Post-lecture notes from Sarah

Date of "The Independent" about how the universe began:
24. April 1992

Cosmological constant and dark energy:
The cosmological constant lambda represents the energy density of the vacuum of space and was introduced by Einstein to achieve a static universe, because he did not believe in the expansion at first. This constant should make this possible by playing the "counterpart" of gravity. When Hubble made his observations, lambda was assumed to be zero, but with the discovery of an acceleration of the expansion of space in the 1990s, it is not zero any more, but connected with the – yet unknown – dark energy (https://arxiv.org/abs/astro-ph/9805201). It is also not known if it is really constant or if it changes over time.

Violation of 2nd law of thermodynamics:
There is currently no observation of a violation, the entropy can only stay the same or increase. The energy of the Cosmic Microwave Background decreases with time, whereas the expansion of space adds new vacuum energy. The universe is thought to have started in a very low state of entropy, which increases over time until a possible "heat death", where the universe would be more or less in a total equilibrium. (I did not understand completely the details behind that question though.)

Energy in picture of the development of the universe:
It is the energy density of the according time after the Big Bang. Unfortunately it is not said which volume they take into account, but nevertheless it can be used as a reference when comparing different moments of time.

Observations of the geometry of the universe:
There are by now a few independent observations confirming with the "help" of the fluctuations in the Cosmic Microwave Background, that the universe appears to be flat (with small error bars): WMAP, Planck, BOOMERanG, MAT/TOCO, Maxima, DASI...

Difference between Doppler effect and cosmological redshift:
The Doppler effect caused by motions in space tells us something about the source when the light was emitted. The cosmological redshift caused by space expansion tells us something about what was happening while the light was travelling. If you use the measured redshift from a far away galaxy and plug it into the relativistic Doppler equation, you get a recessional velocity, which is not accurate to describe the measured distance even if it has been moving away from us with that speed for the entire history of the universe. This article

might also help for clarification: http://users.df.uba.ar/sgil/physics_paper_doc/papers_phys/cosmo/doppler_redshift.pdf