Phase Transition in Anisotropic Cosmology: Bouncing Model in f(R,T) Gravity

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1. Research Objective

- Investigate a **Bianchi type-V anisotropic cosmological model** in $f(R,T)$ gravity.
- Explore a **bouncing universe scenario** to avoid the Big Bang singularity.
- Examine the role of **anisotropy** and **modified gravity** in cosmic evolution.

2. Key Assumptions

- Functional form: $f(R,T) = R + 2\lambda T$
- Jerk parameter j is proportional to the negative deceleration parameter: $j \propto -q$
- Equation of state: $p = \alpha\rho$ with $\alpha \neq -1$

Bianchi type-V metric is

$$ds^2 = -dt^2 + M^2 dx^2 + N^2 e^{-2x}(dy^2 + dz^2)$$

where M, N are functions of cosmic time t only.

Field Equations of the Model in f(R, T) gravity

$$2\frac{\ddot{N}}{N} + \frac{\dot{N}^2}{N^2} - \frac{1}{M^2} = (2\lambda - 1)p + \Lambda$$

$$2\frac{\dot{M}\dot{N}}{MN} + \frac{\dot{N}^2}{N^2} - \frac{3}{M^2} = (2\lambda - 1)\rho - \Lambda$$

$$\frac{\ddot{M}}{M} + \frac{\ddot{N}}{N} + \frac{\dot{M}\dot{N}}{MN} - \frac{1}{M^2} = (2\lambda - 1)p + \Lambda$$

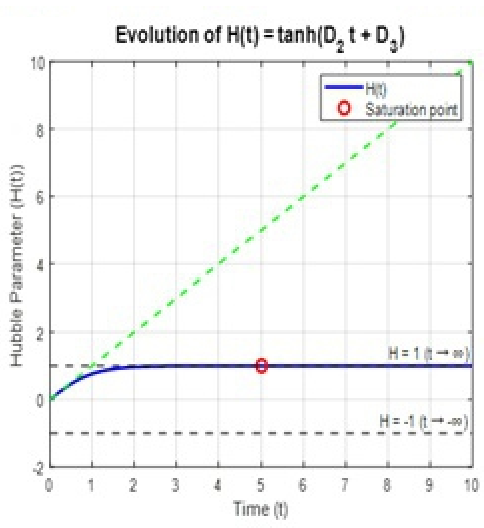
$$\frac{\dot{M}}{M} - \frac{\dot{N}}{N} = 0$$

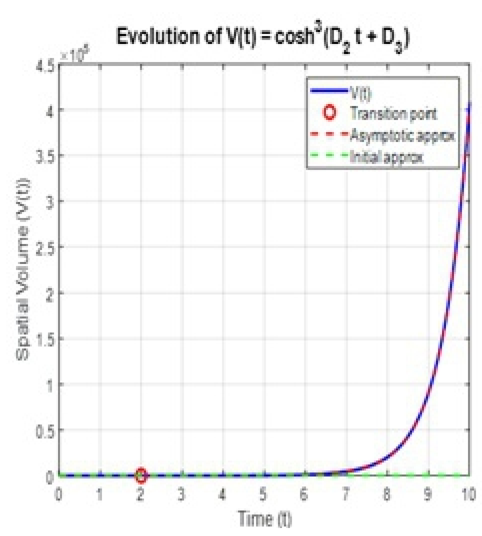
Where dot (.) represents the partial derivative w.r.t. time t

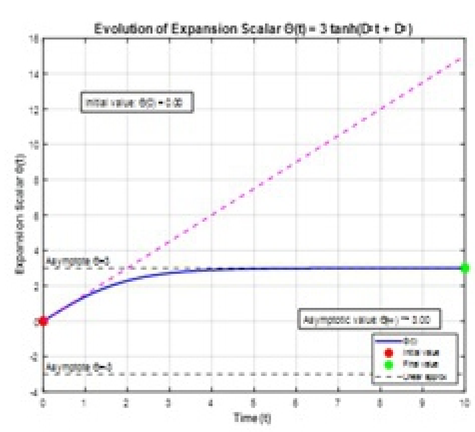
3. Main Results

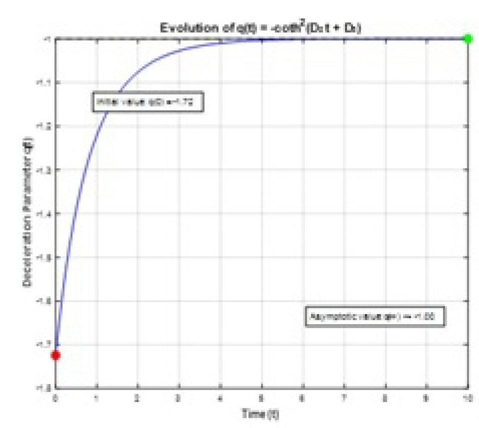
- **Bounce Solution:**
  Hubble parameter **H(t) crosses zero**, indicating a **smooth transition** from contraction to expansion without singularity.
- **Accelerated Expansion:**
  Deceleration parameter **q<0** always, confirming late-time cosmic acceleration.
- **Asymptotic ΛCDM Behaviour:**
  At late times, **j→1** and **q→−1**, recovering ΛCDM-like kinematics.
- **Unique Kinematic Signature:**
  Snap parameter $s = j^2$ **(always positive)**, distinguishing the model from ΛCDM where s=0.
- **Physical Parameters:**
  Energy density ρ, pressure p, and cosmological constant Λ **evolve smoothly** from **finite early-time** values to **constant late-time** values.

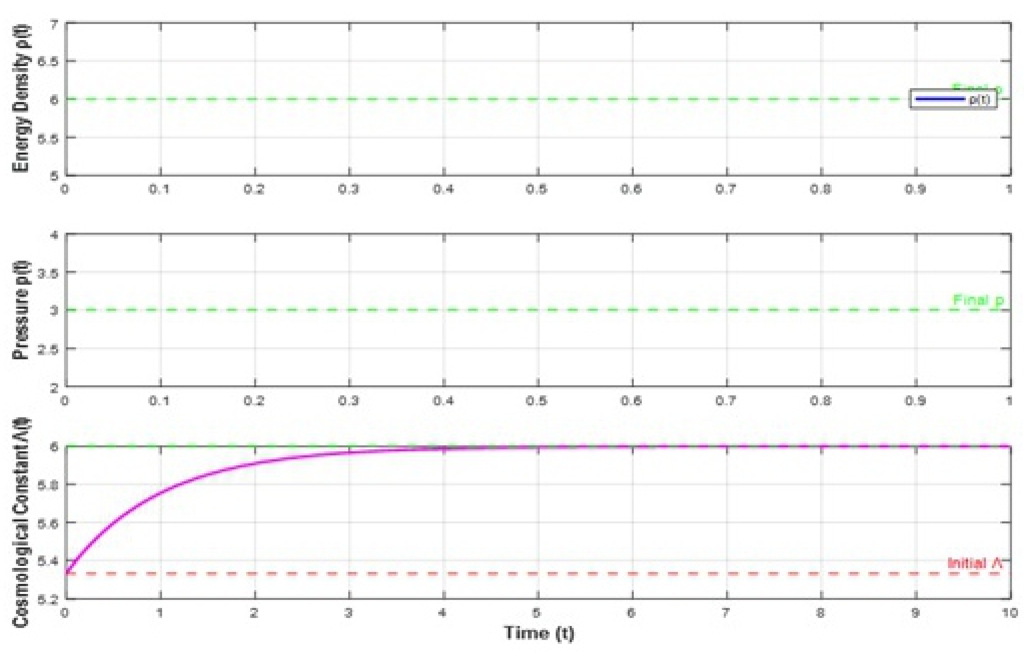
4. Graphical Representation

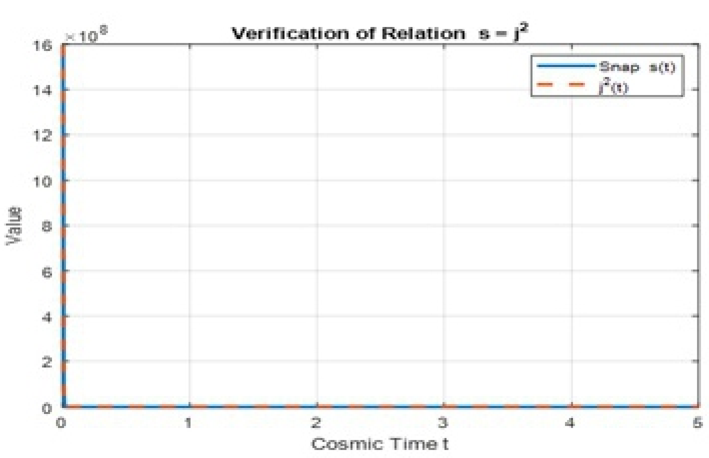












- Evolution of $H(t), q(t), j(t), s(t)$ vs. cosmic time t.
- Smooth bounce shown via $\theta(t)$ (expansion scalar) crossing zero.

5. Significance and Imnplications

- **Non-singular bouncing cosmology** within modified gravity.
- **Late-time acceleration** without exotic dark energy.
- **Testable kinematic signature (s>0) observable with future telescopes.**

Reveals how **anisotropy influences** early-universe dynamics

6. Conclusion

- Asymptotic behaviour comparison:

Parameter	Our Model (late times)	ΛCDM (late times)	Significance
q	− 1	− 1	Matches de-sitter
j	1	1	Matches ΛCDM
s	1	0	Key discriminant

7. Key Words

Bouncing cosmology, Jerk parameter, Snap parameter, Dark energy

8. Contact Information

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