The linked orbital and star formation histories of satellite galaxies

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JO204 in A957 (courtesy Deb+2020)
*not to scale

First pericentre:
- Maximum ram pressure
- Maximum tides

"Infall"

Accretion ceases on approach

First apocentre (backsplash)
Orbital history, star formation history

Driven by:
- First pericentre
- Drop in star formation rates

ram pressure? tides?
The model

\[ f \]

\[ f_{\text{before}} \]

\[ f_{\text{after}} \]

\[ t_{\text{mid}} \]

\[ \Delta t \]

\[ t - t_{fp} \]
Testing on mock data

- Select simulated galaxies around clusters at $z \sim 0.6$
- Track forward/backward to determine time since/until first pericentre $t-t_{fp}$
- Bin by $t-t_{fp}$ and determine fraction of active (star forming) galaxies
Testing on mock data

- Suppose for now that $t-t_{fp}$ is magically observable...
- Constrain parameters of the model
Orbits in (projected) phase space

Arthur+2019
Orbital parameter distributions

- $V_{\text{los}}/\sigma_{3D} = 0.9, R/r_{\text{vir}} = 0.5$
  - $N = 7520$
  - $N = 4848$
  - $N = 5164$

- $V_{\text{los}}/\sigma_{3D} = 0.6, R/r_{\text{vir}} = 0.5$
  - $N = 12603$
  - $N = 9481$
  - $N = 8732$

- $V_{\text{los}}/\sigma_{3D} = 0.3, R/r_{\text{vir}} = 0.5$
  - $N = 18054$
  - $N = 15199$
  - $N = 14696$

- $V_{\text{los}}/\sigma_{3D} = 0.0, R/r_{\text{vir}} = 0.5$
  - $N = 22656$
  - $N = 18637$
  - $N = 18375$

Projected radial position $R/r_{\text{vir}}$ at $z=0$ vs. projected (LoS) velocity $V_{\text{los}}/\sigma_{3D}$ at $z=0$. Probability density plots show the distribution of orbital parameters over time since cluster infall (Gyr).
Testing on mock data

• Now can take into account likely orbits for each satellite.

• Constrain parameters of the model
Testing on mock data

- Now can take into account likely orbits for each satellite.
- Constrain parameters of the model
Model input visualised

For each observed satellite candidate:
- Radial offset $R$
- Velocity offset $V$
- One of:
  - $(g-r)$ colour
  - SFR
  - HI detected?
Model constraints: SDSS + ALFALFA
Physical interpretation

- **Clusters:**
  - Partial ram-pressure stripping of neutral gas on initial approach, enough to drop out of ALFALFA.
  - Remaining gas fuels star formation for ~3 Gyr after pericentre.

- **Groups:**
  - Quench some satellites, but most survive ~longer than the age of the Universe?
  - The typical group satellite has not had time to be quenched by its host.
  - Or perhaps the merging timescale < the quenching timescale.
Summary

- Clear detection of the sequence of environmental processing:
  - Gas stripped (non-detections from ALFALFA)
  - Star formation shuts off (Balmer lines disappear, reddening)
- Broadly consistent with the ‘delayed-then-rapid’ picture for quenching, but find longer timescales than most others.
- Contrast with contemporary simulations where quenching tends to be early, ~during the first passage, especially in clusters.

Physical origin of the quenching timescale

Wetzel et al. (2013), $\log_{10}(M_{\text{vir}}/M_\odot) = [12, 13]$
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Wetzel et al. (2013), $\log_{10}(M_{\text{vir}}/M_\odot) = [14, 15]$
Wheeler et al. (2014), $\log_{10}(M_{\text{vir}}/M_\odot) = 13.5$
Fillingham et al. (2015), $\log_{10}(M_{\text{vir}}/M_\odot) = 12.5$
EAGLE satellites, $\log_{10}(M_{\text{vir}}/M_\odot) = [13, 14.6]$
The future: individual SFHs

Coma satellite GMP 3254

Upadhyay+ in prep
The future: individual SFHs

Upadhyay+ in prep