Cosmology 1

2024/2025
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Second intermediate test
Topic: FRW models.
Deadline: April 29, 11:00.

The Dark Energy Spectroscopic Instrument (DESI) collaboration has recently claimed evidence of an evolving dark energy. They measured the position of the Baryonic Acoustic Oscillation peak in the two-point correlation function of galaxies, and used it as a standard ruler, thus measuring the angular diameter distance at three redshifts, reported in the table. Moreover, redshift-space distorsions induced by peculiar velocities make it possible to measure the Hubble parameter at the same redshift; the measurements are given in the table. As a disclaimer, the evidence for evolving dark energy comes from the combination of DESI data with distant supernove, so these data alone do not demonstrate much.

redshift	d_A (Mpc)	H (km/s/Mpc)
0.9	1688 ± 47	112.1 ± 3.8
1.2	1781 ± 46	136.9 ± 5.7
1.5	1793 ± 28	154.7 ± 6.0

Let us assume, as it is customary, that the evolution of the equation of state of dark energy can be parametrized as:

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

(1) Using the third Friedmann equation, work out the evolution of the energy density of a component with a generic, time-dependent equation of state parameter $w(a)$, then specialize the equation to the w_0–w_a case given above.

(2) Assume a fiducial flat ΛCDM model with cosmological parameters $\Omega_m = 0.319$, $\Omega_\Lambda = 1 - \Omega_m$ and $H_0 = 67$ km/s/Mpc. Compute the angular diameter distance d_A and the hubble parameter H as a function of redshift, and compare these values to the DESI measurements. Report the redshift at which d_A is max in this cosmology.

(3) Now assume that dark energy has an evolving equation of state. Keeping Ω_m and H_0 fixed, find what part of the w_0–w_a parameter space gives acceptable fits to the DESI data.

(4) In case you obtained the answer to point (3) too easily, try to leave Ω_m free as well and see what happens.

As a hint, it is convenient to compute the integral for the comoving distance, $\int c\,dt/a(t)$, in z instead than in t.