Top-heavy stellar initial mass functions in ultra compact dwarf galaxies

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What are ultra compact dwarf galaxies (UCDs)?

- Half-light radii of less than 50 pc.
- Masses between 10^6 and 10^8 Solar masses.
- High densities.
- Intermediate- to high ages.
- Rare, but characteristic population in the local universe.
- Origin unknown, but...

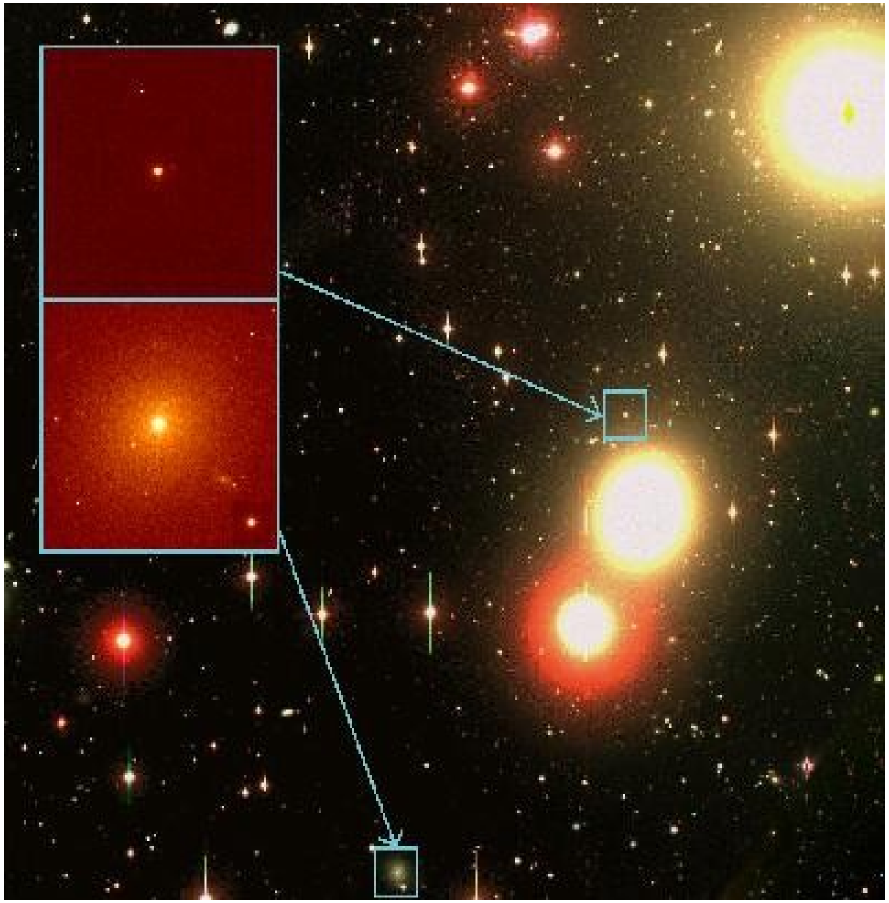
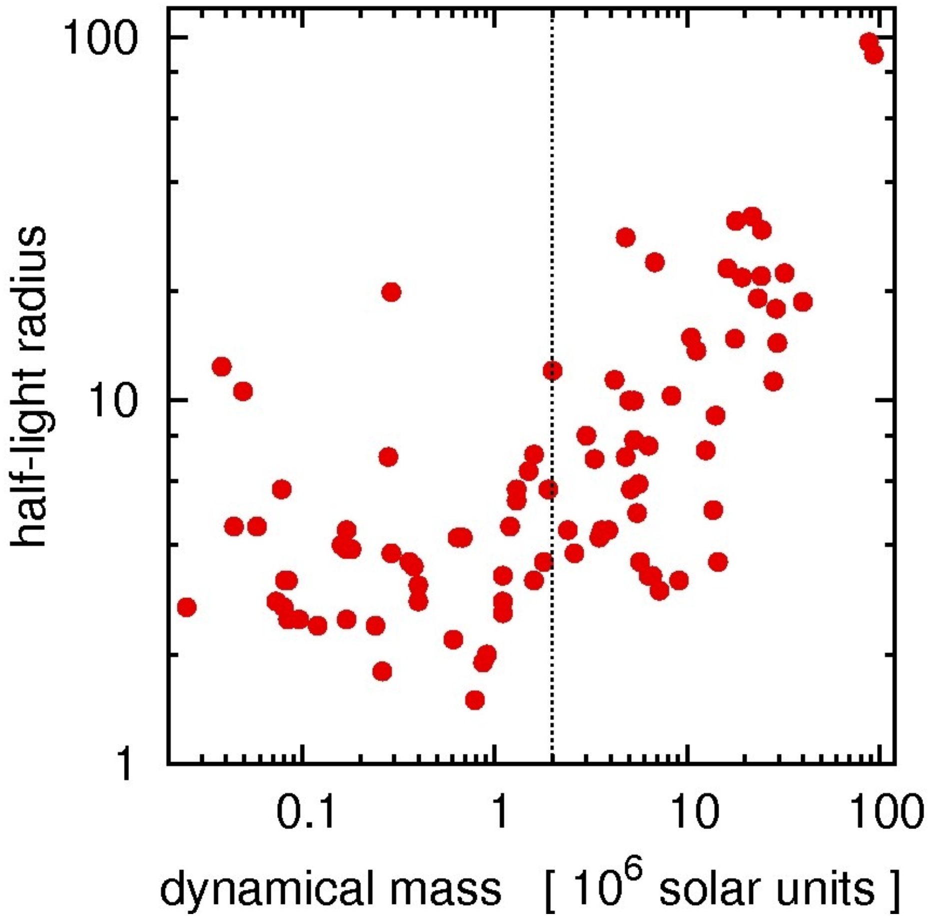


Image by M. Hilker

...different theories on the nature of UCDs have been brought forward:

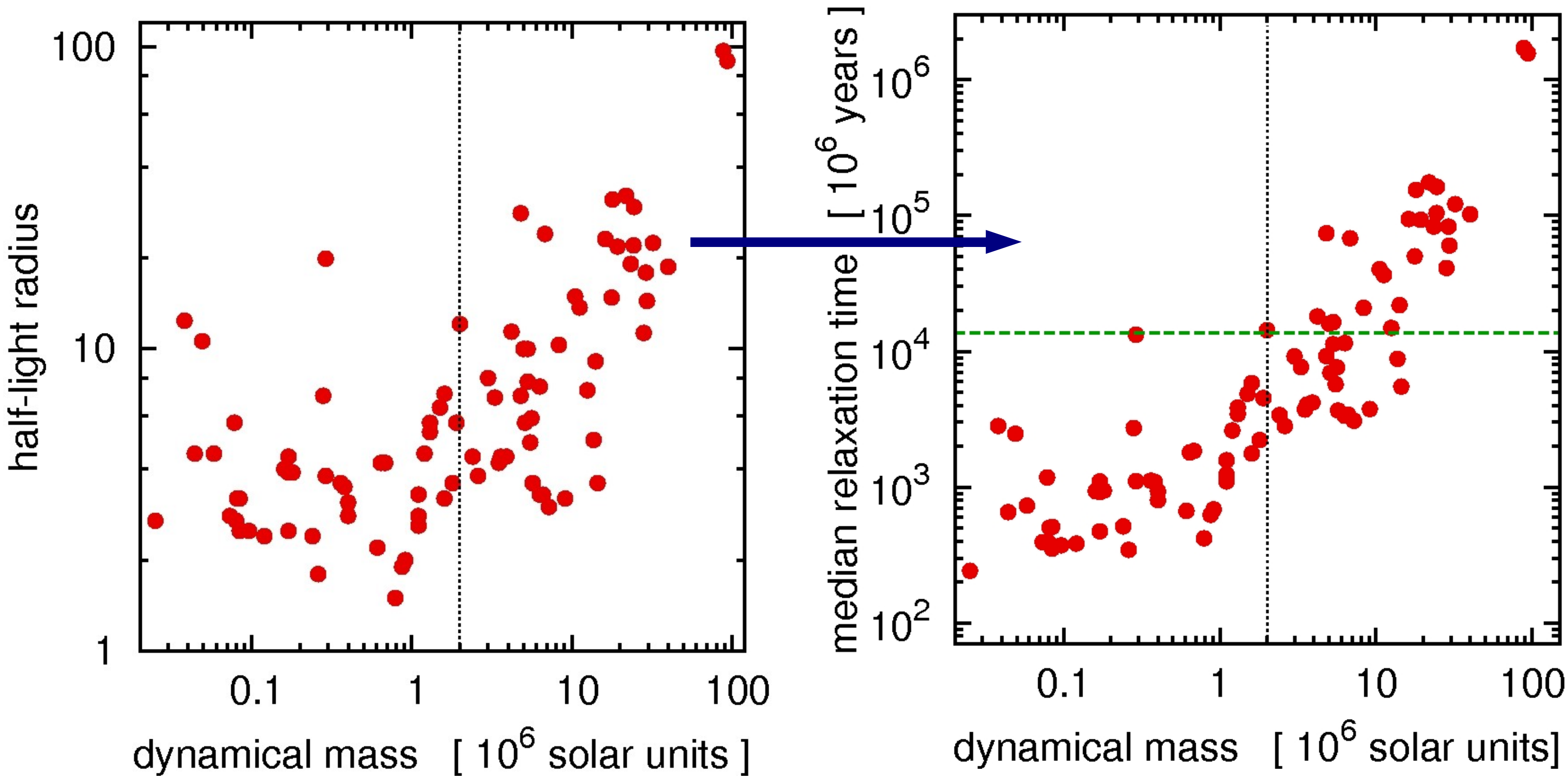
- UCDs are merged star-cluster complexes (Fellhauer & Kroupa 2002).
- UCDs are the remnants of disrupted nucleated dwarf galaxies (Bekki et al. 2003; Goerdt et al. 2008).
- UCDs are primordial structures that formed in the early universe (Drinkwater et al. 2004).
- UCDs are the most massive globular clusters (Mieske et al. 2002, 2004; Forbes et al. 2008).

Properties of UCDs



(data from Mieske et al. 2008)

Properties of UCDs



(data from Mieske et al. 2008)

Median relaxation times according to Spitzer & Hart (1971)

Properties of UCDs

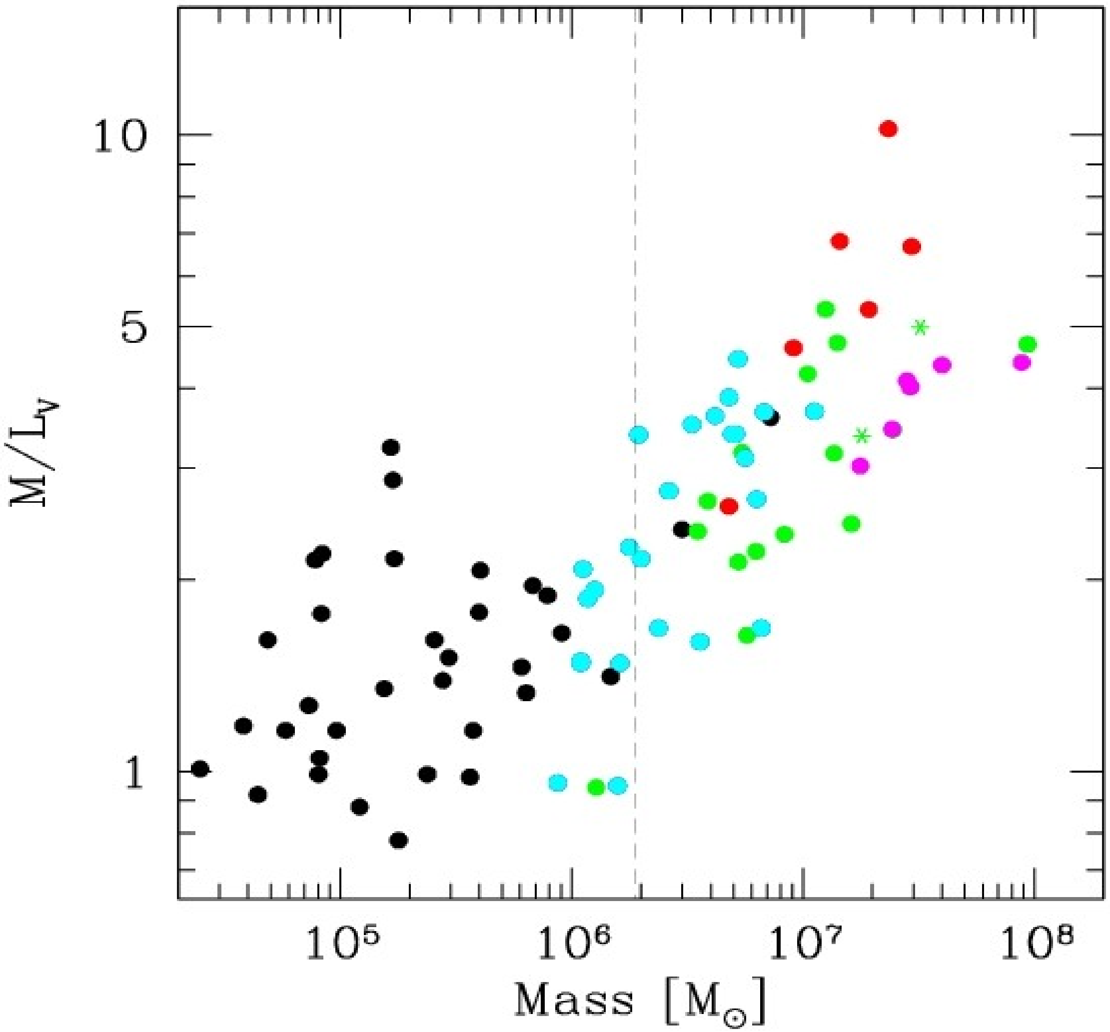
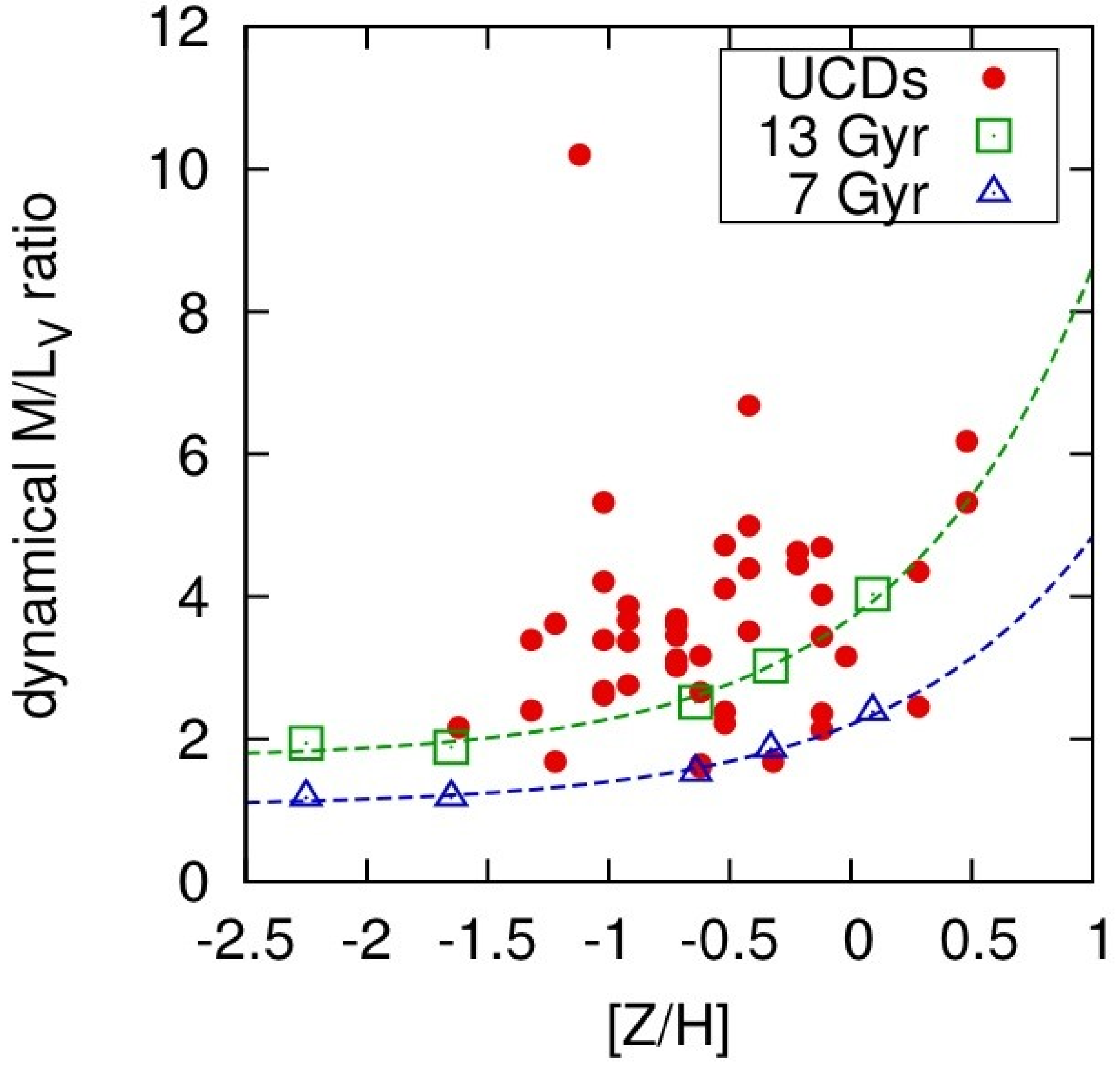


Figure from Mieske et al. (2008)

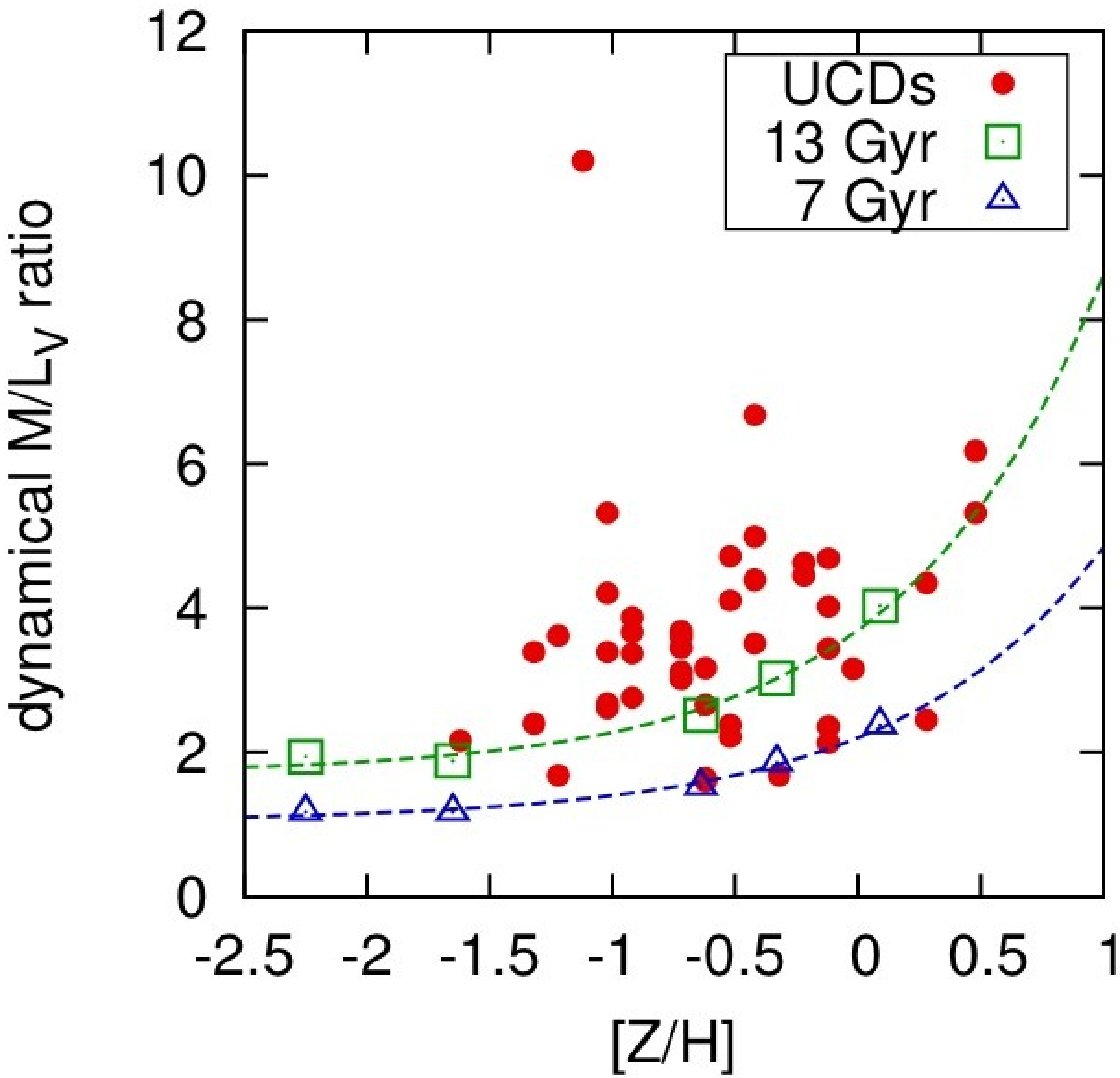
- Shown here are dynamical mass-to-light ratios
- Mass-to-light ratios depend on age and metallicity

The effect of metallicity on the mass-to-light ratio



- Estimate the metallicity of UCDs
- Compare their mass-to-light (M/L) ratio to simple stellar population (SSP) models

The M/L ratios of the UCDs



- A majority of the UCDs has a higher M/L ratio than SSP models with the canonical initial stellar mass function (IMF) predict
- There is no clear trend between mass and M/L ratio of UCDs
  → consider the average M/L ratios of UCDs

Why are the mass-to-light ratios of UCDs so high?

- Is it because UCDs contain non-baryonic dark matter?

  Probably not, the expected dark matter densities would be too low (Murray 2009).

- Is it because the IMF is bottom-heavy in UCDs?

  This is being investigated by measuring the CO-index, a tracer for low-mass stars (Mieske & Kroupa 2008).

- Or is it because the IMF is top-heavy in UCDs?

  The high mass-to-light ratio would in this case be the consequence of a high abundance of stellar remnants.

Bottom- or top-heavy IMF?

- High density of massive stars → strong radiadion field → outer parts of forming stars are evaporated → bottom-heavy IMF

- High density of proto-stars → high encounter rates between them → effective build-up of massive stars through mergers of protostars → Top-heavy IMF

A bottom-heavy stellar initial mass function (IMF) in UCDs?

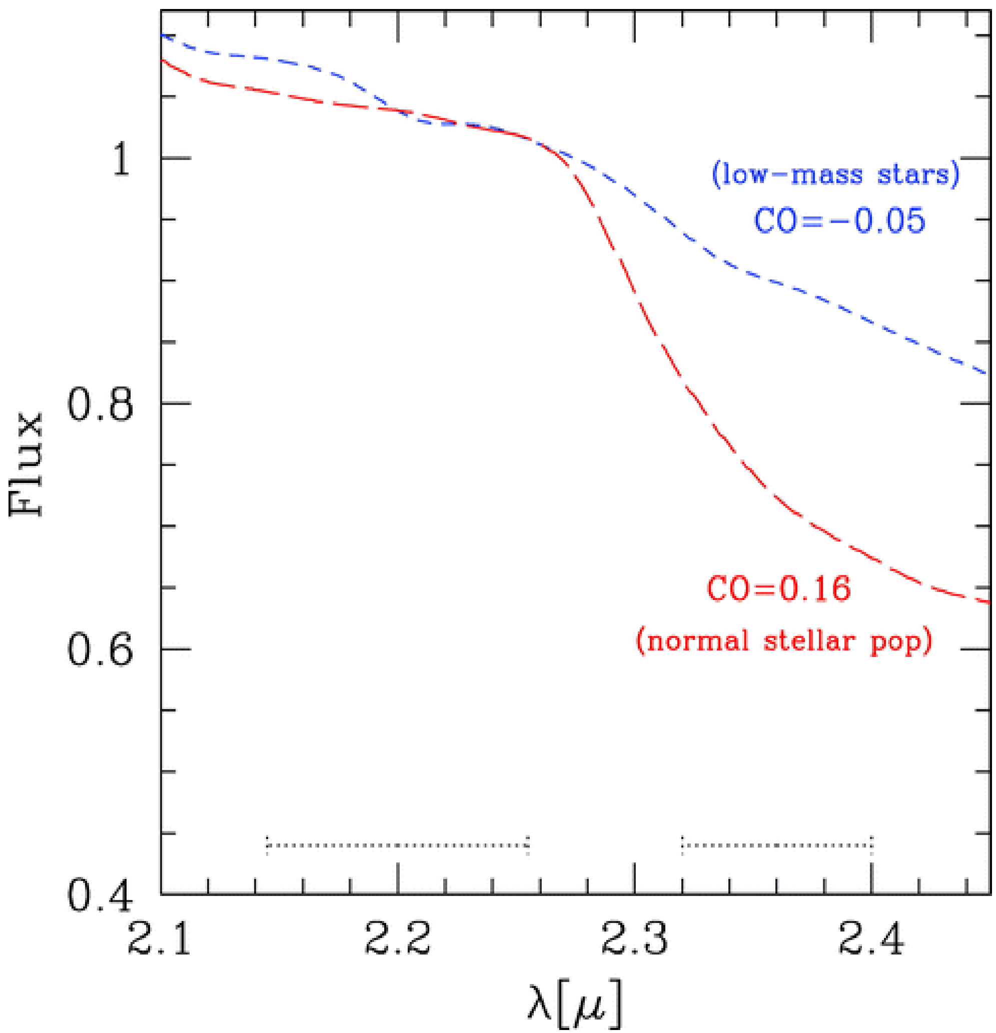
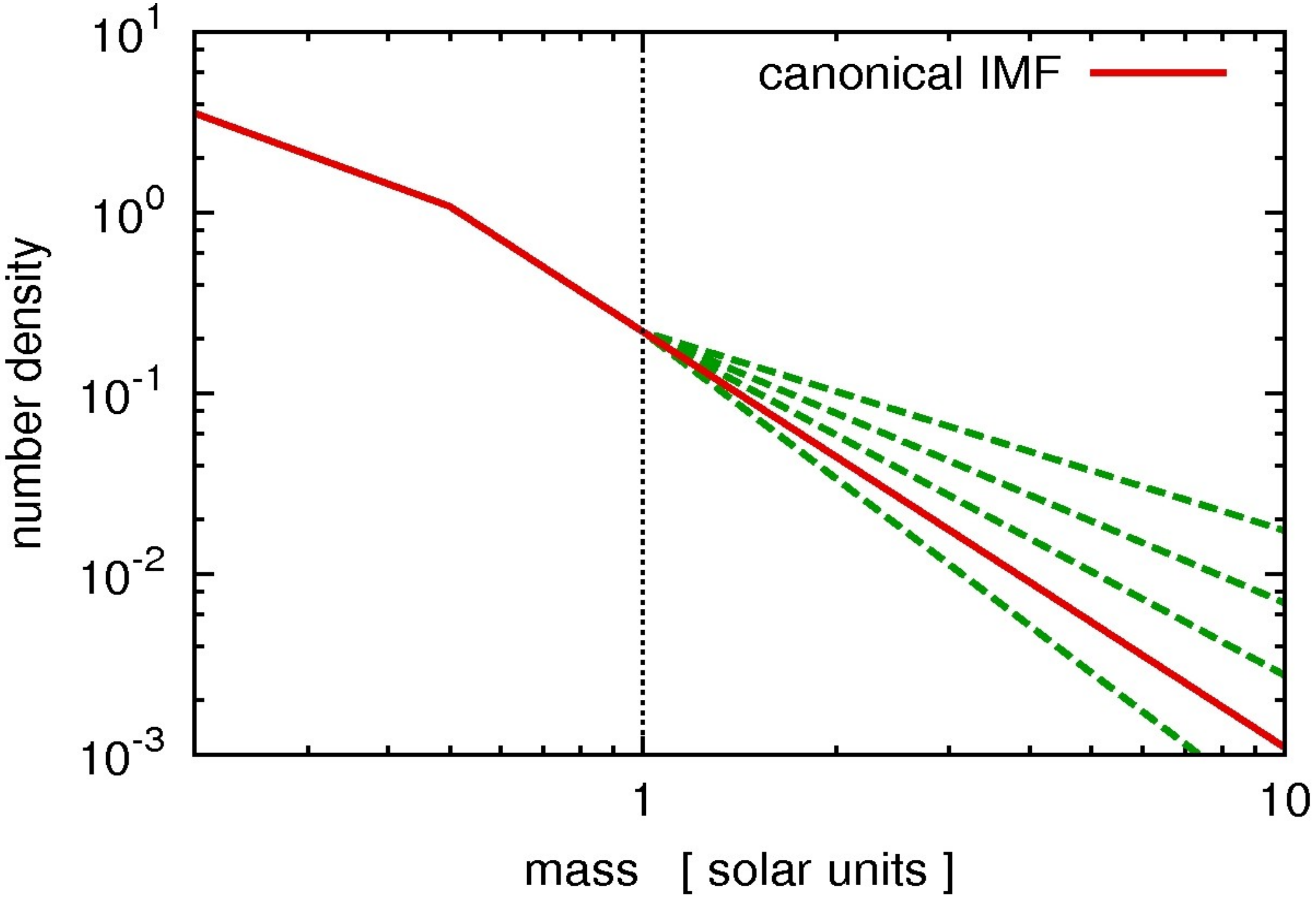


Figure from Mieske & Kroupa 2008

Low-mass stars can be traced by their specific radiation...

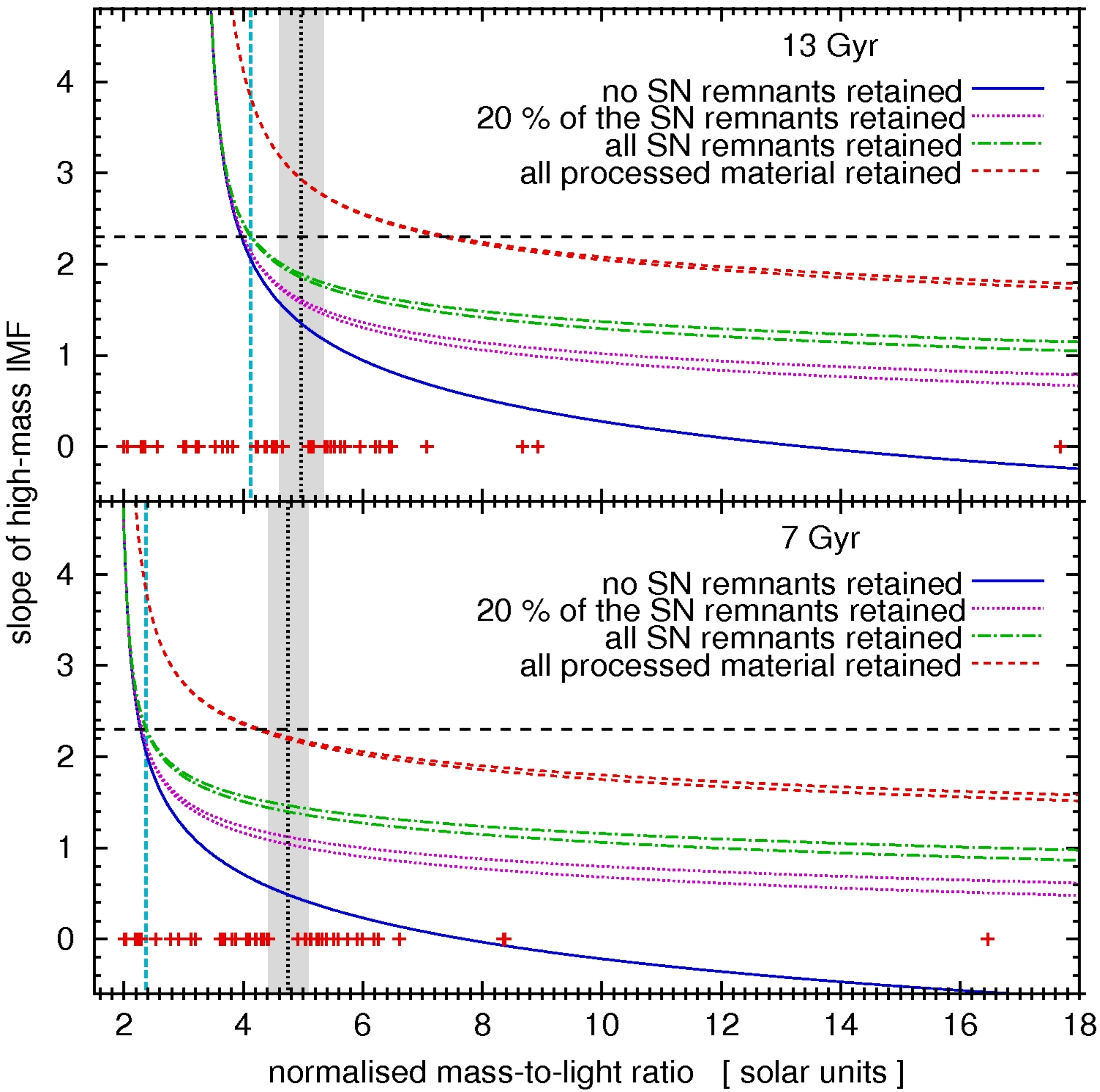
...but as they are faint, only very many of them change the light of the stellar population clearly.

A top-heavy IMF in UCDs?

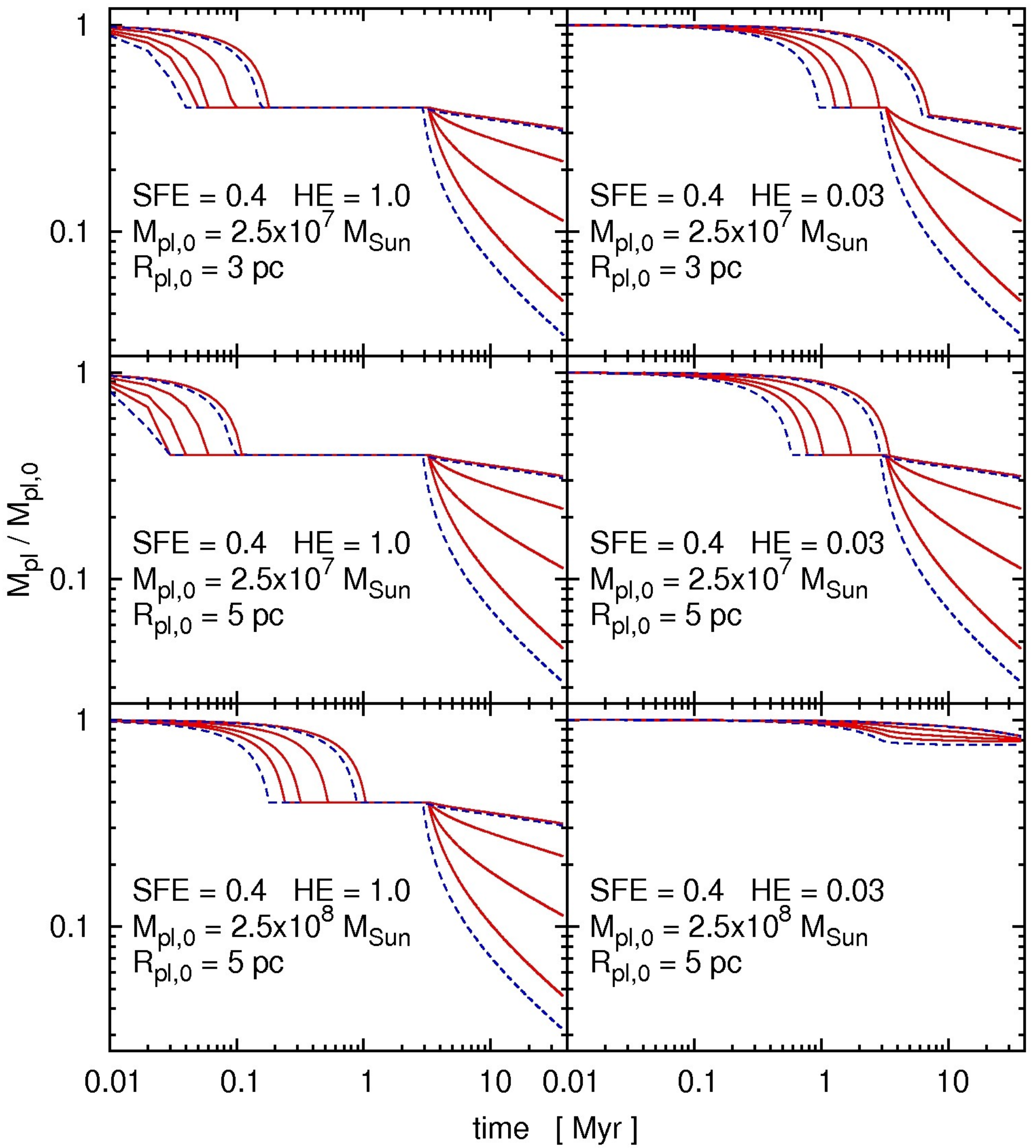


Model the IMF in UCDs by finding a high-mass IMF slope so that the given mass-to-light ratio is realised (Dabringhausen, Kroupa & Baumgardt 2009).

The predicted high-mass IMF slopes

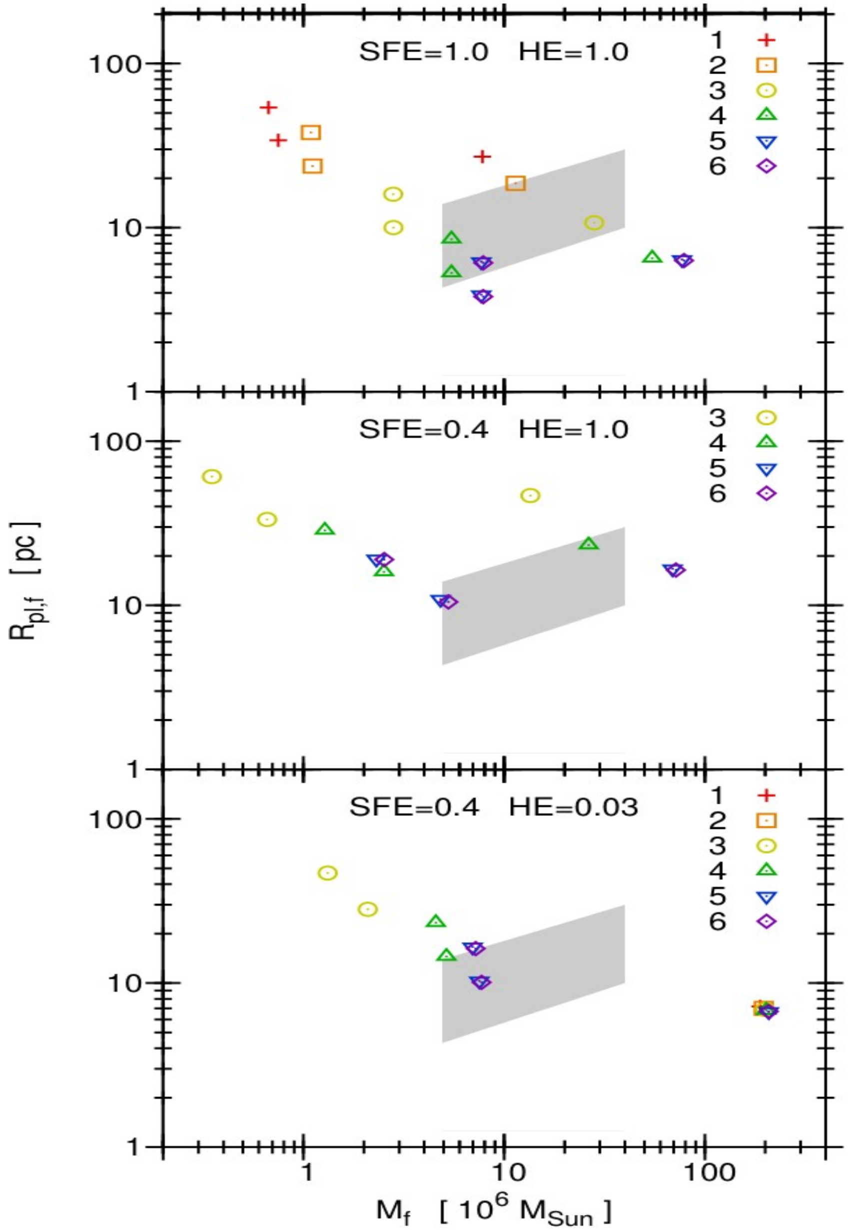


Would UCDs with a top-heavy IMF survive their early evolution?



- Assume that UCDs form in a starburst.
- Create mass-loss histories (gas expulsion and stellar evolution).
- Model dynamical evolution of the UCDs using the mass-loss histories.

Would UCDs with a top-heavy IMF survive their early evolution?



Some of the calculated models reproduce the final parameters of UCDs

➞ UCDs can also survive with top-heavy IMFs

(Dabringhausen, Fellhauer & Kroupa 2009).

Conclusions

- UCDs have on average a higher mass-to-light ratio than expected if they are a pure stellar population that formed with the canonical IMF.
- A top-heavy IMF in UCDs is a possible explanation for this finding.
- A top-heavy IMF does not contradict their survival until today.