The structure and formation of Early-Type Dwarf Galaxies

Thorsten Lisker
Zentrum für Astronomie der Universität Heidelberg

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

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Structure and formation of early-type dwarfs
When do we call a galaxy an early-type dwarf?

- Low luminosity
- Low surface brightness
- Low Sérsic index
- Smooth appearance

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Structure and formation of early-type dwarfs
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”
Forming a (diffuse, bulgeless) dwarf galaxy

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“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


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

Meyer et al. (2013)

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Structural similarity of early-type dwarfs with BCDs?

Meyer et al. (2013)
Structural similarity of early-type dwarfs with late-type spirals?

Meyer et al. (2013)

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Structure and formation of early-type dwarfs
Internal dynamics of early-type dwarfs vs. spirals

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

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Structure and formation of early-type dwarfs
The morphology-density-history relation

Lisker et al. 2013

Virgo

Galaxy fraction

elliptical

early-type disk and transition type

late type

Subhalo fraction

long

intermediate

short

Time spent in larger halo

0 0.5 1 1.5

Projected clustercentric distance / Mpc

Lisker et al. 2013

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Structure and formation of early-type dwarfs
The morphology-density-history relation

Lisker et al. 2013:
Low-mass galaxies in today’s cluster cores experienced environmental influence since early epochs.
The morphology-density-history relation

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

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

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

Image: Volker Wendel
Early-type dwarfs in the Local Group

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

Blue central region due to recent star formation!

Image: Volker Wendel
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)
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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What shaped the objects that we call early-type dwarfs today?

- 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
- Tidal perturbations trigger bars and spiral arms in dwarfs
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- New central stars from reaccreted or newly accreted gas
- 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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  (SF stops $\rightarrow$ optical appearance smoother; thickens stellar disk)
- Dwarfs already form as diffuse systems with thick shape, then lose their gas through SN feedback and/or get stripped