



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

M. Carmen Eliche-Moral Universidad Complutense de Madrid (Spain)

Miguel Querejeta (MPIA), Alejandro Borlaff (IAC), Trinidad Tapia (UNAM)

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The classical sequence of Hubble types



- 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

Falcón-Barroso et al. (2013)

0.8

alifa_concentratio

0.6

3.0

Hubble Type

S0 Sa Sb Sc Sd

3.5



B/D ratios and rotational support spanning from those typical of Sa's to ulletthose of Sc's (Laurikainen et al. 2010, Capellari et al. 2011).



2) Disk-bulge coupling in S0's

Laurikainen et al. (2010)



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



3) Inner components in S0's suggest secular origin

Lenses/ovals

Pseudobulges



Laurikainen et al. (2013)

Kormendy & Bender (2012)



A S0a-S0b-S0c sequence parallel to Sa-Sb-Sc



• 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~1.5-2 (EM+10, Bernardi11a,b, Tiret+11, Weinzirl+11; Méndez-Abreu+12, Barway+13, Prieto+13 Wilman+13, Tapia+14).





- 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

- GalMer database in VO: <u>http://galmer.obspm.fr</u>
- 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.



Selection of S0 and E/S0 remnants and multi-component decompositions



- Morphological classification on mock images of relaxed remnants.
- Final rotational support, star formation rates and gas content typical of S0's.
- \rightarrow 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



Querejeta, EM, et al. (2014, A&A in press) ArXiv:1409.5126



2) Bulge-disk coupling in S0 remnants



Querejeta, EM, et al. (2014, A&A in press) ArXiv:1409.5126

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





10

20

R (kpc)

30

40

10

20

R (kpc)

30

40

10

20

R (kpc)

30

40

Major mergers rebuild the bulge-disk coupling. Minor mergers preserve it



MAJOR MERGER



MINOR MERGER



Conclusions



• Contrary to the popular view, major mergers can result in S0 remnants with realistically coupled bulge-disc structures and pseudobulges in < 3 Gyr.