# The formation of ultra-compact dwarf galaxies and nucleated dwarf galaxies


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האוניברסיטה העברית בירושלים

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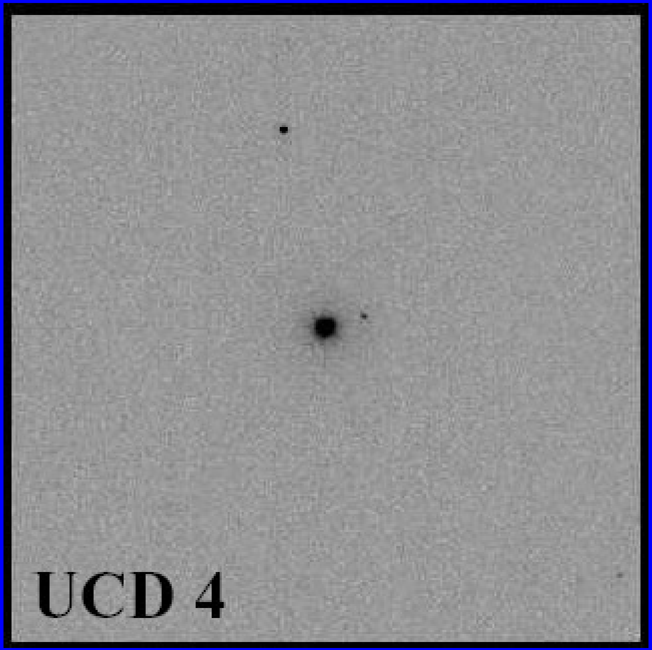
# Outline:

- What ultra compact dwarf galaxies are
- Classical formation scenarios
- The coalescence scenario
- Why it does not work
- The stripped disk scenario
- Why this works

# What UCDs are:

- Recently discovered type of galaxy
- Ultra luminous
- Normally found in galaxy clusters about 100 kpc from the centre
- Look like a star
- Very high M/L ratio (4)



# The classical formation approaches

- Big globular clusters
- Nucleated dwarf galaxies (dE,N)
- Coalescence of GCs
- Remnants of a stripped disk
- Highly compact galaxies formed in the early universe

# The coalescence scenario

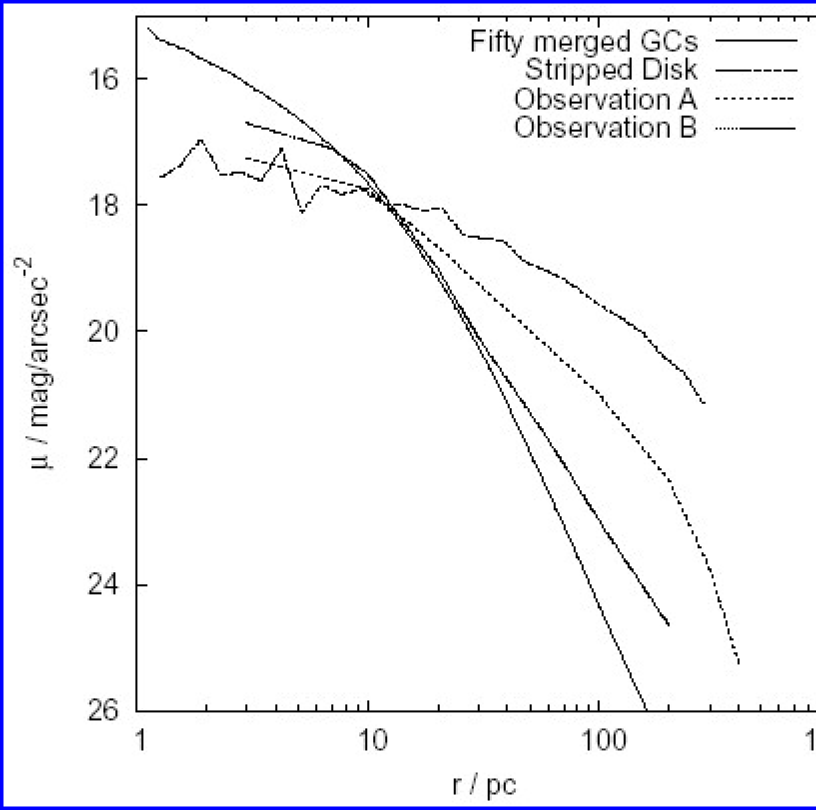
- Dwarf galaxy size dark matter halo
- Primordial GC population
- Dynamical friction: Spiral in
- Merge to a central object
- UCD?

# What we did

- NFW: $M_{Vir} = 1.5x10^9\ M_{sun}$, c = 20, 3 000 000 particles, three shell model
- GC: King profile, 100 000 particles, $M_{tot}$ = 200 000 $M_{sun}$
- 10 or 50 GCs distributed: $N(r) \sim r^{-4}$
- Let them spiral in

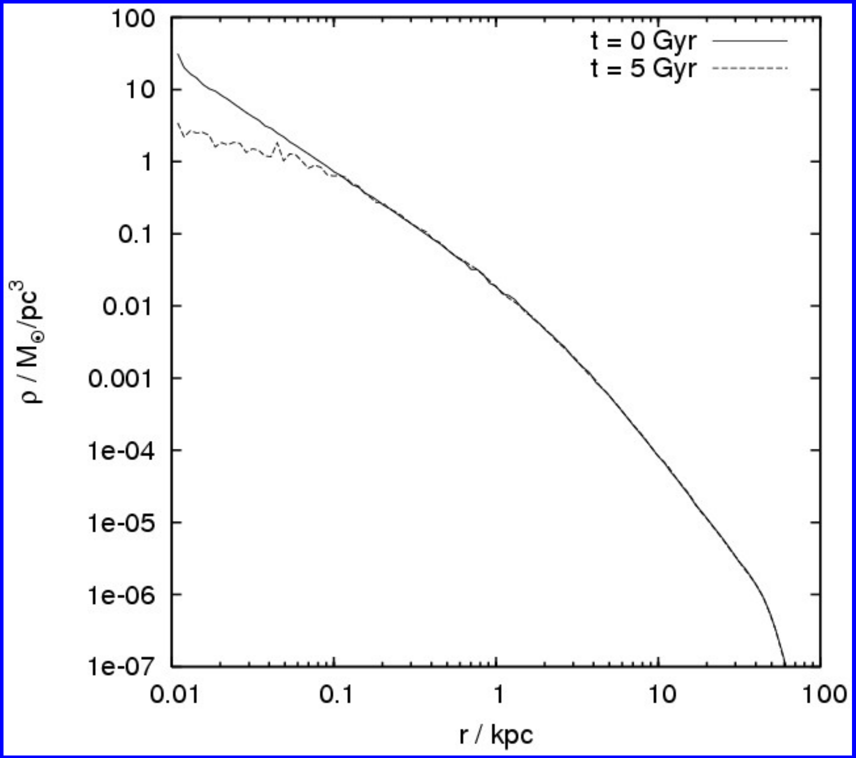
# What we saw:

- GC do merge on a timescale of a few Gyr
- Luminosity profile looks very similar to observed ones
- Central luminosity a wee bit too faint



# Expulsion of DM

- GCs replace DM particles in the centre
- DM density in the centre drops



# Why this formation scenario does not work

- Cannot reach central luminosity with reasonable number of GCs
- DM density drops in the centre due to replacement of DM
- Observed high M/L cannot be reached

# The stripped disk scenario

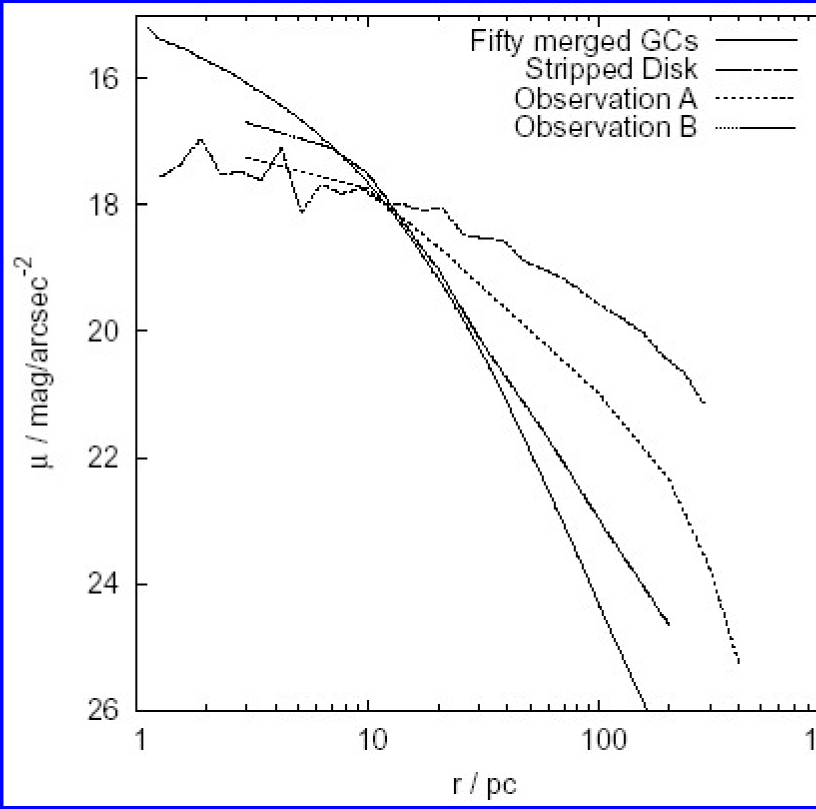
- Galaxy size dark matter halo
- Hot baryonic fraction
- Cooling: Disk formation
- Central dense stellar nuclei
- Orbits galaxy cluster
- DM and the disk is stripped
- Remaining object: UCD [or dE,N (depending on orbit)]?

# What we did

- NFW: $M_{Vir}$ = 5 x $10^{11}$ $M_{O}$, c = 6.2, baryonic mass fraction 6%, 2 200 000 DM particles, 2 000 000 gas particles
- Evolve using SPH with artificial viscosity and cooling, star formation: Katz '96
- Disk forms with central stellar object
- Let it orbit in an artificial galaxy cluster potential ($M_{Vir}$ = 3 x $10^{14}$ $M_{O}$, $r_{Vir}$ = 1.8 Mpc) on various orbits to strip disk and DM

# What we saw

- Disk with central stellar object forms
- DM, disk gets stripped
- Luminosity profile gives good agreement with observations
- Get different type of objects (UCDs, dE,Ns) for orbits with different centre distances

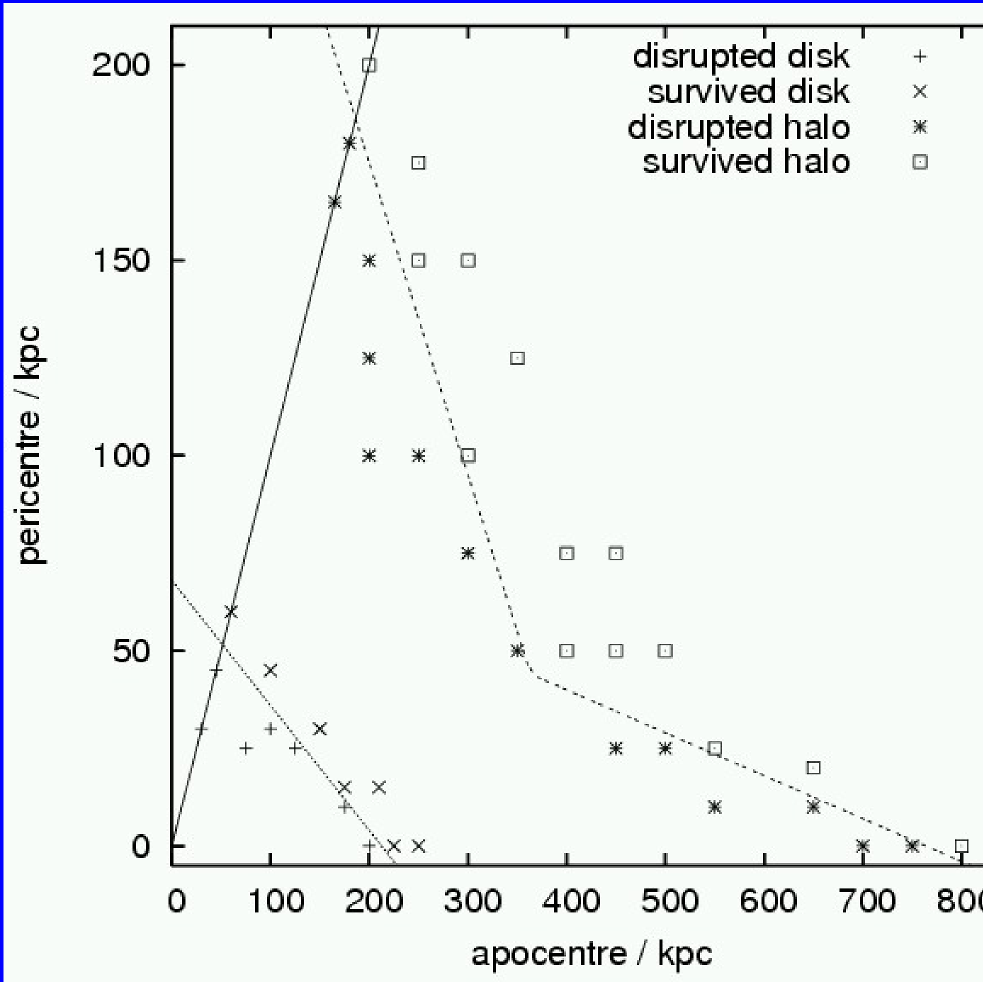


# Stripping simulations

Disk / DM halo only

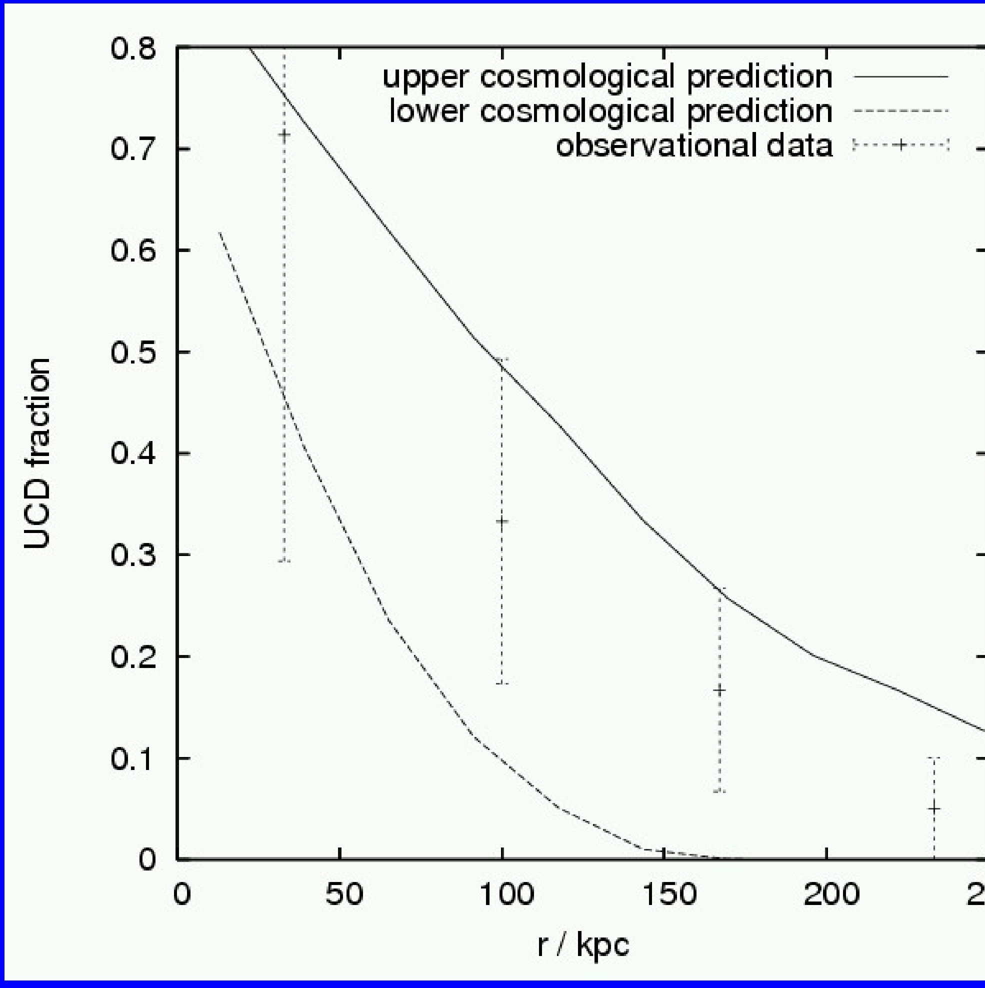
Different orbits

Survival / disruption



# Spatial distribution

Prediction of UCD / dE(N) fraction as a function of radius



# Why this formation scenario works

- Correct luminosity profile
- High enough M/L
- Explains why UCD close to cluster centres, whereas dE,Ns further away

# Any questions?