Probing $f(Q)$ Gravity as a Unified Solution to the H_0 and S_8 Tensions

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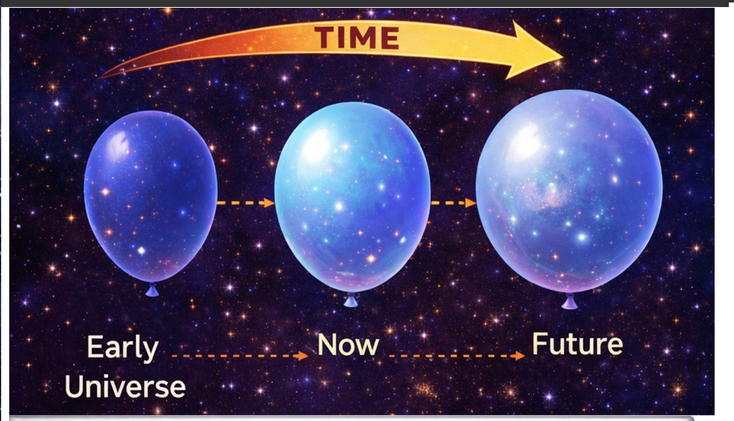
Abstract

In this work, we investigate a modified gravity model within the symmetric teleparallel framework, where gravity is described by the non-metricity scalar Q. We consider the reconstructed model $f(Q) = \alpha + \beta Q^n$ and constrain its parameters using MCMC techniques with BAO, CC, Pantheon+SH0ES supernovae and $f\sigma_8$.

Our results show that the model produces H_0 values consistent with late-time observations, while slightly reducing the tension S_8 relative to ΛCDM. Although parameter degeneracies remain significant, these results suggest that $f(Q)$ gravity may provide a viable geometric extension of standard cosmology, warranting further investigation with future high-precision data.

Introduction



Results

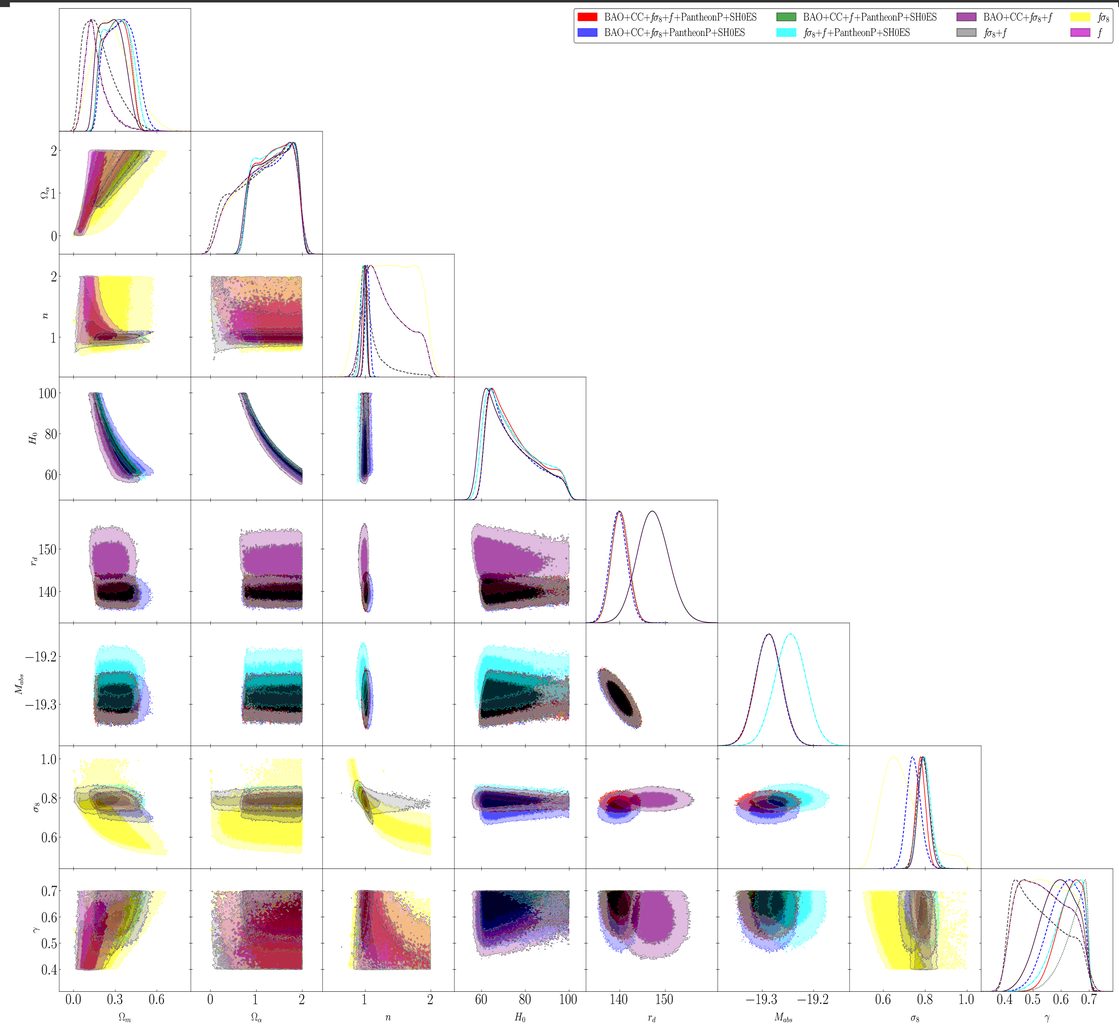


Figure: Constraints on the $f(Q)$ model using datasets CC, BAO, f_{σ_8}, f, and PantheonP+SH0ES. Here Ω_m denotes $\Omega_{m,0}$.

Observational Way Out

$f(Q) = \alpha + \beta Q^n$ such that $H(z) = H_0\left(\frac{\Omega_m(1+z)^3 + \frac{\Omega_\alpha}{2}}{2-\frac{1}{n}}\right)^{\frac{1}{2n}}$

Best-fit Cosmological Parameters

Observation	$\Omega_{m,0}$	Ω_α	n	H_0	S_8
BAO+CC+PantheonP+SH0ES	$0.342^{+0.111}_{-0.113}$	$1.419^{+0.404}_{-0.471}$	$1.037^{+0.038}_{-0.037}$	$71.383^{+15.326}_{-8.071}$	$0.782^{+0.027}_{-0.026}$
PantheonP+SH0ES	$0.543^{+0.267}_{-0.213}$	$1.263^{+0.489}_{-0.486}$	$1.284^{+0.215}_{-0.217}$	$73.283^{+12.813}_{-8.148}$	—
BAO+CC	$0.309^{+0.139}_{-0.108}$	$1.412^{+0.406}_{-0.483}$	$1.017^{+0.063}_{-0.063}$	$68.109^{+15.572}_{-8.064}$	—
BAO+CC+$f\sigma_8$+f+PantheonP+SH0ES	$0.303^{+0.087}_{-0.094}$	$1.403^{+0.397}_{-0.444}$	$1.004^{+0.024}_{-0.025}$	$72.246^{+14.997}_{-8.465}$	$0.782^{+0.027}_{-0.026}$
BAO+CC+$f\sigma_8$+PantheonP+SH0ES	$0.337^{+0.104}_{-0.108}$	$1.426^{+0.394}_{-0.461}$	$1.031^{+0.034}_{-0.035}$	$71.362^{+14.956}_{-7.985}$	$0.791^{+0.039}_{-0.037}$
BAO+CC+f+PantheonP+SH0ES	$0.310^{+0.087}_{-0.094}$	$1.428^{+0.399}_{-0.446}$	$1.006^{+0.022}_{-0.023}$	$71.693^{+14.641}_{-8.302}$	—
$f\sigma_8$+f+PantheonP+SH0ES	$0.315^{+0.099}_{-0.102}$	$1.402^{+0.413}_{-0.452}$	$0.965^{+0.037}_{-0.040}$	$71.428^{+15.940}_{-8.949}$	$0.817^{+0.036}_{-0.033}$
BAO+CC+$f\sigma_8$+f	$0.270^{+0.090}_{-0.088}$	$1.400^{+0.415}_{-0.460}$	$0.984^{+0.030}_{-0.035}$	$69.757^{+15.693}_{-8.638}$	$0.753^{+0.029}_{-0.028}$
$f\sigma_8$+f	$0.168^{+0.134}_{-0.003}$	$1.220^{+0.554}_{-0.735}$	$1.028^{+0.235}_{-0.087}$	—	$0.587^{+0.047}_{-0.044}$
$f\sigma_8$	$0.270^{+0.155}_{-0.121}$	$1.247^{+0.531}_{-0.678}$	$1.393^{+0.408}_{-0.409}$	—	$0.646^{+0.074}_{-0.066}$

Table: Best-fit $f(Q)$ parameters with late-time datasets. Only few parameters are shown for clarity.

Conclusion and Future Plans

- $f(Q)$ (with $f_Q = 1$ today) gives $H_0 \sim 68$–73 km/s/Mpc.
- $f(Q)$ (with $f_Q = 1$ today) gives $S_8 \sim 0.78$–0.82,.
- $\therefore f(Q)$ partially alivate the tensions with late-time datasets
- Future studies should relax $f_Q = 1$ and combine early- and late-time probes to fully test the model.

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