The structure and formation of

Early-Type Dwarf Galaxies

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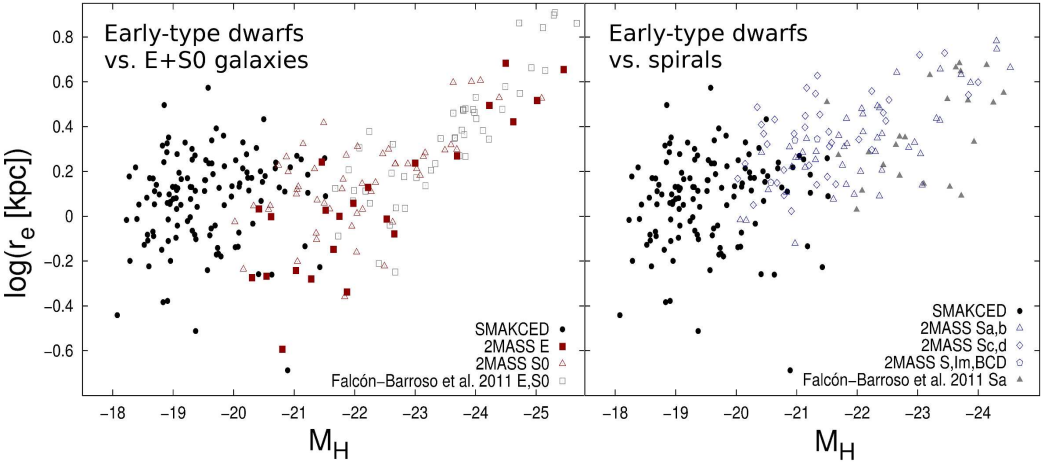
Deconstructing Galaxies

When do we call a galaxy an early-type dwarf?



Janz et al. 2013: Near-IR analysis of >100 Virgo early-type dwarfs

SMAKCED collaboration — www.smakced.net

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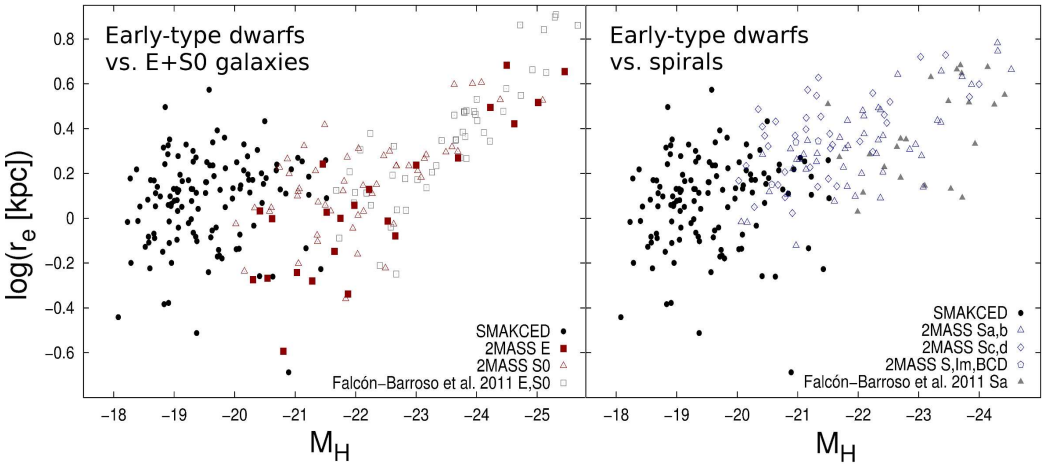

dE / spheroidal
"early-type dwarf"

cE

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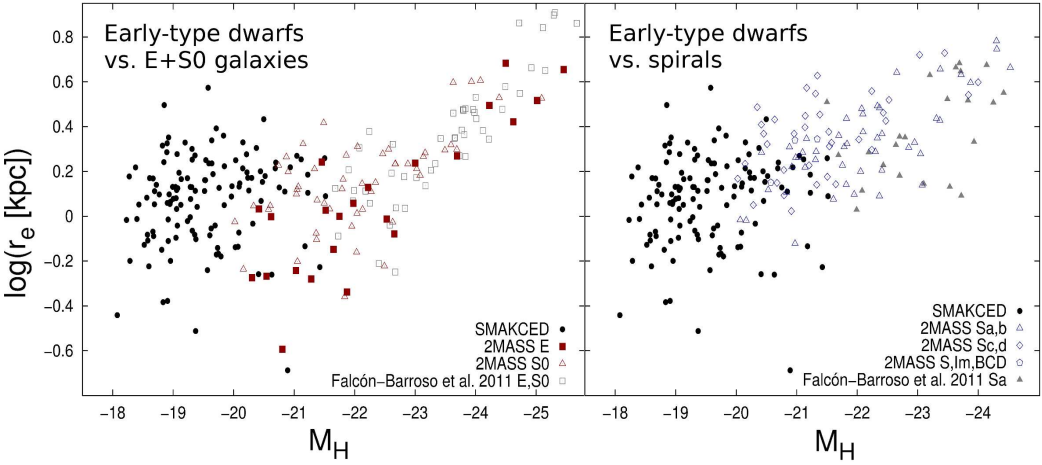

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Low luminosity
Low surface brightness
Low Sérsic index
Smooth appearance

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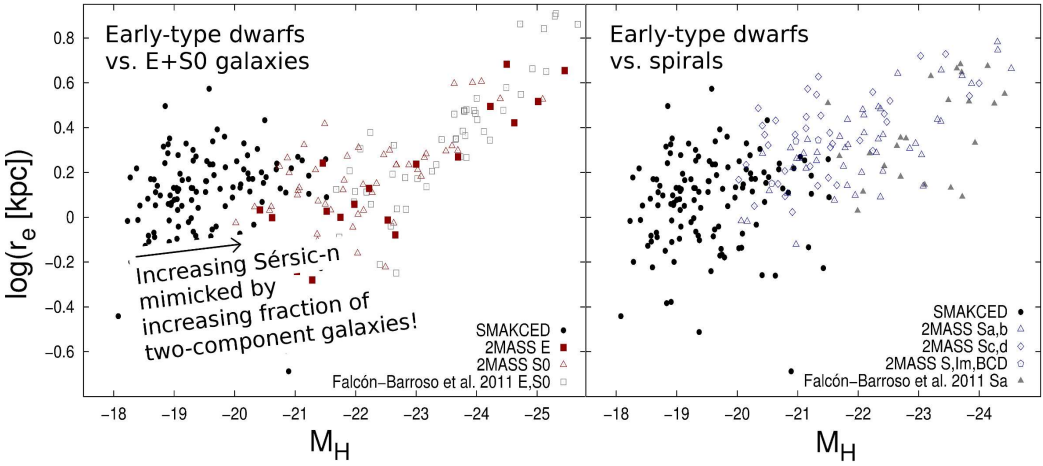

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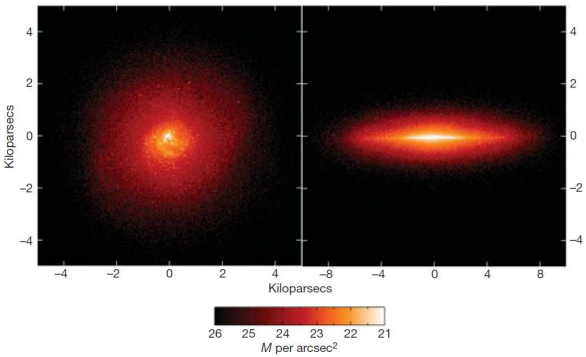
Forming a (diffuse, bulgeless) dwarf galaxy



Governato et al. 2010:

"Strong outflows from supernovae remove low-angular-momentum gas, which inhibits the formation of bulges"

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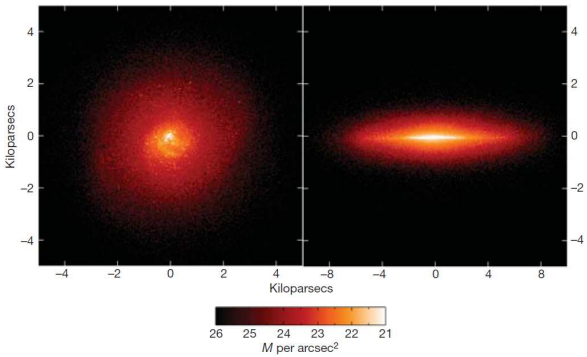


Governato et al. 2010:

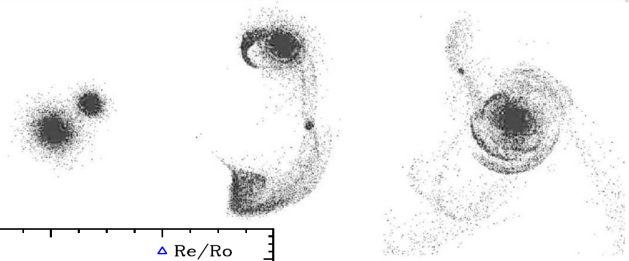
"Strong outflows from supernovae remove low-angular-momentum gas, which inhibits the formation of bulges"

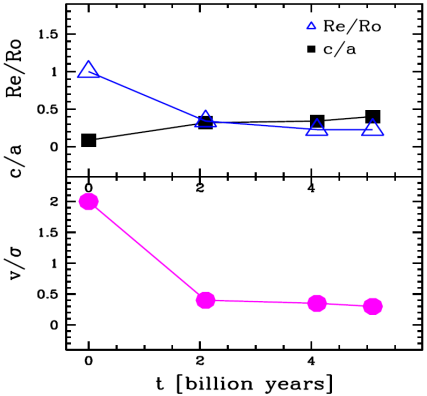
Kaufmann et al. 2007:

Dwarfs form as thick systems

"the presence of an effective temperature floor in the interstellar medium (...) naturally explains the tendency for low-mass galaxies to be more spheroidal"

Various forms of gravitational stripping and heating of a disk

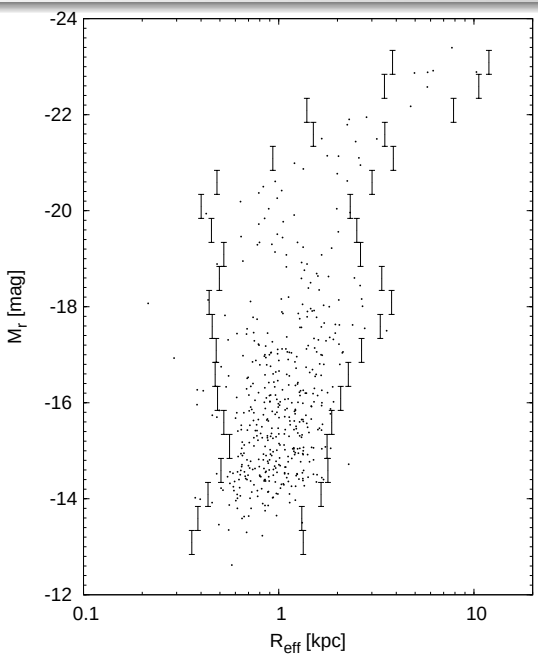




D'Onghia et al. 2009:
Resonant stripping

cf. Mayer et al. 2001, Mastropietro et al. 2005, Aguerri et al. 2009, Smith et al. 2010, Villalobos et al. 2012

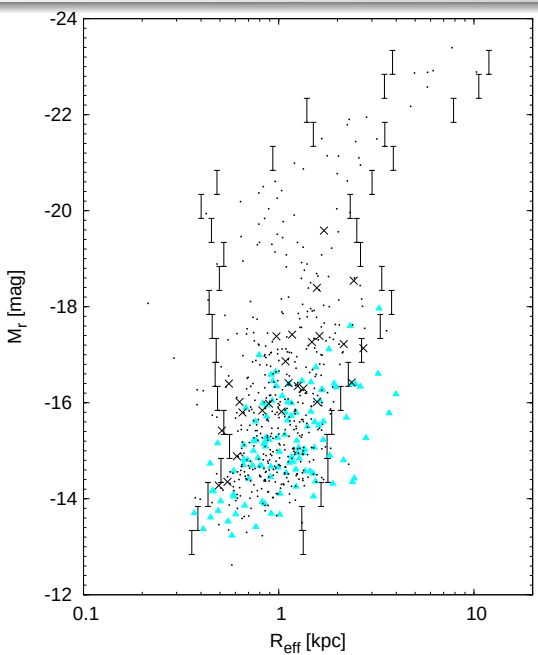
Structural similarity of early-type dwarfs with...



Meyer et al. (2013)

Im ▲
Sm ×
Sc ●
Sd ●
BCDs(LSB) ■
early-types ·

Structural similarity of early-type dwarfs with...irregulars?



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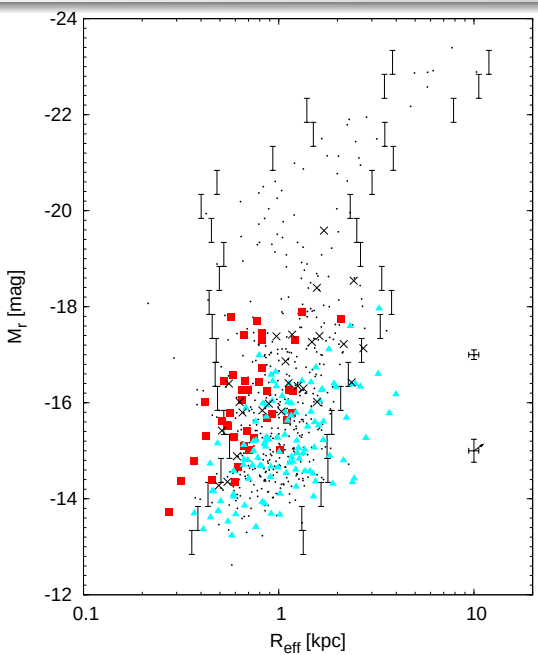
Structural similarity of early-type dwarfs with...BCDs?



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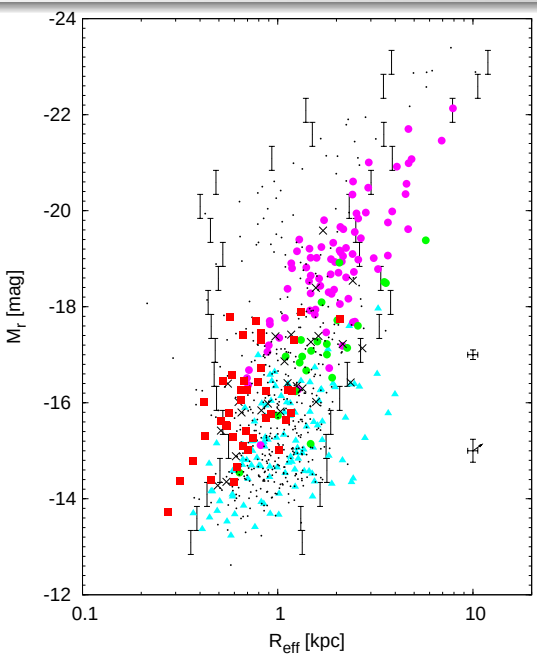
Structural similarity of early-type dwarfs with...late-type spirals?



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Internal dynamics of early-type dwarfs vs. spirals

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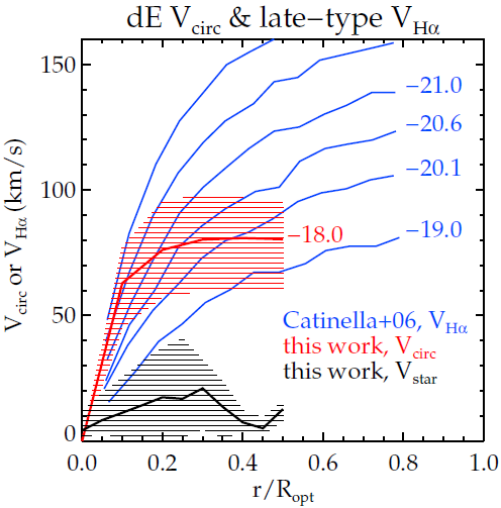
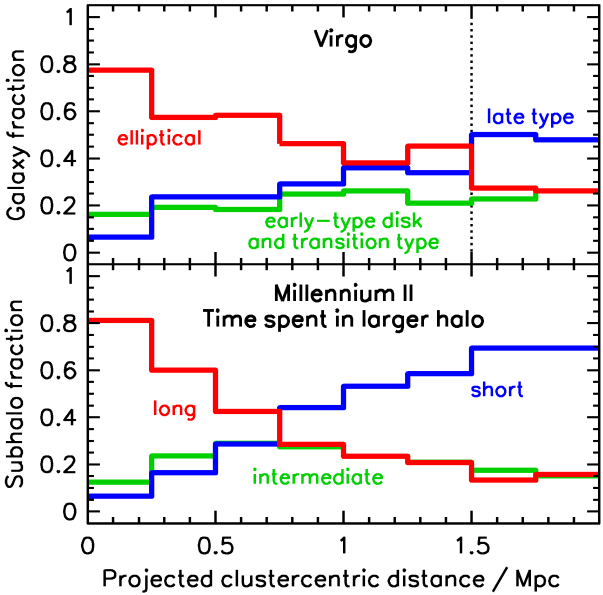


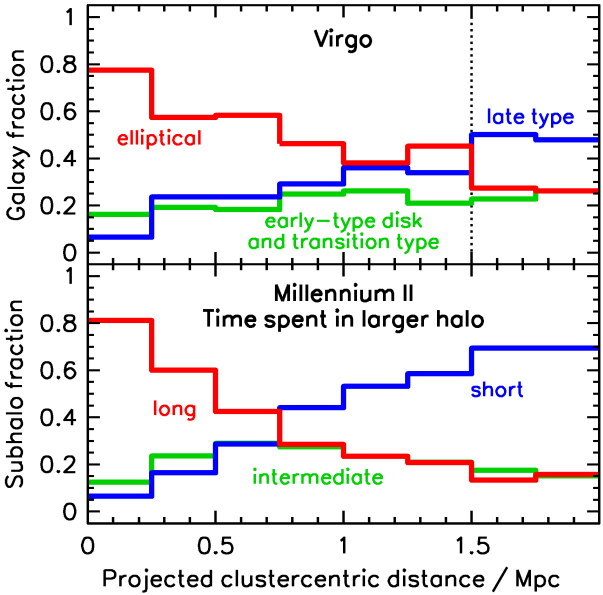
Ryś et al. (subm.):
Internal dynamics of early-type dwarfs

The morphology-density-history relation



Lisker et al. 2013

The morphology-density-history relation



Lisker et al. 2013:

Low-mass galaxies in today's cluster cores experienced environmental influence since early epochs.

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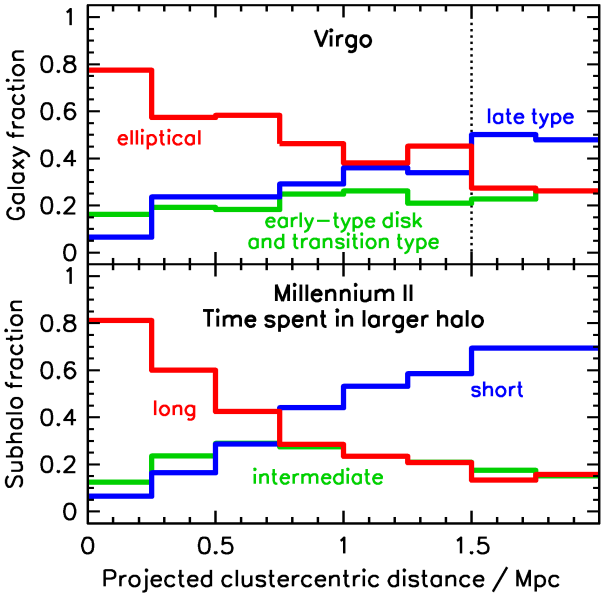


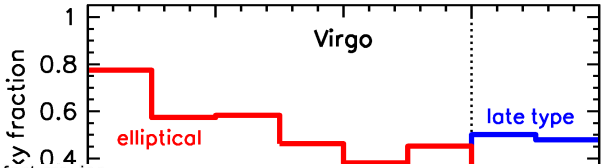
Lisker et al. 2013:

Low-mass galaxies in today's cluster cores experienced environmental influence since early epochs.

Today's late-type galaxies have evolved in different environments and probably formed under different conditions than the progenitors of early-type dwarfs!

Sanchez-Janssen & Aguerri 2012: GC systems of brighter early-type dwarfs incompatible with those of present-day spirals

The morphology-density-history relation



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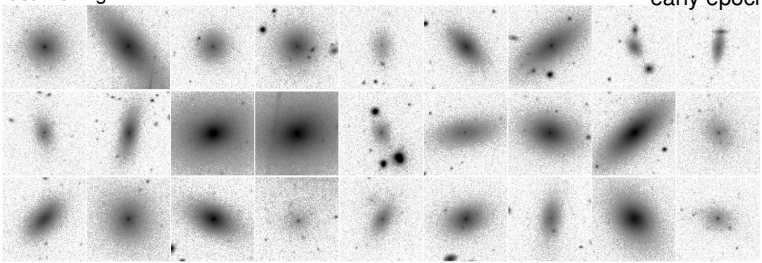
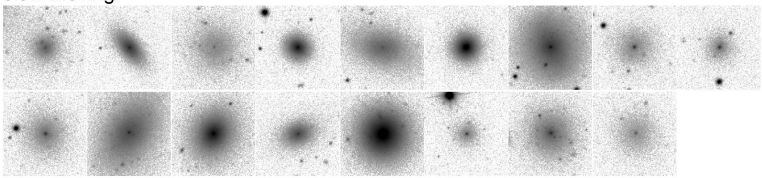
fast-moving:



Lisker et al. 2009

slow-moving:



First generation of early-type dwarfs in the cluster core?

Early-type dwarfs in the Local Group

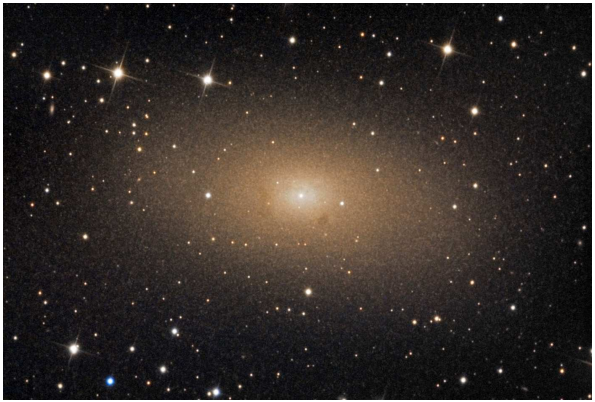
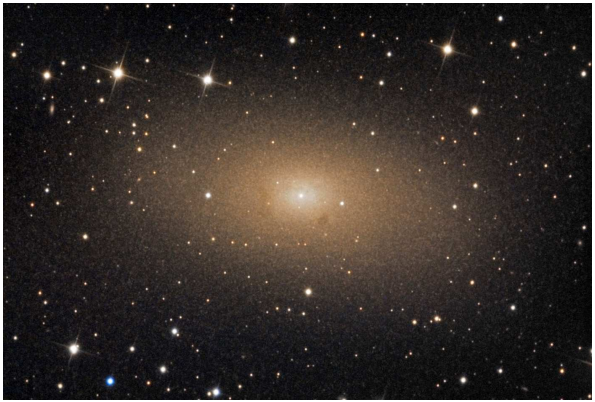


Image: Volker Wendel

The best-known dwarf elliptical galaxy:
NGC 205, satellite of Andromeda

Early-type dwarfs in the Local Group



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The best-known dwarf elliptical galaxy:
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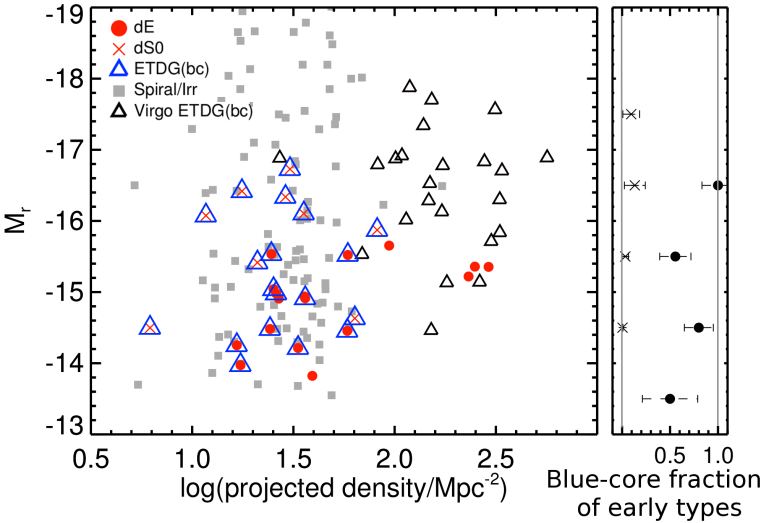
Blue central region due to recent star formation!

Many blue-core early-type dwarfs in the Ursa Major cluster

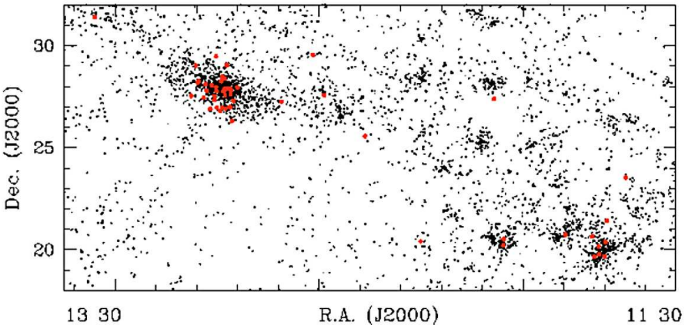


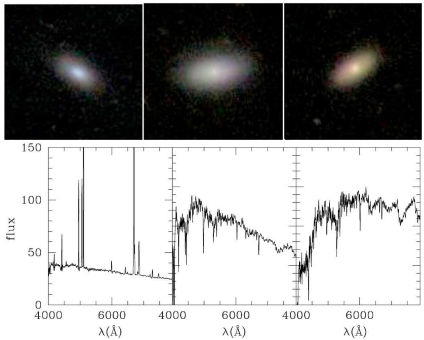
Pak et al. in prep.:

Early types in the Ursa Major cluster

Virgo blue cores: Lisker et al. 2006b, Kim et al. 2010

Post-starburst galaxies: new additions to cluster populations





Gavazzi et al. 2010:

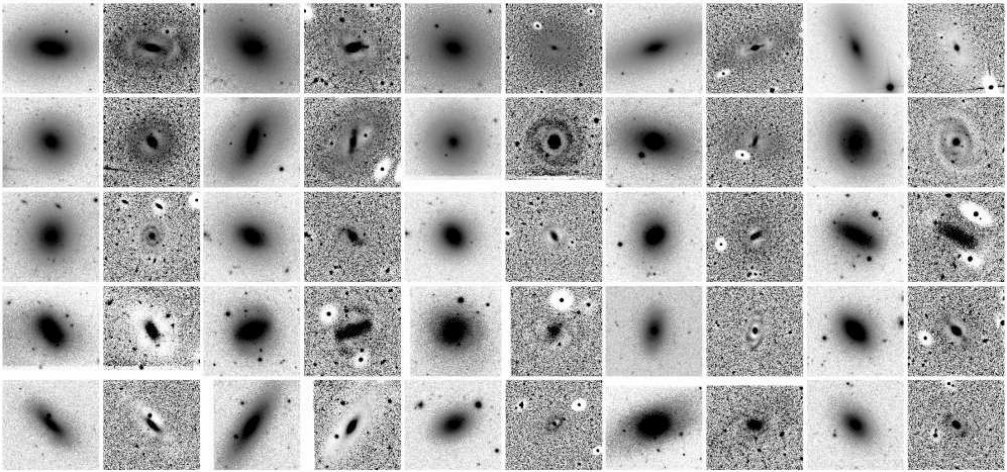
Recently quenched galaxies in the Coma supercluster are found around the densest regions

→ Ram pressure stripping

(cf. Smith et al. 2012 for effects on stellar disk)

Also see
Barazza et al. 2009: colour-density relation exists in multi-cluster system Abell 901/902

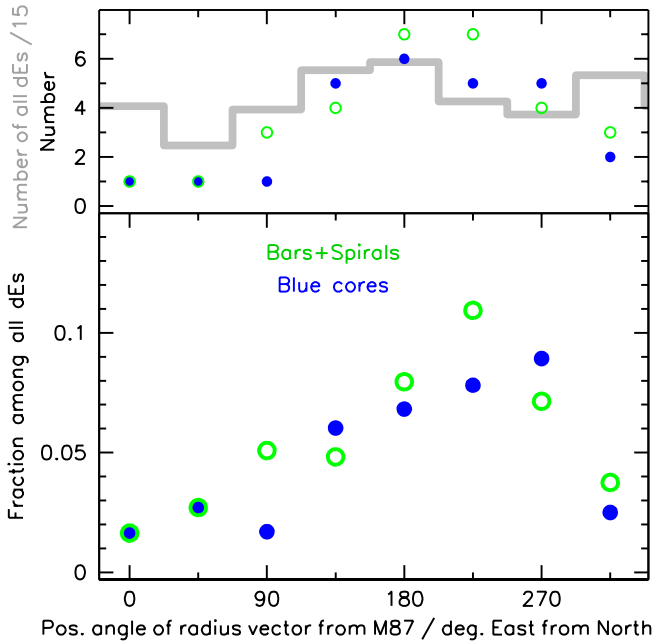
Disk features in Virgo early-type dwarfs



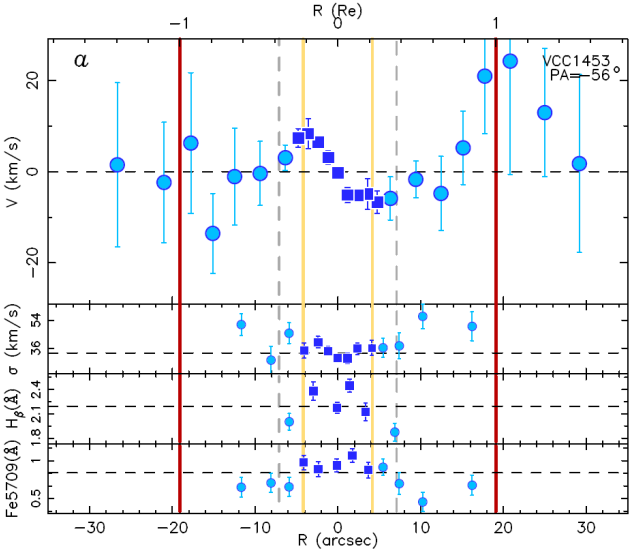
Lisker et al. 2006a

For multi-component decomposition of early-type dwarfs,
see McDonald et al. 2011 and Janz et al. 2012 (SMAKCED)

Preferred cluster region of disks and blue cores



Kinematically decoupled cores in Virgo early-type dwarfs



Toloba et al., subm. (SMAKCED)

(also see Thomas et al. 2006)

Conclusions

What shaped the objects that we call early-type dwarfs today?

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- Early tidal interaction in proto-cluster environment
- Continuous tidal stirring in groups
- Occasional close passages and mergers in groups/field
- Fast, strong tidal interactions in massive clusters
- Tidal interactions of massive galaxies form tidal dwarfs
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- Removal of gaseous halo due to ram pressure
- Stripping of gas disk due to ram pressure
  (SF stops → optical appearance smoother; thickens stellar disk)

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- Dwarfs already form as diffuse systems with thick shape, then lose their gas through SN feedback and/or get stripped