Angular momentum conservation in LCDM simulations

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Introduction

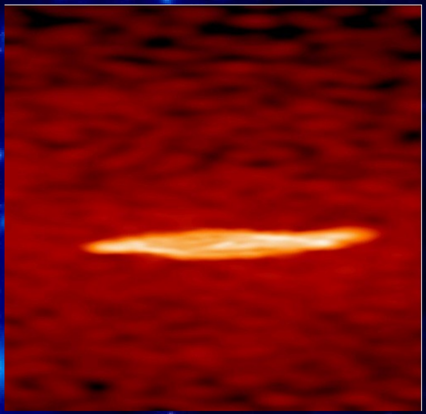
- Hierarchical clustering scenario, Fall & Efstatthiou: model:galaxy formation process, gas and DM experience the same gravitational torques, $J_D/M_D=J_H/M_H$
- ΛCDM universe, formation and evolution of galactic disks: mass accretion, mergers, SF and SN feedback that regulates it.
- Mergers, accretions and interactions: rol in the galaxy evolution, eg Brooks et al. 2011, angular momentum distribution of the galaxy: gas outflows, accretions. Sales et al. 2012.

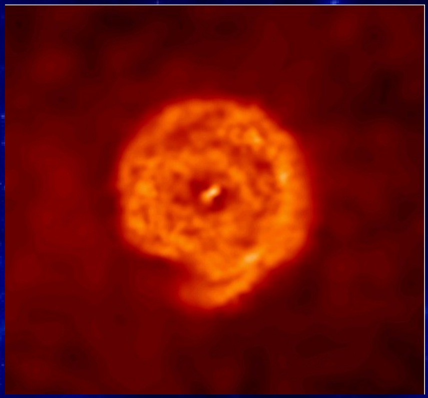
Numerical Experiments

- Cosmology: ΛCDM Ω_Λ=0.7, Ω_m=0.3, Ω_b=0.04, σ_8=0.9 and H_0= 100 h km s^{-1} Mpc^{-1}, con h=0.7.
- Simulation Box: 10 Mpc h^{-1} - 2 x 230^3 part., ~ 10^5 part. r_{opt}
- Particle masses: DM = 5.93 x10^6 h^{-1} $M_\odot$ y 9.12x10^5 $h^{-1}M_\odot$ for the gas.
- GADGET-3 (Springel 2005)

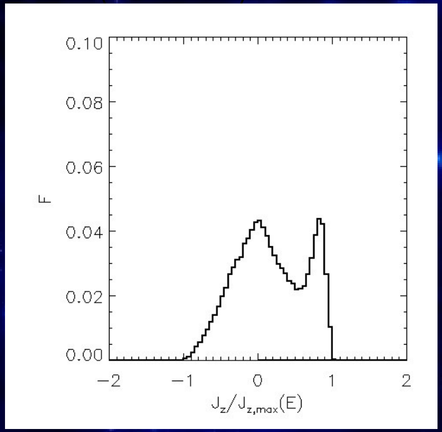
Numerical Experiments

- Our model: metallicity dependent radiative cooling; stocastic SF; chemical metal enrichment; multiphase model for the ISM; SN feedback (Scannapieco et al. 2005, 2006).
- Energy eyected per SN event (x .10^{51} erg): distributed between the two phases
- Galaxy catalog: FoF + SUBFIND (Springel et al. 2001)
- ~300 galaxias a z=0

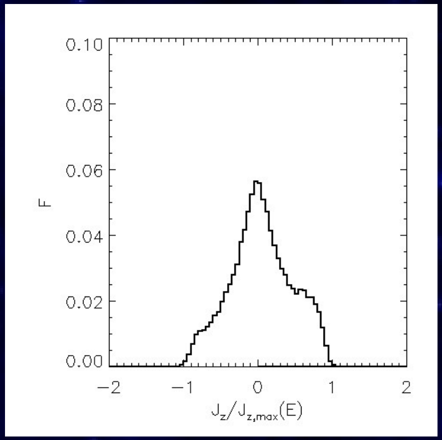


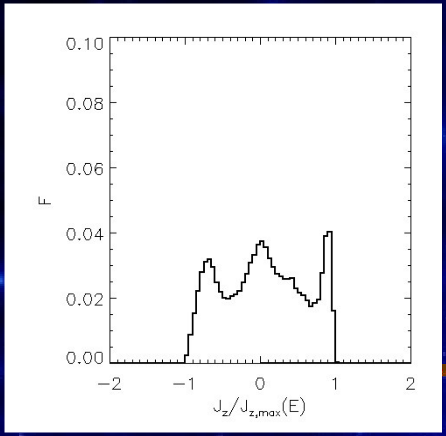


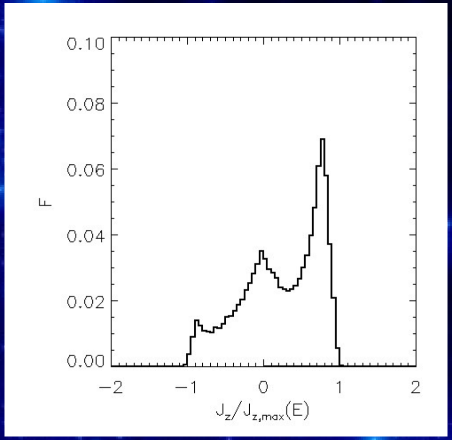
Variety of morphologies



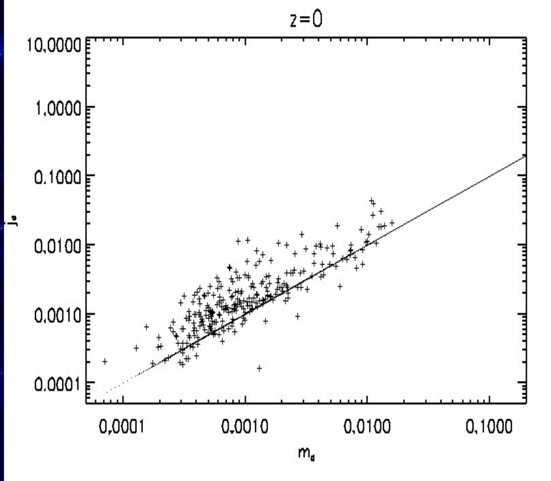
- Rotated system: disk perpendicular total angular momentum (face-on)
- Bulge-disk decomposition: $\varepsilon = j_i/j_{max}$
- Different morphologies were obtained

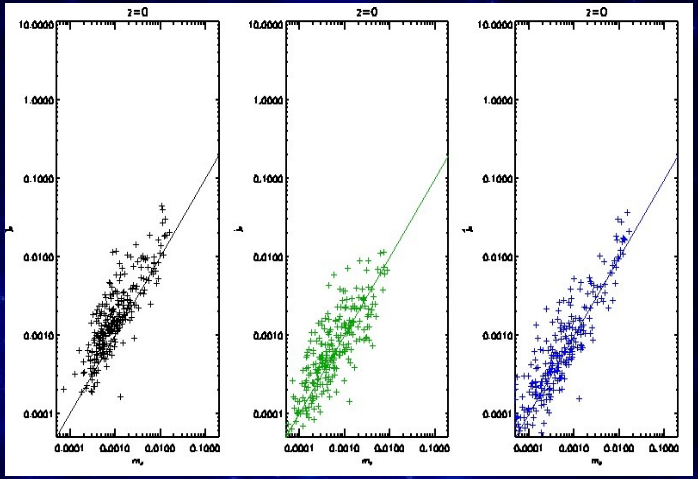






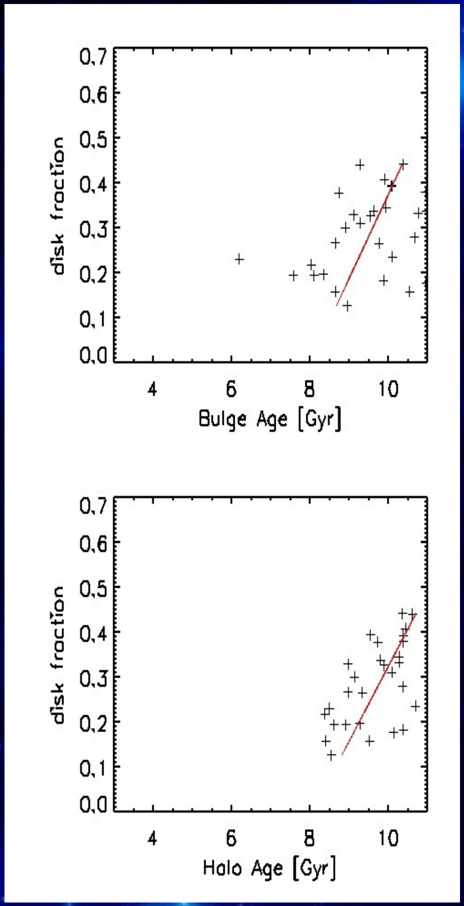
Angular Momentum



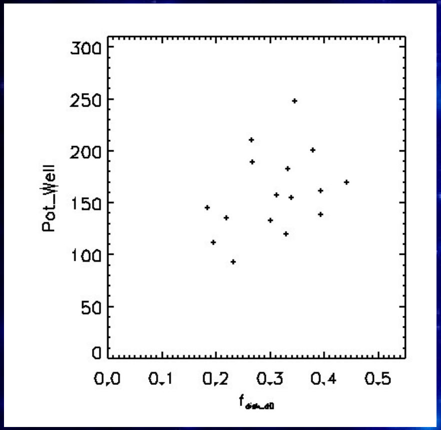


- Angular momentum content : m_D vs j_D
- If galaxies with an important disk component -> follow F&E
- Also found at higher redshifts
- Characteristic Radius: R_{bar} – R_{HM}.

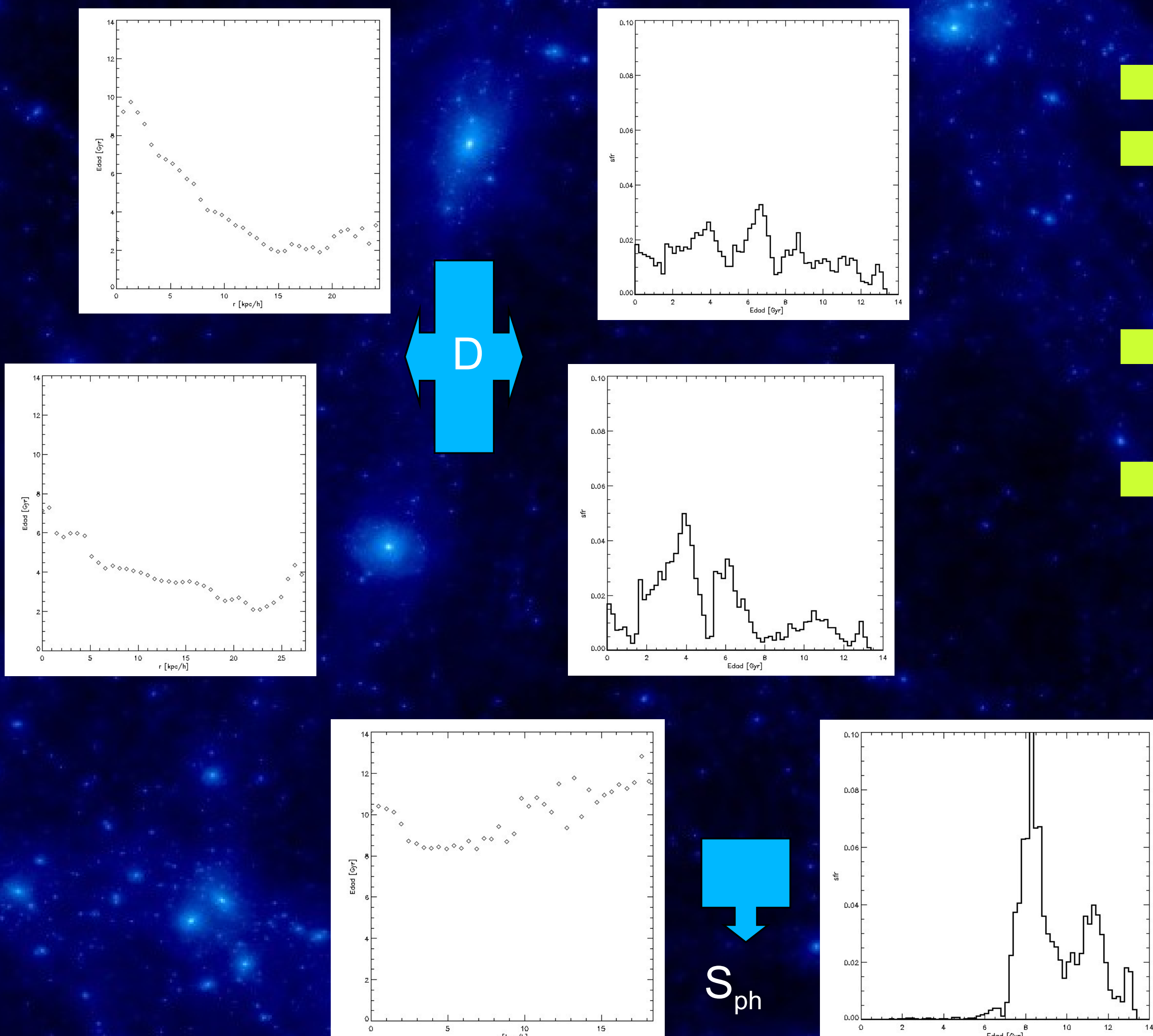
Disk at z = 0



- Slight correlation between the mean age of halo and bulge, and the final disk fraction.
- Deepness of the potential well



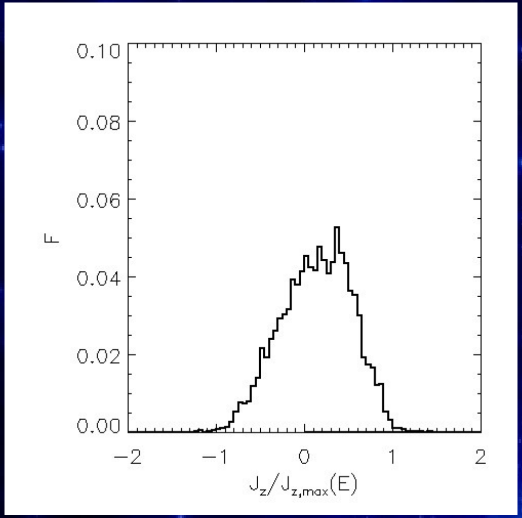
Stellar Formation



- Inside-out formation.
- SFR:el feedback regulates efficiently the SF.
- If the continuous SF -> disks IO
- (At z=0: max. stellar disk fractions: 0.4 a 0.5)

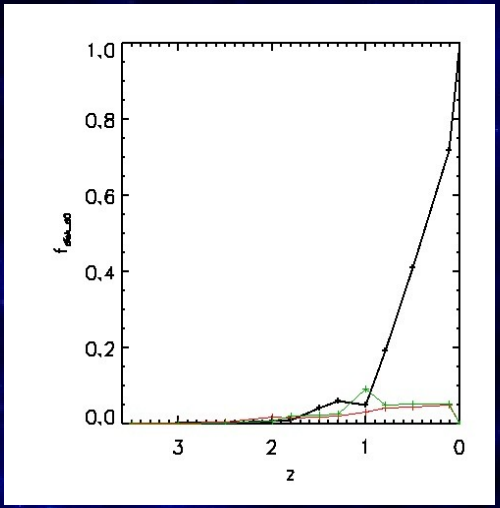
Evolution with redshift

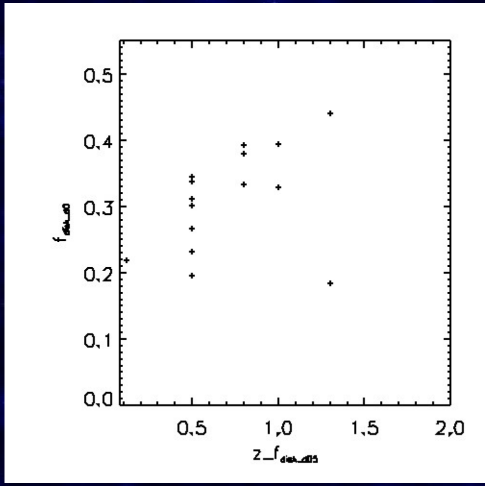
- Important disk components in place at z=2.
- Evolution in time: a fraction are partially or totally destroyed
- Dependence with the formation history

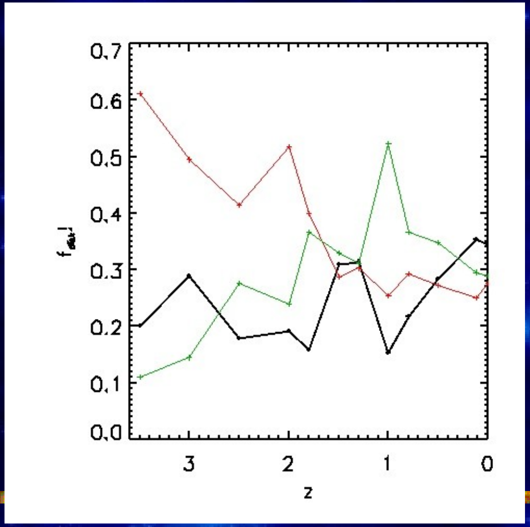


Galaxy Assembly

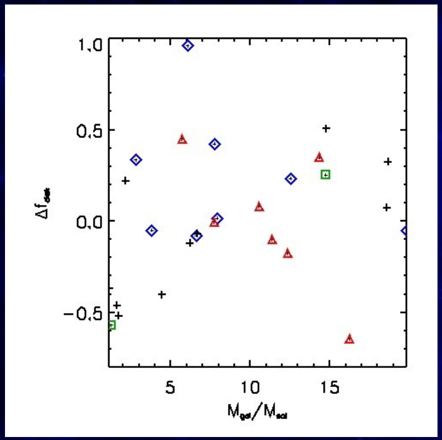
- Mergers & interactions: important in driving the galaxy evolution
- Merger tree: we follow the main progenitor branch (DeRossi et al.2012 in press)
- Evolution of the disk component with redshift.
- Fraction of the particles forming the z=0 disk, through time

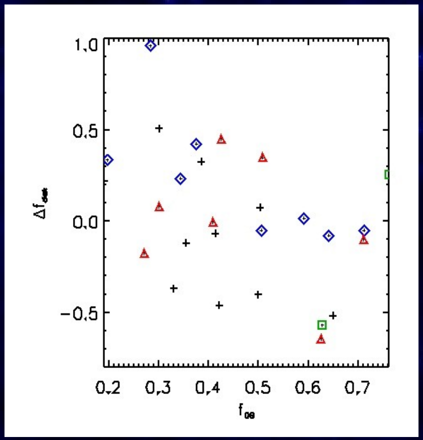


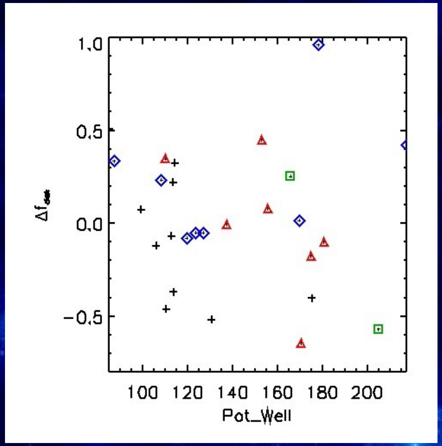




Mergers & Interactions







- Correlations between Δ disk_fraction with z and:
- $(J^{gal}_{disk}t, J^{ba}_{rsat})$ the angle between the stellar disk angular momentum of the galaxy and the baryonic angular momentum of the satellite
- J aligned, positive change in disk fraction

Conclusiones

- ✓ Our simulated galaxies assemble following F&E model
- ✓ The final morphology and survival of important disk components depend on several interacting factors.
- ✓ The presence of an old halo and bulge components seems to allow higher disk fractions to be obtained.
- ✓ If the star formation rate is continuos the disk forms in an inside-out fashion.
- ✓ Mergers and interactions affect the evolution, but they don't seem to determine by themselves the morphology of the galaxy at redshift zero.