As Timothy mentioned above, Cold Dark Matter (CDM) is the cornerstone of the Lambda-CDM model. That the dark mater is "cold" is important because it is believed to consist of heavy particles that, unlike the Hot Dark Matter, can clump together gravitationally. This supports our observations that the universe is not perfectly homogenous and that the structure and hierarchy seems to appear on all scales - from planetary systems to superclusters of galaxies. It is believed that the early universe was filled with a photon-baryon fluid that consists of coupled photons, electrons and protons. Due to the Heisenberg's uncertainity principle it is guaranteed that this fluid was inhomogenous, i.e. it had density fluctuations. The analysis of those fluctuations leads to the natural fact that fluctuations of 10^6-10^{13} M_{Sun} were amplified with time, and this mass range coincides with empirical galactic structures we observe (Carroll & Ostlie 2006). Our understanding is that at z~20, baryonic matter in our universe was attracted to the clumps of the dark matter, collapsed and formed spheroidal components of galaxies and, later, intergalactic medium and central engines of quasars which appear at z>=10. At z~7, first galaxies were formed with the highest currently known galactic redshift of 7.51 belonging to the dwarf z8_GND_5298 in Ursa Major (Finkelstein et al. 2013).

The other crucial ingridient of the Lambda-CDM model is Lambda – the dark energy assumed to be responsible for the acceleration of the expansion rate of our universe as it is assumed to have negative pressure. From the size of individual spots we observe in the CMB, we assume that our universe is nearly flat, that is density parameter $\Omega_0=\rho_0/\rho_c=1\pm2\%$, whereby ρ_0 is the combined average mass density of all forms of matter and ρ_c is the critical density of the universe (a point between expanding and contracting universe). However, all the matter we detect, including dark matter estimated via galaxy cluster dynamics, comprises of only $0.24\rho_{c.}$ So the remaining 0.76 of the universe mass must come from some sort of dark energy which is, perhaps the vacuum energy - an energy of an empty space appearing due to quantum fluctuations (virtual particles appearing and annihilating spontaenously.)

There are a few challenges associated with the Lambda-CDM model. They are well covered by Famaey & McGaugh (2013) and I will provide a brief summary below, except for the challenges associated with acceleration constant a_0:

1) Missing satellite dwarfs. Lamba-CDM simulations predict vast numbers (~100-600) of subhaloes hosting satellite galaxies around the main halo with a galaxy like Milky Way. We only observe a limited number of dwarf satellite galaxies in the Local Group. The problem is partially being solved as we discover more satellites in the Local Group.
2) Satellite phase-space correlation challenge. The Lambda-CDM predicts satellite galaxies to be isotropic while we observe Milky Way satellites to lie in a relatively thin disk.
3) Angular momentum challenge. Lambda-CDM simulations predict lower angular momentums from galaxy mergers (hierarchical clustering) resulting in much smaller galaxy disks and denser elliptical systems, if compared to our observations.
4) Density-morphology relation. Why more dwarf elliptical galaxies are observed in denser environments?
5) Pure disk challenge. Fundamental to Lambda-CDM hierarchical clustering, galaxy mergers should typically create bulges and it is very difficult to create bulgeless think disk galaxies, such as UGC 7321, IC 5249, IC 2233, UGC 711 – see figure 1 in the Appendix.
6) Stability challenge. Quasi-spherical CDM halos stabilize low surface density

disks and prevent them from forming bars and spirals.

7) Bulk flow challenge. The merging Bullet Cluster has too high collision velocity (3100 km/s), compared to the bulk flow velocities predicted by the Lambda-CDM model.
8) The high-z clusters challenge. Lambda-CDM predicts that galaxy clusters are formed later than what our empirical observations show, e.g. high-z clusters like El Gordo at z=0.87 and XMMU J2235.3-2557 at z=1.4.
9) Local void challenge. The Lambda-CDM model predicts that a typical void between galaxy clusters should host about 20 galaxies while the Local Void has only 3.
10) Cusp-core challenge. Lambda-CDM simulations predict “cuspy” distribution of dark matter after the collapse of a halo (more dark matter density near the core of a galaxy) while rotational curves of external galaxies imply constant density cores.
11) Missing baryons challenge. With predicted $\Omega_b=\rho_b/\rho_c=0.046$, we still can’t find where these baryons reside. The sum of cold gas and stars is only 5% of the Ω_b.
12) Baryonic Tully-Fisher relation that states that baryonic mass (and, in general, visible luminosity) of a galaxyis proportional to the rotational velocity to a certain power. Predictions of the power in this relation by Lambda-CDM model is not fully consistent with observations, however certain advancements are made with more recent and detailed models (McCaugh 2012).

REFERENCES:

Carroll, B. W., & Ostlie, D. A. 2006, An introduction to modern astrophysics and cosmology
Famaey, B., McGaugh, S. 2013, J. Phys.: Conf. Ser. 437
Finkelstein, S. L., Papovich, C., Dickinson, M., et al. 2013, Nature, 502, 524
Kormendy, J. 2013, Secular Evolution of Galaxies, Cambridge University Press
McGaugh, S. 2012, AJ, 143, 15

APPENDIX

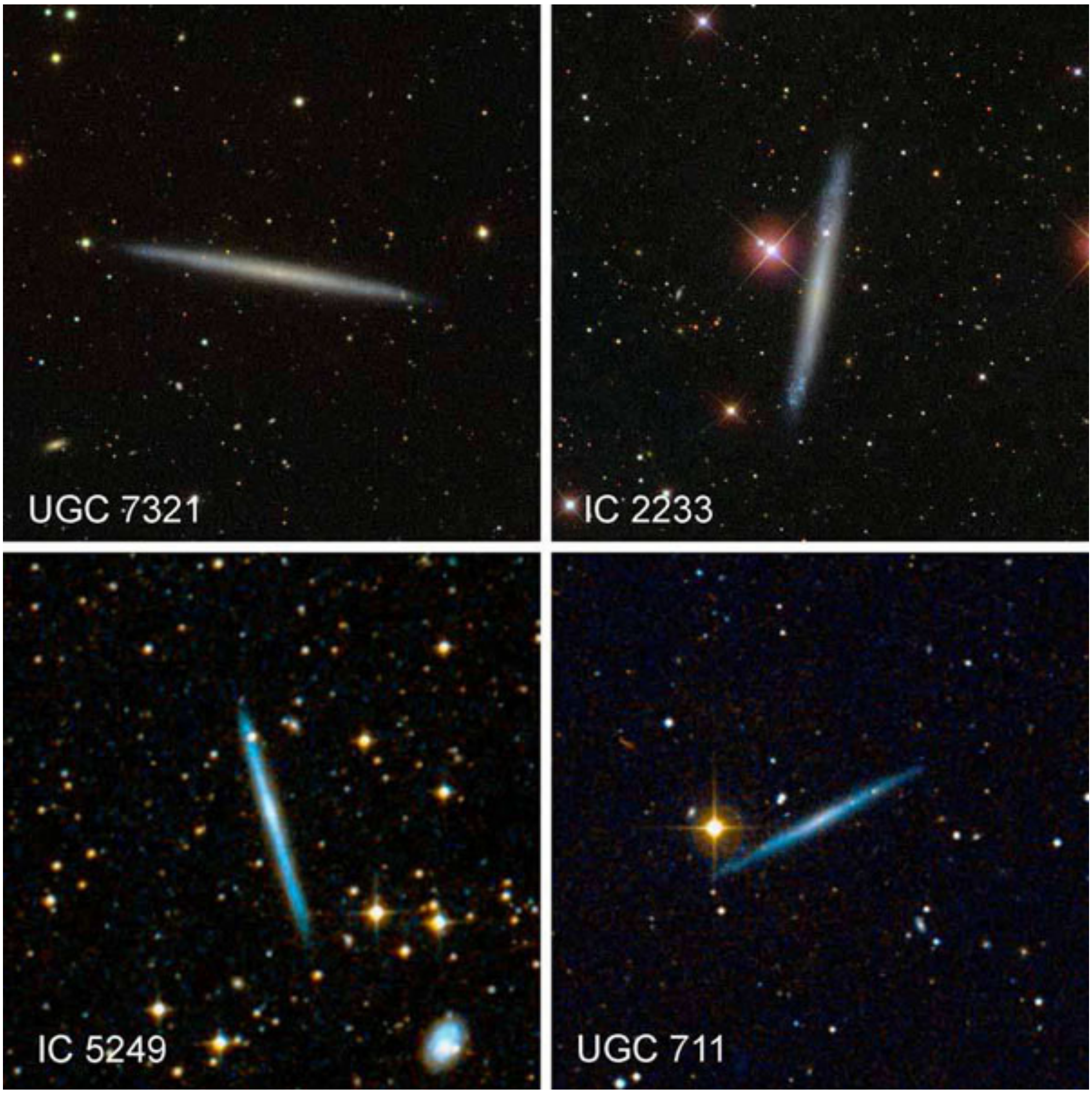

Fig 1 - Edge-on, completely bulgeless, pure-disk galaxies. Image from Kormendy (2013).