Creating S0s with major mergers: a 3D view

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Introduction: Are S0s faded spirals?

- Lenticulars (S0s) form a sequence parallel to spirals
  \[\text{Laurikainen et al. (2010), Cappellari et al. (2011), Kormendy & Bender (2012)}\]

Hubble’s tuning fork (1936)

ATLAS$^3$D comb (2011)
Introduction: Are S0s faded spirals?

- Lenticulars (S0s) form a sequence parallel to spirals
  \textit{Laurikainen et al. (2010), Cappellari et al. (2011), Kormendy & Bender (2012)}

- Ram-pressure stripping in clusters can transform spirals into S0s
  \textit{Aragón-Salamanca et al. (2006), Croll & Kenney et al. (2007)}

- But S0s as common in groups as in clusters: other mechanisms? mergers?
  \textit{Wilman et al. (2009), Bekki & Couch (2011)}

- Can bulge-disc coupling observed in S0s rule out (major) mergers?
  \textit{Laurikainen et al. (2010)}

- Gas-rich discs can sometimes survive major mergers
  \textit{Springer & Hernquist (2005), Hopkins et al. (2009)}
GalMer simulations of galaxy mergers

- GalMer $N$-body simulations of galaxy mergers (tree-SPH technique)
  
  Chilingarian et al. (2010) [Combès, Di Matteo, Melchior, Semelin]

- Identify S0s resulting from major mergers:
  Discs first destroyed, but soon (~1 Gyr) rebuilt
GalMer simulations of galaxy mergers

- GalMer N-body simulations of galaxy mergers (tree-SPH technique) [Chilingarian et al. (2010)]
- Identify S0s resulting from major mergers:
  Discs first destroyed, but soon (~1 Gyr) rebuilt

Simulation gSa+gSd, $i=75^\circ$, peric. = 16 kpc, $v_0=200$ km/s, prograde
RGB synthetic images (red=K band; green=g; blue=NUV)
Bulge-disc coupling in S0s

Disc scale-length

Disc $h_d$ (kpc)

Observations:
- Laurikainen+10
  - S0
  - S0/a+Sa
- Laurikainen+04
  - Sa–Sc
  - Sc–Sd

GalMer progenitors:
- Sa
- Sb
- Sd

GalMer mergers:
- remnant

QUEREJETA et al. (2015a)
Bulge-disc coupling in S0s

Disc $h_d$ (kpc)

Bulge effective radius

Bulge $r_e$ (kpc)

Observations:
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QUEREJETA et al. (2015a)
Bulge-disc coupling in S0s

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GalMer progenitors:
- Sa
- Sb
- Sc
- Sd

GalMer mergers:
- remnant

QUEREJETA et al. (2015a)
Bulge-disc coupling in S0s

Photometric decomposition of merger remnants

Observations:
- Laurikainen+10
  - Orange: S0
  - Yellow: S0/a+Sa
- Laurikainen+04
  - Green: Sa–Sc
  - Blue: Sc–Sd

GalMer progenitors:
- Orange: Sa
- Green: Sb
- Blue: Sd

GalMer mergers:
- Black diamonds: remnant

QUEREJETA et al. (2015a)
Bulge-disc coupling in S0s

Observations: Laurikainen+10
- S0
- S0/a+Sa

Laurikainen+04
- Sa–Sc
- Sc–Sd

GalMer progenitors:
- Sa
- Sb
- Sd

GalMer mergers:
- remnant

QUEREJETA et al. (2015a)
Bulge-disc coupling in S0s

Observations:
- Laurikainen+10
  - Orange circles: S0
  - Yellow diamonds: S0/a+Sa
- Laurikainen+04
  - Green squares: Sa–Sc
  - Blue triangles: Sc–Sd

GalMer progenitors:
- Yellow diamonds: Sa
- Green squares: Sb
- Blue triangles: Sd

GalMer mergers:
- Black diamonds: remnant

QUEREJETA et al. (2015a)
Photometric results

- Bulge-disc coupling in agreement with observations:
  - $R_e - h_d - B/T - n - M_k(\text{bulge}) - M_k(\text{disc})$ planes

- Remnant bulges follow observed photometric scaling relations:
  - Kormendy relation, Fundamental Plane...

- Remnant discs obey observational scaling relations as well:
  - $h_d - M_k(\text{disc}) - \mu_{0,d}$

- Also scaling relations for anti-truncated discs in S0s

...but what about \textit{kinematics}?
(the 3D view)
3D kinematic comparison with CALIFA

Angular momentum within $R_e$

Light concentration

$\lambda_{Re}$

$R_{90}/R_{50}$

QUEREJETA et al. (2015b)

VAN DE VEN et al. (in prep.)
3D kinematic comparison with CALIFA

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Summary

Identify S0-like remnants from major mergers of spirals in GalMer

- Disc but no spiral arms
- Dynamically relaxed
- SFR, gas content typical of S0s

Realistic images + Photometric decompositions

Simulate IFU CALIFA strategy