Scalar-tensor cosmologies with a potential in the general relativity limit

Margus Saal\textsuperscript{1}

Laur Järv\textsuperscript{2}, Piret Kuusk,\textsuperscript{2}
\textsuperscript{1} Tartu Observatory, Estonia
\textsuperscript{2} University of Tartu, Estonia

Scalar-tensor theory of gravity in Jordan frame

\[ I_{STT} = \frac{1}{2\kappa^2} \int d^4x \sqrt{-h} \left[ \Psi R(h) - \frac{\omega(\Psi)}{\Psi} \Psi |^\alpha \Psi |^\alpha - 2\kappa^2 V(\Psi) \right] \]

\[ + \int d^4x \sqrt{-h} L_{matter} \]

1. Scalar field is non-minimally coupled to gravity in Jordan frame (scalar and tensor degrees of freedom are mixed)

2. Coupling function \( \omega(\Psi) \) and potential \( V(\Psi) \) characterizing different STT theories, assume positive energy density \( 2\omega(\Psi) + 3 > 0, V(\Psi) > 0 \).

3. Gravitational "constant"is (space)time dependent: \( G \sim \Psi^{-1} \), assume \( 0 < \Psi < \infty \)

4. General relativity limit from weak field approximation (PPN): \( \omega \to \infty \) and \( \omega^{-3} \omega' \to 0 \)
General goal: explaining dark energy, testing gravity at large scales.

Notice:

- Many proposed modified gravity theories can be cast in the form of scalar-tensor gravity (STG) - higher dimensions, branes, $f(R)$, VSL

- “Attractor mechanism” - wide classes of STG cosmologies dynamically converge to fixed points (Damour, Nordtvedt 1993)

Present work:

- Determine the conditions for attractive fixed points in STG cosmology

- Find the general analytic form of solutions around these fixed points
Summary of work done

- We have found and characterized the fixed points of STG cosmology in the case when potential dominates over cosmological matter density (JKS 2008, JKS 2010a).

- In particular, we have also found the general analytic form of solutions around the ’GR’ fixed point (JKS 2010b).

- This can be applied to cosmological expansion: can tell whether the solutions of any particular theory have oscillating, phantom crossing etc behavior near GR (JKS 2010b).
Example of oscillating dark energy (JKS 2010))

- Take $\omega(\Psi) = \frac{\Psi}{2(1-\Psi)}$, $\kappa^2 V(\Psi) = V_0 e^{3(1-\Psi)}$, the “GR point” is at $\Psi_* = 1$.

- Initial conditions satisfy solar System bounds.

- Oscillations of $w_{\text{eff}} = -1$ measured in the units of the analogue of Hubble time, $T = H_* t = \frac{C_1}{3} t$. 