The formation of a sequence of S0a-S0b-S0c galaxies through major mergers

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• S0 galaxies traditionally considered as transition types.
• A picture coherent with hierarchical scenario, in which bulges and disks grow independently.
1) Diversity of properties in S0’s

- B/D ratios and rotational support spanning from those typical of Sa’s to those of Sc’s (Laurikainen et al. 2010, Capellari et al. 2011).
2) Disk-bulge coupling in S0’s

- Disk-bulge coupling in S0’s favours simple fading, gas stripping, secular processes.
- It seems to exclude major mergers.

Laurikainen et al. (2010)

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3) Inner components in S0’s suggest secular origin

Lenses/ovals
- NGC 2787 $K_s$ (bar-lens)
- IC 5240 $K_s$ (X-shaped)
- NGC 1543 B (inner lens)
- NGC 524 $K_s$ (inner lens)

Pseudobulges

Laurikainen et al. (2013)  Kormendy & Bender (2012)

EGEE2014
• S0’s constitute a Sequence of S0a-S0b-S0c types, parallel to that of Sp’s (van den Bergh 1976, Laurikainen+10, Capellari+11, Kormendy&Bender12).
But also evidence of merging origin in some S0’s…

- Pre-processing and post-processing in clusters through mergers (McGee+09, Berrier+09, de Lucia+12, Dressler+13, Vijayaraghavan+13).

- Cluster S0s usually located within groups and exhibit merger relics (Rudick+09, 10, Janowiecki+10, Mihos+13).

- Nearly 50% of present-day S0’s reside in groups (Berlind+06, Crook+07, Wilman+09).

- Evidence pointing that major mergers must have been relevant for E-S0’s since $z\sim 1.5-2$ (EM+10, Bernardi11a,b, Tiret+11, Weinzirl+11; Méndez-Abreu+12, Barway+13, Prieto+13 Wilman+13, Tapia+14).
Motivation

- Can major mergers result into realistic S0 galaxies?
- Can we definitively exclude them from formation scenarios of S0’s on the basis of their structural properties?

We will center on the structural properties of S0’s.
Dissipative N-body simulations


- Available ~1000 dissipative N-body simulations of major and minor mergers (Chilingarian+10).

- TreeSPH code (Semelin & Combes 2002), SF method as Mihos & Hernquist (1994), SN feedback and metallicity evolution.

- Wide variety of orbital configurations, mass ratios (1:1 → 3:1 and 7:1 → 20:1), morphologies of progenitors (E, S0, Sa, Sb, Sd).

- Computed up to 3.5 Gyr of evolution.
- Morphological classification on mock images of relaxed remnants.
- Final rotational support, star formation rates and gas content typical of S0’s.
  
  → 25 E/S0’s and 42 S0’s from major mergers, 29 S0’s from minor mergers.

EM et al. (in preparation)
1) B/T ratios span the whole range of observational values

ArXiv:1409.5126
2) Bulge-disk coupling in S0 remnants

ArXiv:1409.5126
3) Pseudobulges in 30% and lenses in 90% of the S0 remnants

ArXiv:1409.5126
Eliche-Moral et al. (in preparation)

Major mergers rebuild the bulge-disk coupling. Minor mergers preserve it.
Contrary to the popular view, major mergers can result in S0 remnants with realistically coupled bulge-disc structures and pseudobulges in < 3 Gyr.