Solving the Friedmann equation for a Dark Fluid equation of state.

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Solving the Friedmann equations for two different dark fluid equations of state

- Looking at two different equations of state that aims to parametrize between dark energy and dark matter dominated epochs.

- Modified Chaplygin gas (MCG):

$$P = A_2\rho - \frac{A_1}{\rho^\alpha}, \qquad \alpha > -1 \tag{1}$$

- The PPUDF equation of state:

$$P = P_a + P_b\left(z + \frac{z}{1+z}\right) \tag{2}$$

Energy density and acceleration of a for MCG case

- **Solving the Fluid equation for a MCG equation of state:**

$$\rho = \left[\frac{C_2\,(1+z)^{3(\alpha+1)(1+A_2)} + A_1}{1+A_2}\right]^{\frac{1}{1+\alpha}} \tag{3}$$

- **Deceleration parameter** $q \equiv -\frac{\ddot{a}a}{\dot{a}^2}$

$$q = \frac{\frac{A}{2}\left((3B_1-2)\left(B_3\,(1+z)^{3B_1\beta}+B_2\right)^{\frac{1}{\beta}} - 3B_1B_2\left(B_3\,(1+z)^{3\beta B_1}+B_2\right)^{\frac{1-\beta}{\beta}}\right)}{A\left(B_3\,(1+z)^{3(\beta)(B_1)}+B_2\right)^{\frac{1}{\beta}} - \kappa F\,(1+z)^2} \tag{4}$$

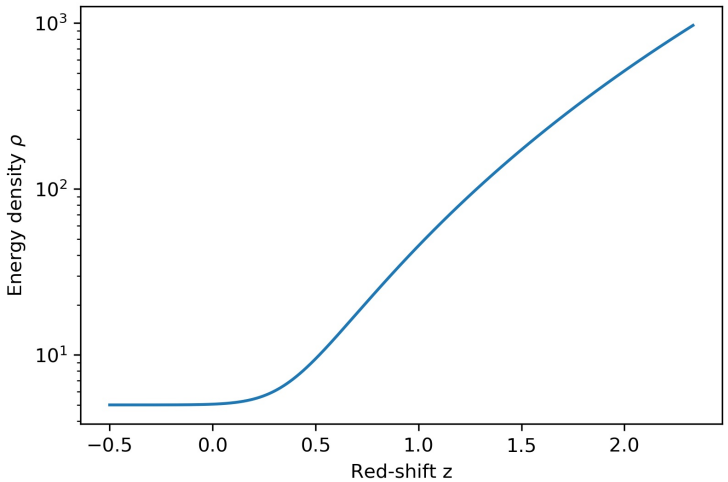

Figure: Here we have taken $A_1 = 50$, $A_2 = C_2 = 1$ and $\alpha = 1$. The figure shows energy density ρ vs red-shift z.

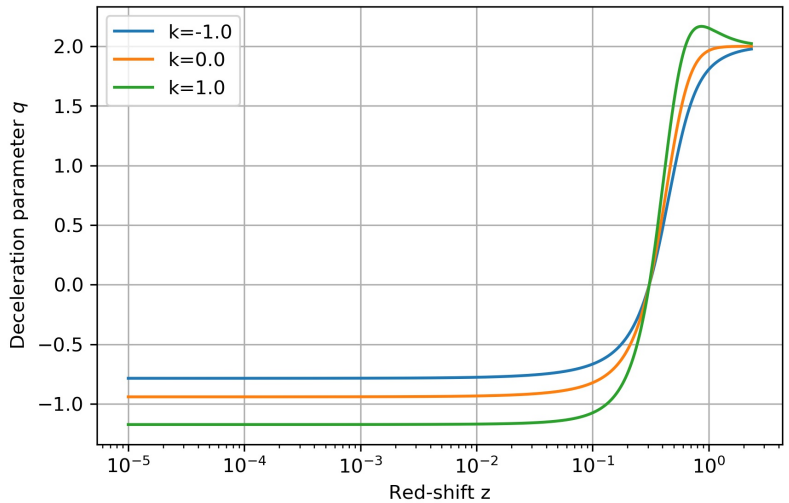

Figure: The figure shows deceleration parameter q vs red-shift z.

Energy and acceleration of a for PPUDF case

- **Solving the Fluid equation for a PPUDF equation of state:**

$$\rho = -P_a + \frac{3}{4} P_b \left[(1+z)^{-1} - 2(1+z) \right] + C(1+z)^3 \tag{5}$$

- **Deceleration parameter** $q \equiv -\frac{\ddot{a}a}{\dot{a}^2}$

$$q = \frac{A\left[2P_a - \frac{3}{2}P_b\left(\frac{3}{2}(1+z)^{-1} + (1+z)\right) + C(1+z)^3\right]}{2A\left(-P_a + \frac{3}{4}P_b\left[(1+z)^{-1} - 2(1+z)\right] + C(1+z)^3\right) - \kappa F (1+z)^2} \tag{6}$$

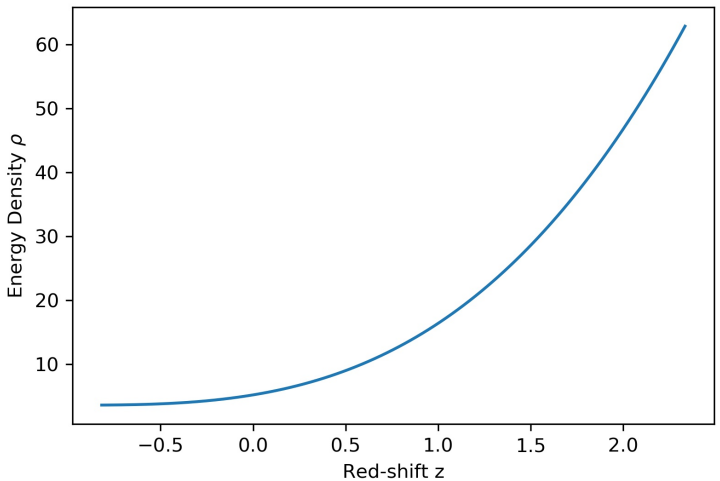

Figure: The figure shows energy density ρ vs red-shift z.

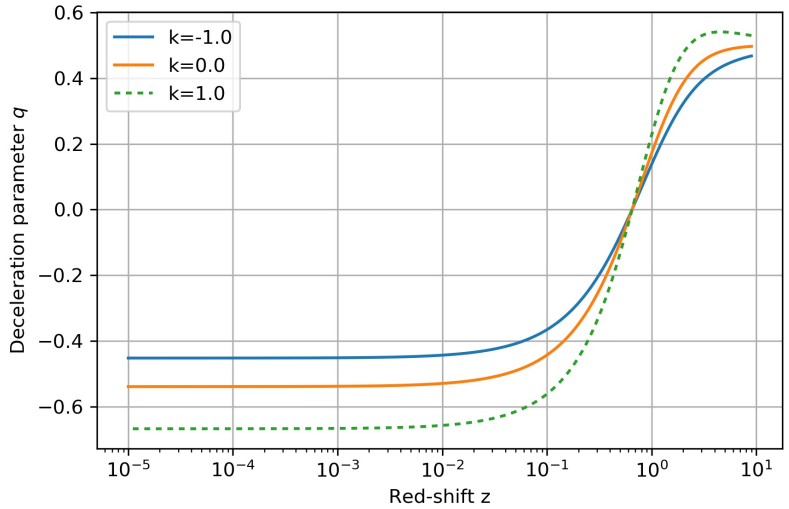

Figure: The figure shows deceleration parameter q vs red-shift z.

Conclusions and Acknowledgements

- Both Chaplygin gas and the PPUDF equations of state result in behaviour for the energy densities and acceleration that corresponds with the Concordance model for dust dominated epochs and Dark energy dominated epochs.
- It is possible to unify the epochs of both dark elements into a single dark fluid epoch by parametrizing the equation of state.
- Shortcomings of the Chaplygin gas and PPUDF models.
- Future work on this would include constraining the free parameters with observation.
- I just wish to thank Dr. Abebe and Dr. Mongwane for their inputs and supervision as well as NASSP for the funding.