



Cosmology and Large-Scale Structure

WS 17/18

Problem sheet 3

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Problem 1 [Accelerated expansion]

Show that in a flat Universe with matter and general dark energy ($p = w\rho$), one obtains accelerated expansion if the condition $w < -1/(3\Omega_{\text{de},0})$ is fulfilled.

Problem 2 [Dark energy parametrization]

A possible parametrization of the dark energy equation of state is given by

$$w(a) = w_0 + (1 - a)w_a$$

with w_0 and w_a constant. For a flat universe with a matter component and a dark energy component as given above, compute the Hubble parameter $H(z)$ as an explicit function of w_0 and w_a .

Problem 3 [Angular diameter distance]

Assume a flat Universe with a single component with an equation of state

$$p = w\rho \quad (w = \text{const.}; \quad -1 < w < 1) . \quad (1)$$

- (i) Show that the angular diameter distance $d_A(z) = (1+z)^{-2}d_L(z)$ has always a turning point for $w > -1$.
- (ii) At which redshift z_m is this turning point? Sketch $z_m(w)$ in the region $-1 < w < 1$.