NOETHER SYMMETRIES & INFLATIONARY SCENARIOS IN GHOST-FREE F(R,G) GRAVITY

1. INTRODUCTION

Einstein-Gauss-Bonnet models are well-suited for high-curvature regimes relevant to early cosmology, but higher-derivative theories may suffer from **ghost** degrees of freedom due to **Ostrogradsky instabilities**.

Recent **ghost-free extensions of f(R,G) gravity [1]** avoid these issues. However, their complexity often requires reconstruction approaches, where functional forms are imposed externally, neglecting the **intrinsic symmetries**. In this work, viable cosmological scenarios are derived directly from the internal structure of the model using **Noether symmetry methods** and tested for observational viability.

2. THEORETICAL FRAMEWORK

$$S=\int d^4x\sqrt{-g}\left[\frac{R}{2\kappa^2}+\lambda\left(\frac{1}{2}\partial_\mu\chi\partial^\mu\chi+\frac{\mu^4}{2}\right)-\frac{1}{2}\partial_\mu\chi\partial^\mu\chi+h(\chi)G-V(\chi)\right]$$

λ – Lagrange multiplier, μ – mass-dimension constant, χ – auxiliary field

Gauss-Bonnet invariant: $G=R_{\mu\nu\rho\sigma}R^{\mu\nu\rho\sigma}-4R_{\mu\nu}R^{\mu\nu}+R^2$ $\qquad \chi=\mu^2 t$

$$L=-\frac{3}{\kappa^2}\dot{a}^2a+a^3\lambda\left(-\frac{1}{2}\dot{\chi}^2+\frac{\mu^4}{2}\right)-a^3\tilde{V}-8\dot{a}^3h_\chi\dot{\chi} \qquad \tilde{V}(\chi)=-\frac{\mu^4}{2}+V(\chi)$$

3. NOETHER SYMMETRY APPROACH

The model contains a conservation law under the condition $XL=0$, where

$$X=\alpha\frac{\partial}{\partial a}+\gamma\frac{\partial}{\partial\chi}+\dot{\alpha}\frac{\partial}{\partial\dot{a}}+\dot{\gamma}\frac{\partial}{\partial\dot{\chi}} \qquad \dot{\alpha}=\dot{a}\frac{\partial\alpha}{\partial a}+\dot{\chi}\frac{\partial\alpha}{\partial\chi}, \quad \dot{\gamma}=\dot{a}\frac{\partial\gamma}{\partial a}+\dot{\chi}\frac{\partial\gamma}{\partial\chi}$$

Conservation law $\qquad Q=\alpha L_{\dot{a}}+\gamma L_{\dot{\chi}}$

The system of equations obtained after dividing the condition $XL=0$ in the order of derivatives

$$\alpha+2a\alpha_a=0 \qquad \frac{6}{\kappa^2}\alpha_\chi+a^2\lambda\gamma_a=0 \qquad h_\chi\gamma_a=0$$

$$a\,\beta+3\,\lambda\alpha+2\,a\,\lambda\,\gamma_\chi=0 \qquad h_\chi\alpha_\chi=0$$

$$3\,h_\chi\alpha_a+h_\chi\gamma_\chi+h_{\chi\chi}\gamma=0$$

$$\frac{1}{2}a\mu^4\beta+\frac{3}{2}\lambda\mu^4\alpha-3V\alpha-aV_\chi\gamma=0$$

4. SOLUTIONS

$$\tilde{V}=C_2e^{-\frac{3C_1\chi}{a^{3/2}\gamma_0}}, \qquad h=\frac{2\gamma_0C_3}{3C_1}a^{\frac{3}{2}}e^{\frac{3C_1\chi}{2a^{3/2}\gamma_0}}+C_4$$

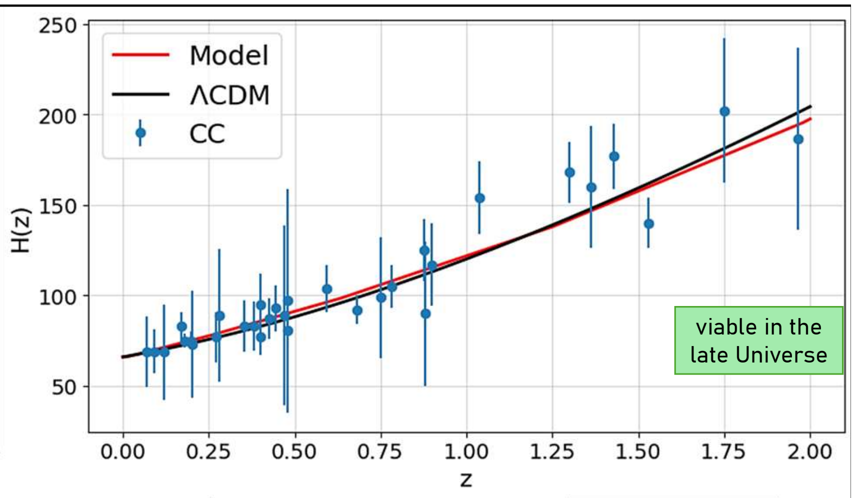
Conservation law

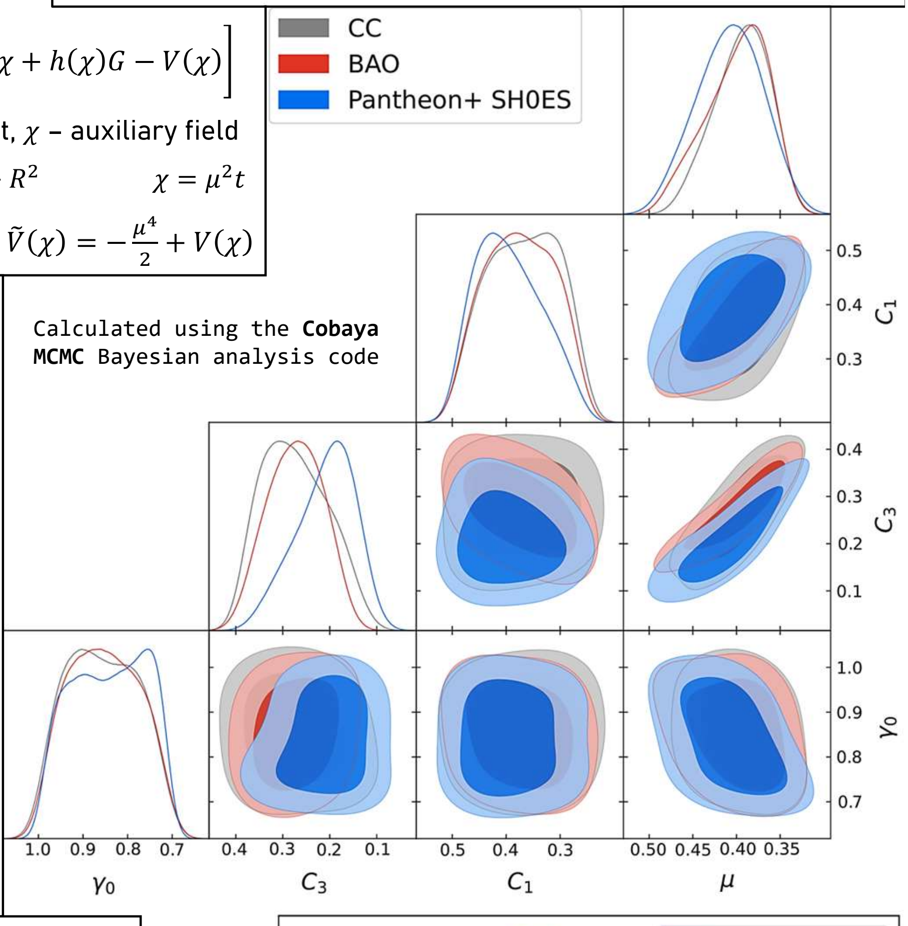
$$Q=-\frac{C_1}{a^{3/2}}\left(\frac{6H}{\kappa^2}+24H^2\mu^2h_\chi\right)-\gamma_0a^3\left(\lambda\mu^2+8H^3h_\chi\right)$$

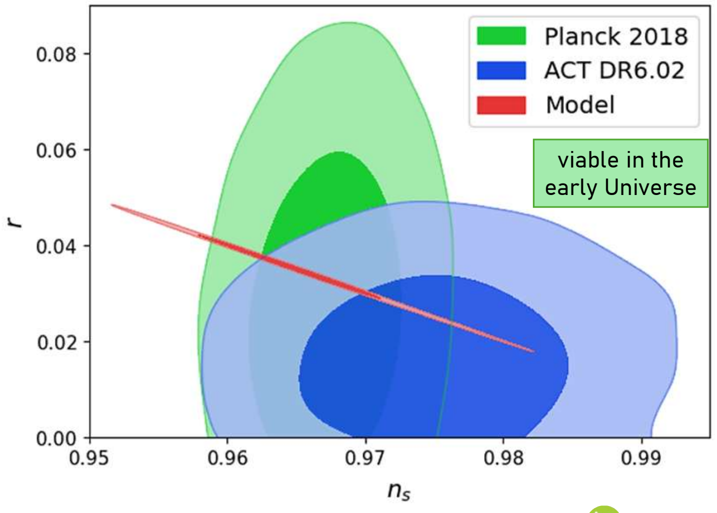
These results are used to numerically solve the following equation obtained from a combination of equations of motion

$$\frac{\dot{H}}{\mu^4}+4H^2h_{\chi\chi}+\frac{8}{\mu^2}\dot{H}Hh_\chi+\frac{3HC_1a^{\frac{3}{2}}}{\mu^2\gamma_0}\left(1+4H\mu^2h_\chi\right)+\frac{q_0a^{-3}}{2\mu^2\gamma_0}=0$$

5. OBSERVATIONAL CONSTRAINTS







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[1] Nojiri, S., Odintsov, S.D., Oikonomou, V.K. *et al.* Viable inflationary models in a ghost-free Gauss–Bonnet theory of gravity. *Eur. Phys. J. C* 79, 565 (2019). https://doi.org/10.1140/epjc/s10052-019-7080-1