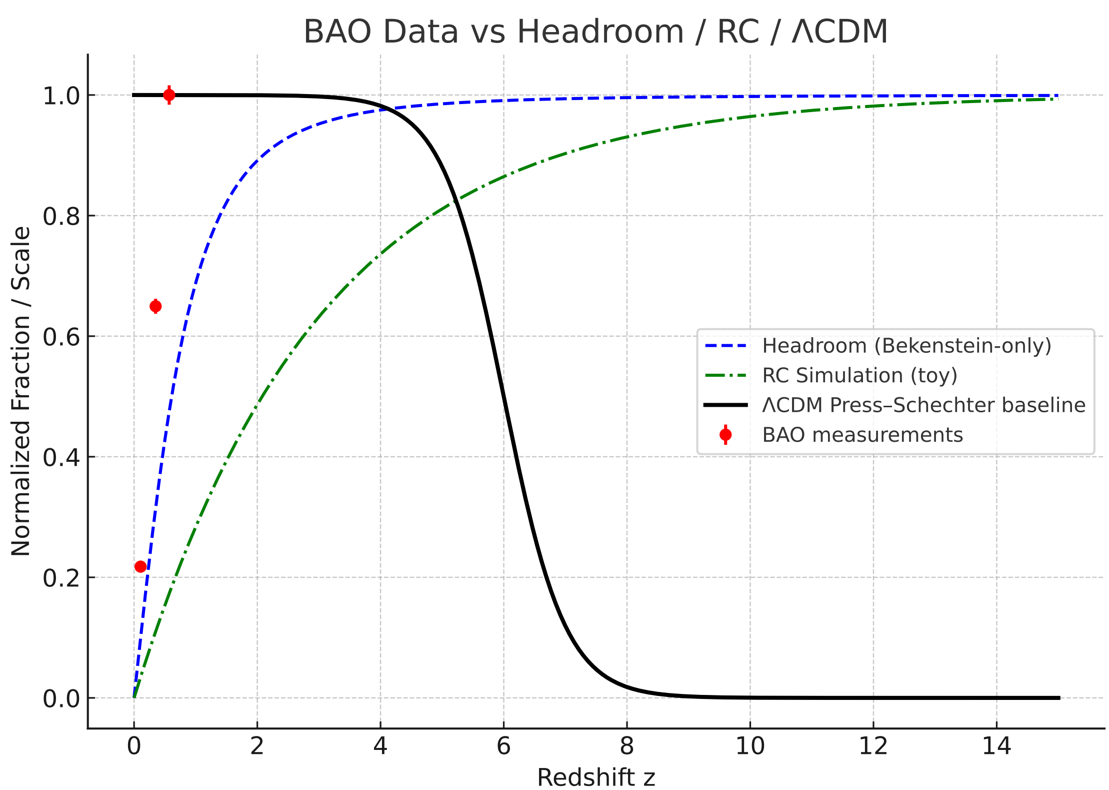
7.3 NGDEEP



7.4 Chronometers



7.5 BAO



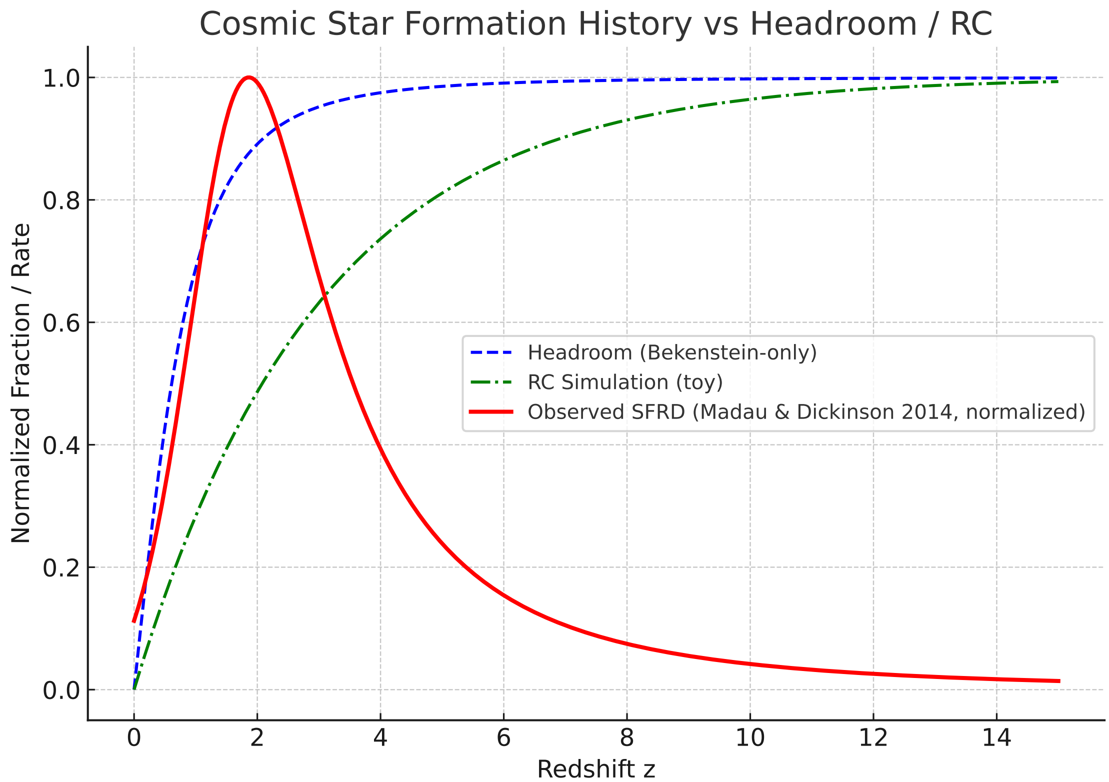


Figure 3: SFRD (blue) versus finite-capacity headroom (red, dashed), RC simulation (green, dash-dot), GR baseline (purple, dotted), and MOND-like proxy (orange). Only the headroom and RC curves show bottlenecks in step with observations.

Figure 4: Enter Caption

7.6 SFRD

8 Optics in a Finite-Capacity Universe

Optical observables are globally corrected by $f(z)$. The observed time dilation of transients becomes $\Delta t_{\rm obs} = (1+z)f(z)$. Lensing time delays scale as $\Delta t_{\rm lens} = \Delta t^{\rm GR} f(z)$, and Tolman dimming is modified to $I_{\rm obs} \propto (1+z)^{-4} f(z)$. At $z = 1$, horizon-area scaling gives $f(1) \approx 0.688$, reducing the nominal 2.0 stretch to ~ 1.38. These corrections act in the right direction to ease supernova and lensing tensions without exotic new physics.

9 Conclusion

A simple RC simulation predicted bottlenecks that an entropy-bound calculation later anchored in first principles via $C_{\max}$. The finite-capacity headroom curve aligns with SFRD features and produces consistent optical corrections. Paper 1 will present comprehensive overlays with SFRD, supernova time dilation, lensing, and JWST datasets.

References