Top – heavy IMFs as possible explanation for the high mass to light ratio of ultracompact dwarf galaxies

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How this talk is organised:

1) What are ultra compact dwarf galaxies (UCDs)?

2) The high mass to light ratio of UCDs

3) Explanations for the high mass to light ratio of UCDs:

   a) metallicity or dark matter

   b) a stellar mass function with a large number of intermediate or high mass stars.

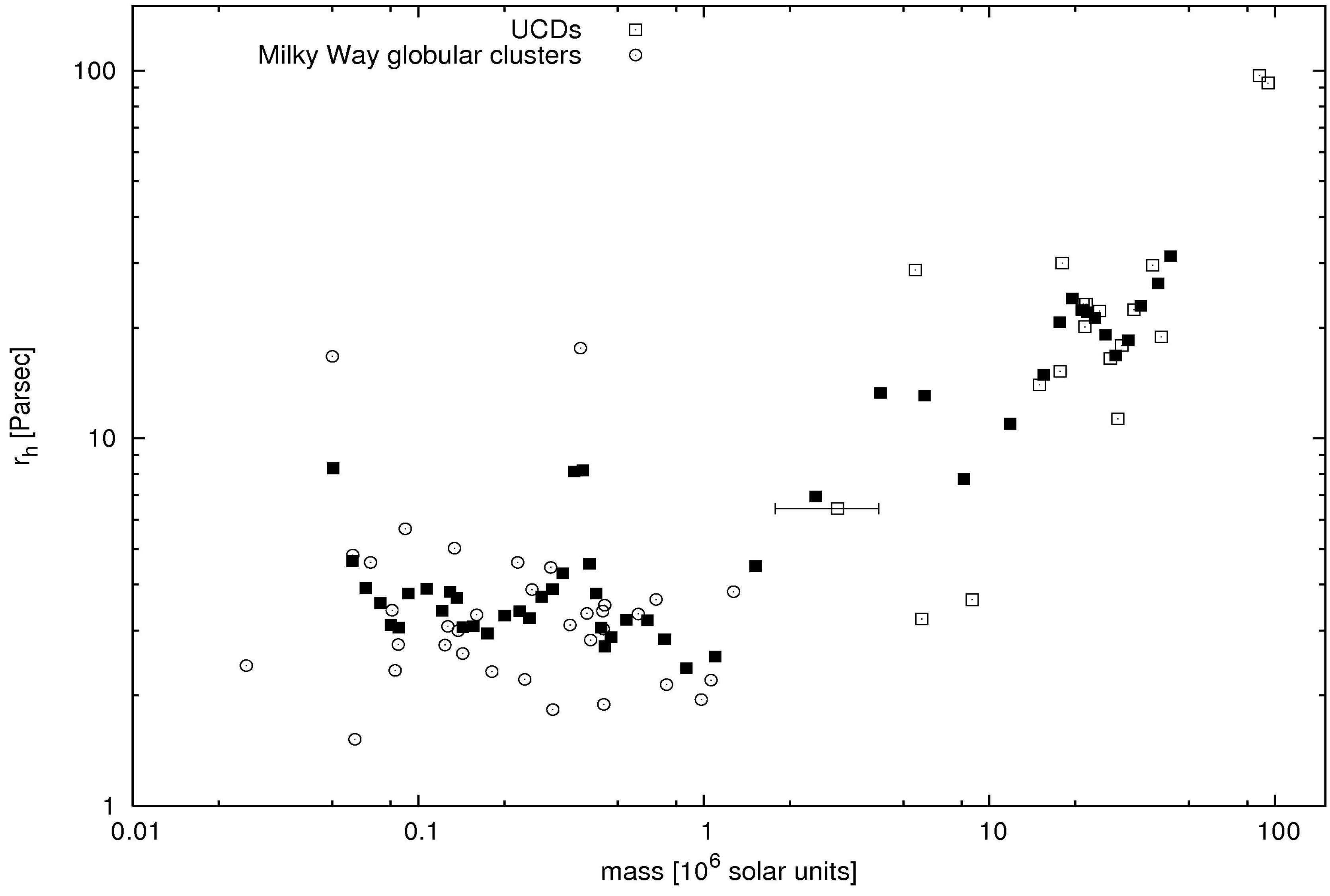
What are Ultra Compact Dwarf Galaxies?

Properties of UCDs:

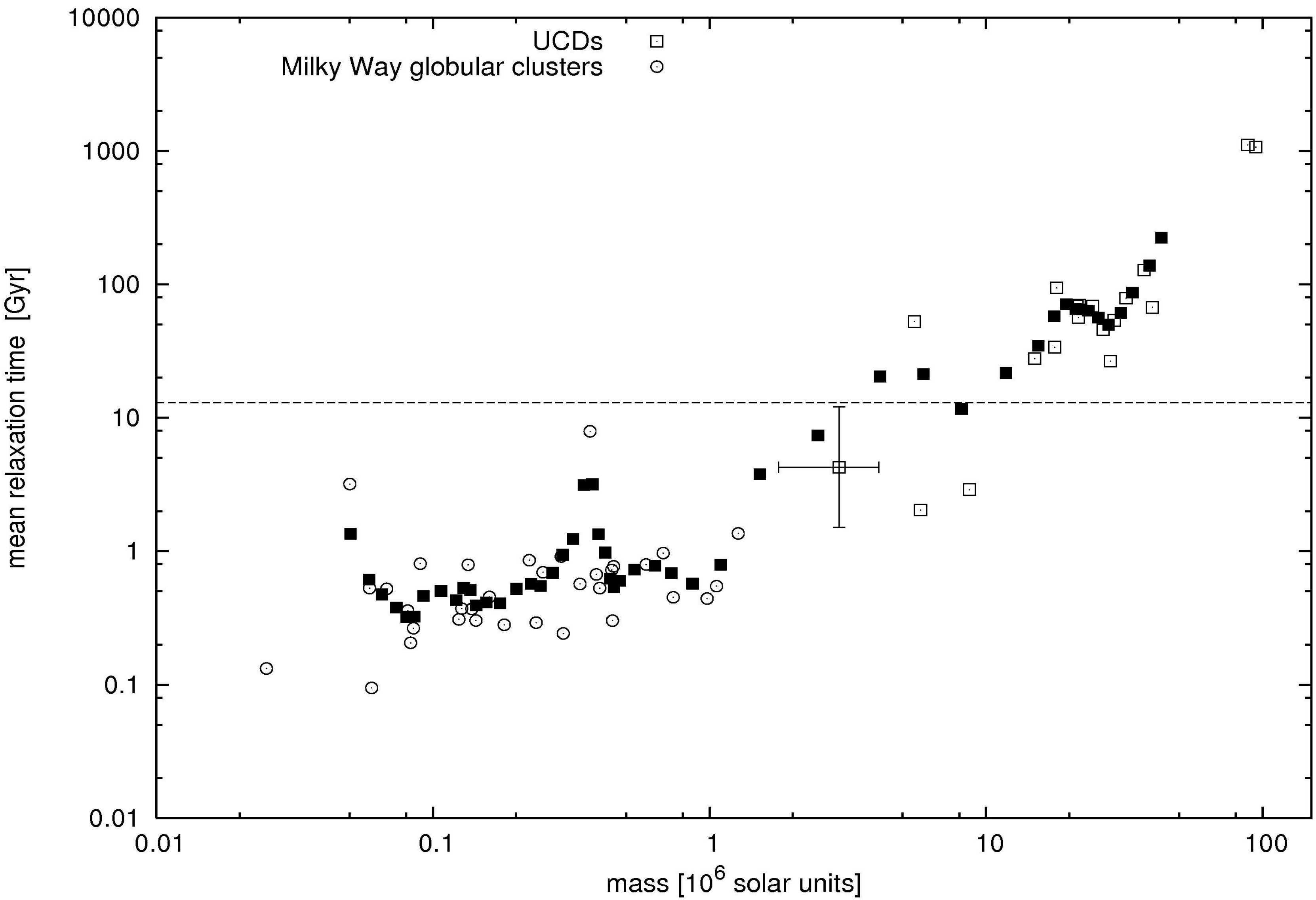
- high age (9 – 13 Gyr)
- characteristic radii larger than for globular clusters but much smaller than in Dwarf Ellipticals
- Masses from some 10^6 to 10^8 solar masses
- quite high mass to light ratio

Note: A UCD has more than one of these properties!

projected half-light radius against mass

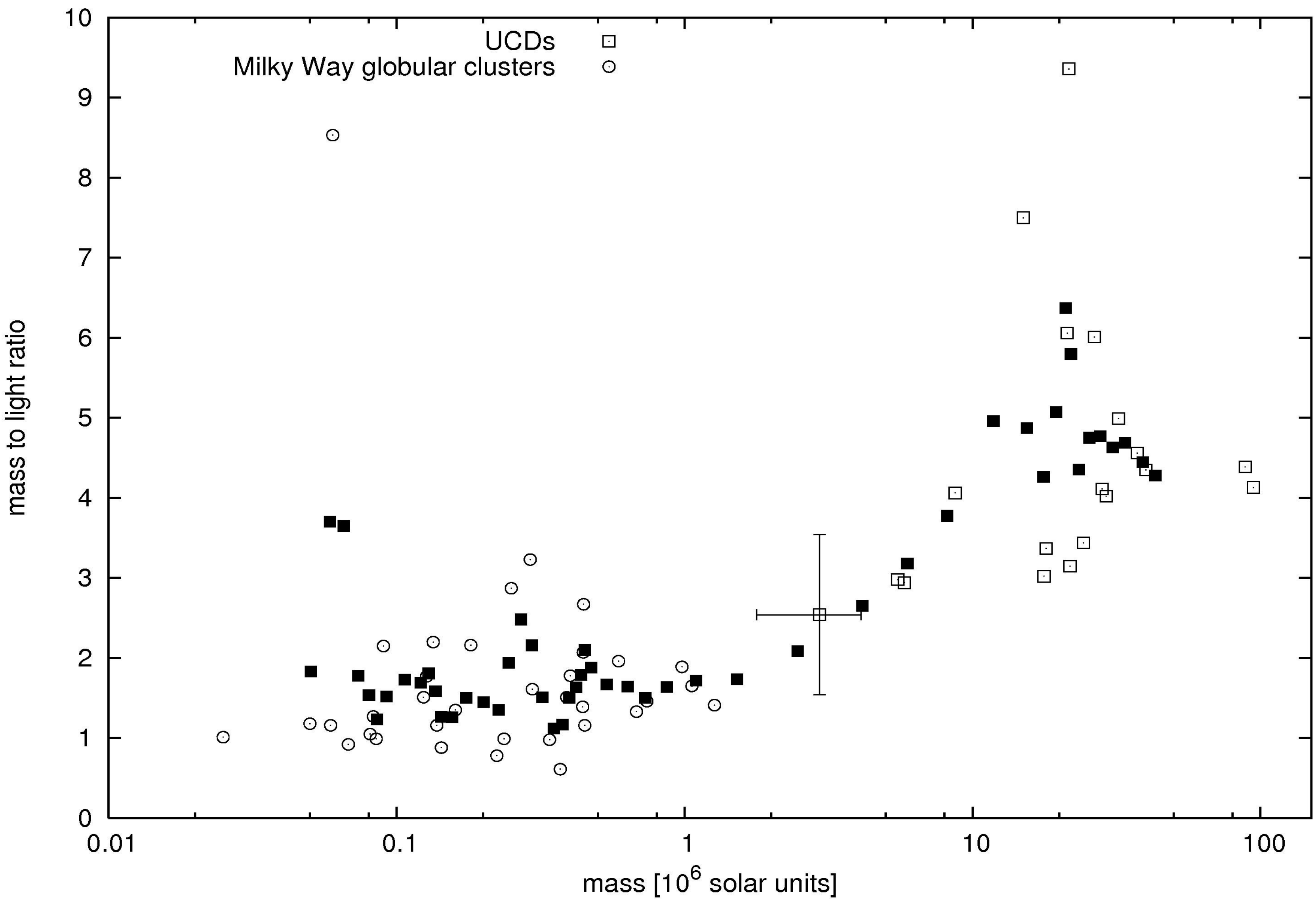


mean relaxation time against mass

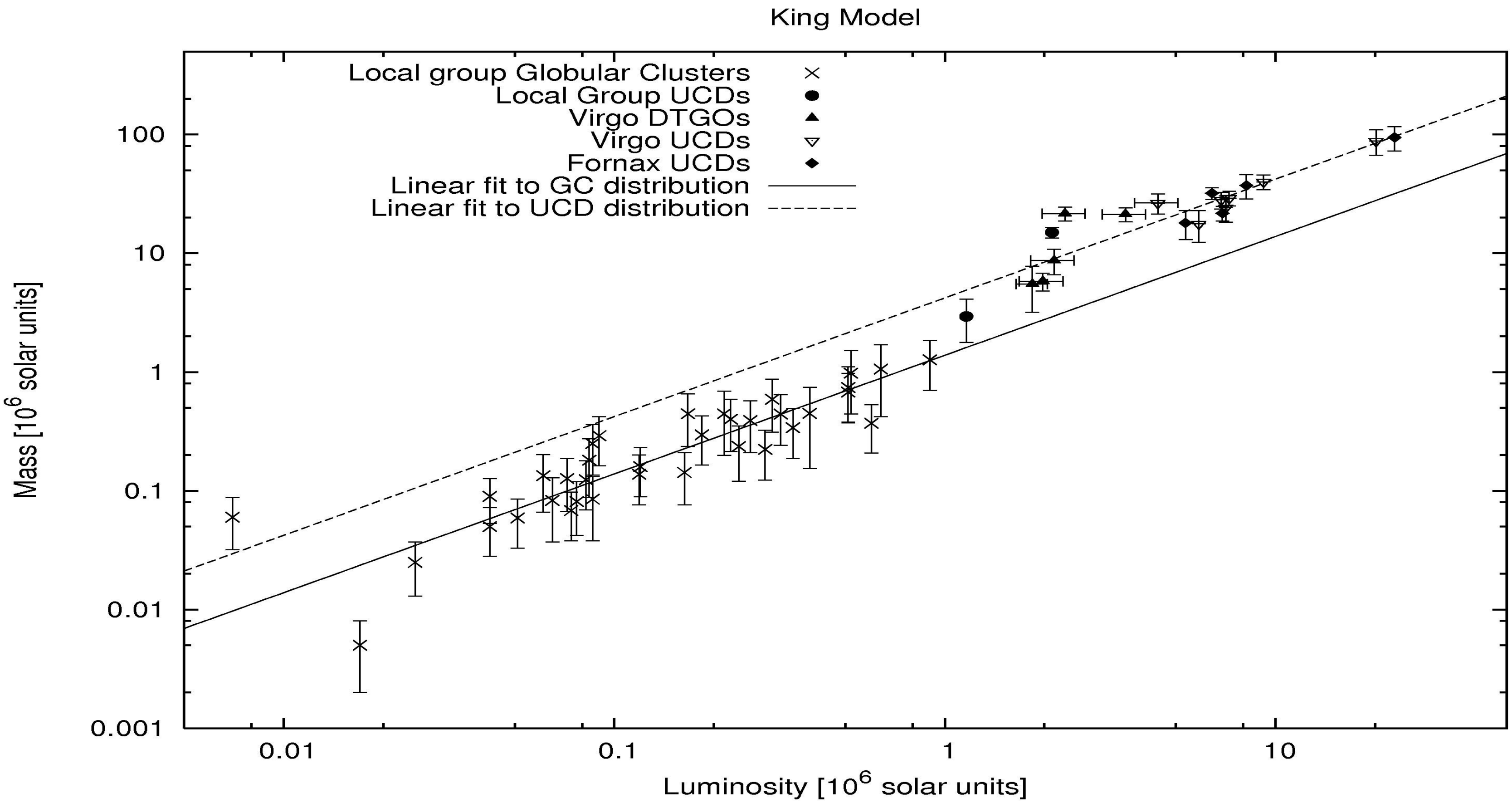


The high mass to light ratio of Ultra Compact Dwarf Galaxies

mass to light ratio against mass



mass against luminosity



- linear fit to globular cluster distribution: $M = (1.38 \pm 0.07)L$
- linear fit to UCD distribution: $M = (4.22 \pm 0.14)L$

Explanations for the high mass to light ratio in Ultra Compact Dwarf Galaxies

a) metallicity or dark matter

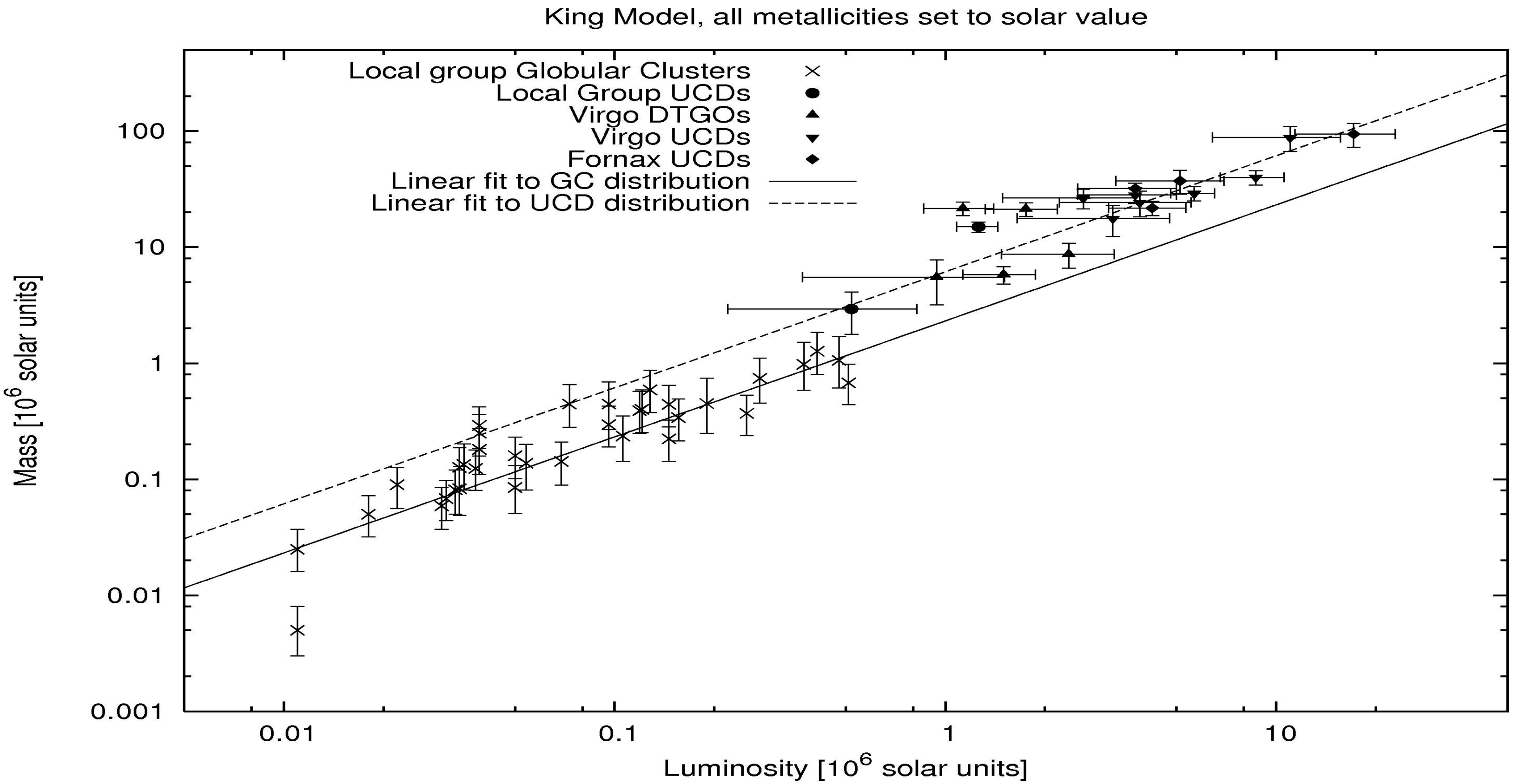
- dark matter: possible, but typical formation scenarios suggest dark matter free UCDs.

- metallicity: Not yet known well enough to exclude this possibility.

Finding the metallicity dependency of the mass to light ratio

1) Find a dependency between luminosity and metallicity of a simple stellar population at a given age (e.g. in Maraston 2005).
2) Fit a simple funtion to the data points.
3) Use the luminosity-metallicity relation to calculate the luminosity the objects would have, if they all had the same metallicity.

mass against luminosity (normalised)



- linear fit to globular cluster distribution: $M=(2.32\pm 0.14)L$
- linear fit to UCD distribution: $M=(6.15\pm 0.365)L$

b) stellar mass functions with a large population of intermediate or high mass stars

Remember the high age of UCDs:

Top-heavy IMFs will lead to lots of stellar remnants (i.e. nonluminous matter).

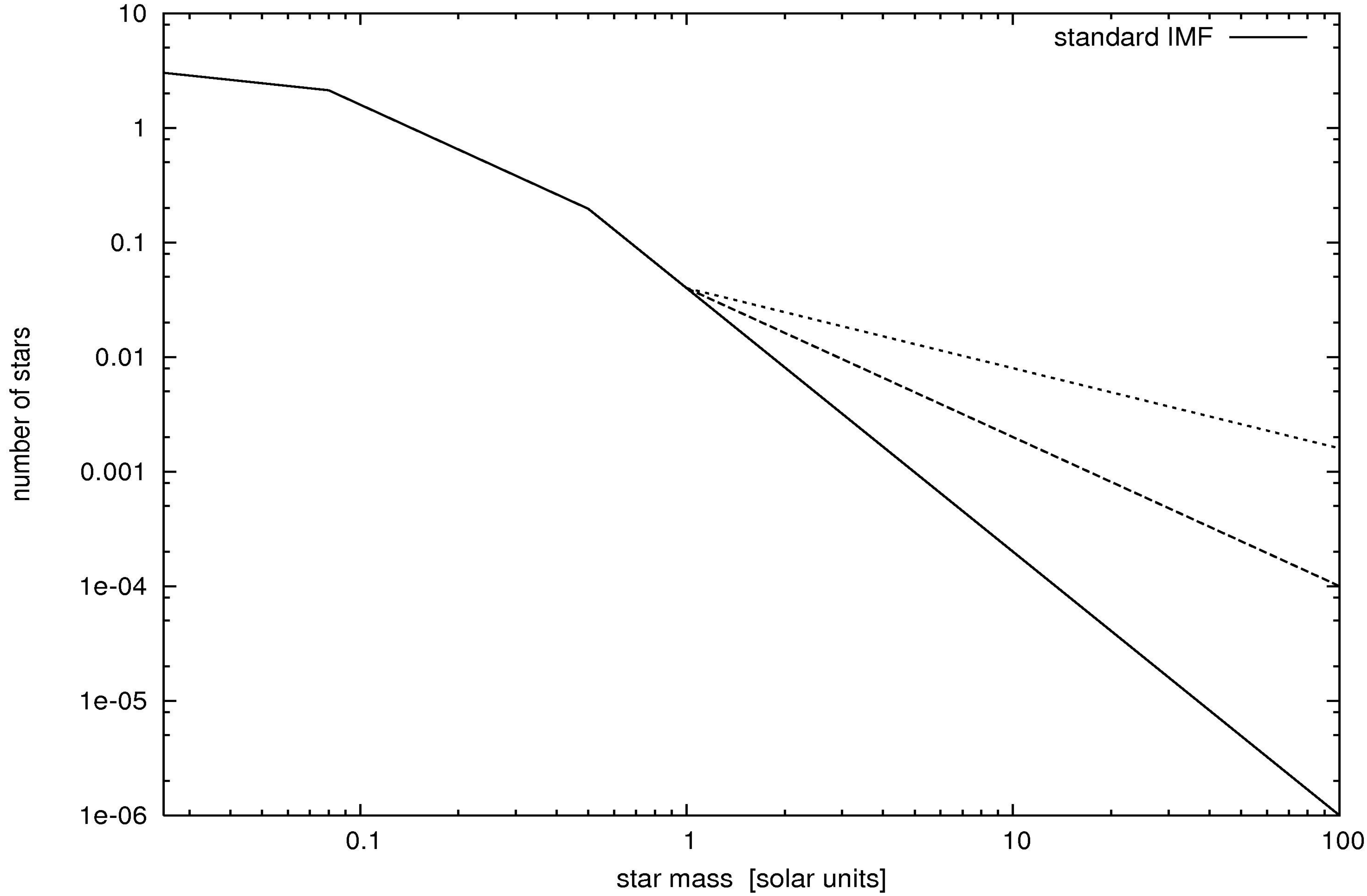
Method:

1) Formulate a model for a stellar population that depends on one or more parameters.

2) Formulate how mass and luminosity of that population depend on the parameters. (After 13 Gyr of stellar evolution).

3) Find sets of parameters such that mass and luminosity of the model population agree with the observations.

A simple model



Working it out...

- Find solutions for the equation

$$\frac{m(\alpha, \ldots)}{l(\alpha, \ldots)} - \frac{M}{L} = 0$$

- m depends on the remnants retained in the UCD and the slope α of the high mass IMF.
- l is constant in this case.

Working it out...

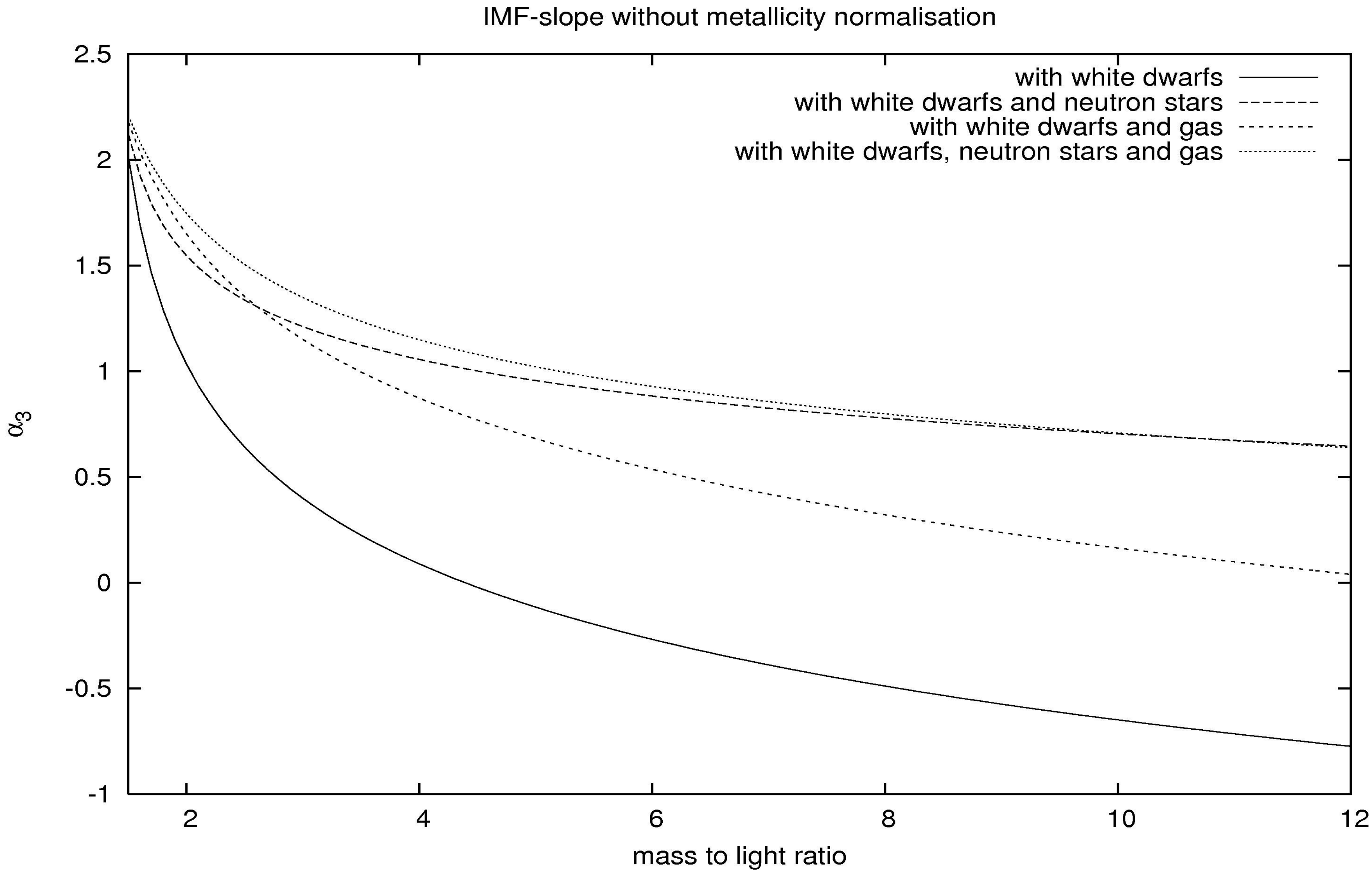
- secondary condition

$$\frac{m(\alpha=2.3)}{l}-1.44=0$$

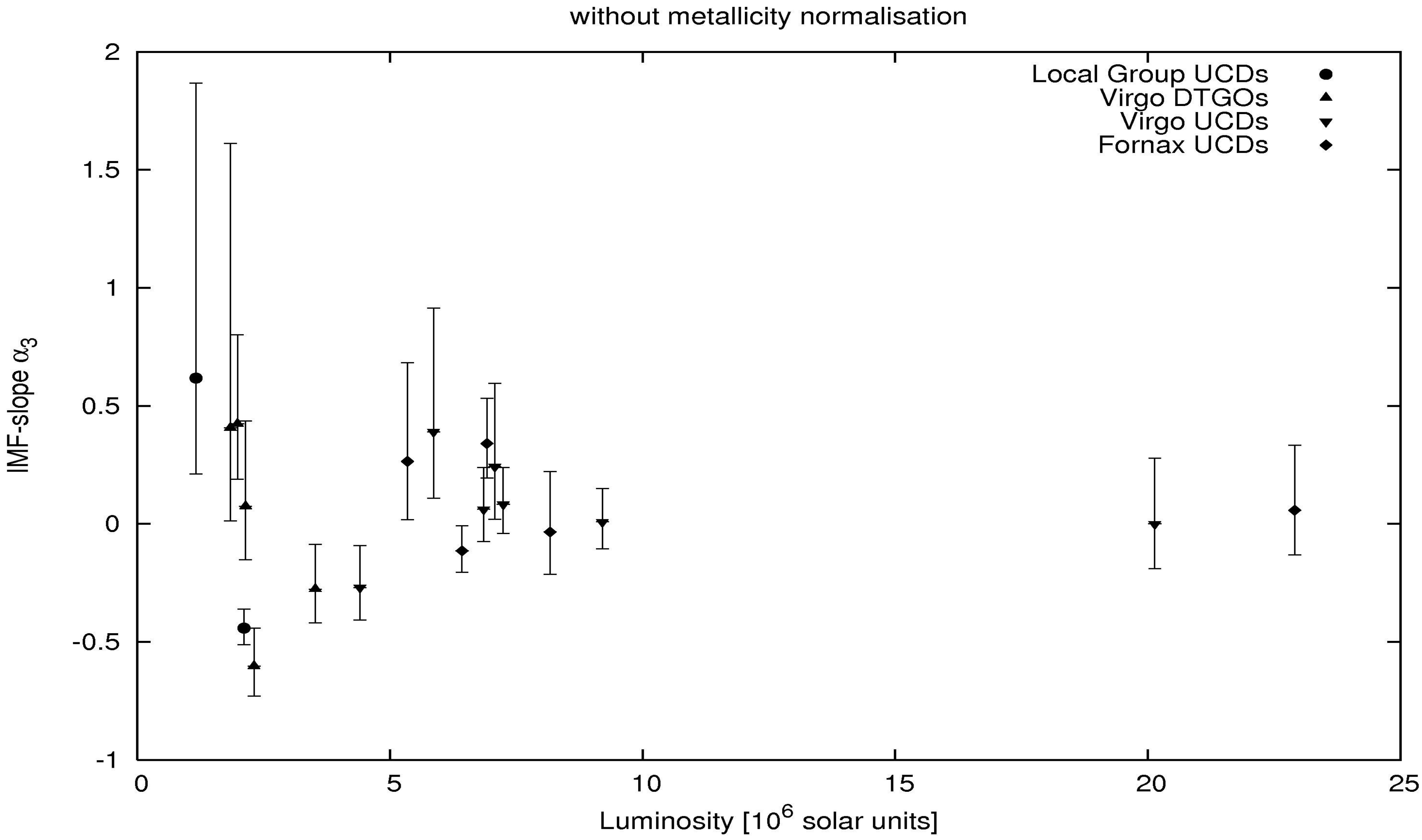
leads to single solution for given mass to light ratio and remnant population.

- Note that the method is thereby calibrated with the mean mass to light ratio of globular clusters, but it might fail when applied to a particular globular cluster.

Dependency of the high mass IMF-slope on the mass to light ratio



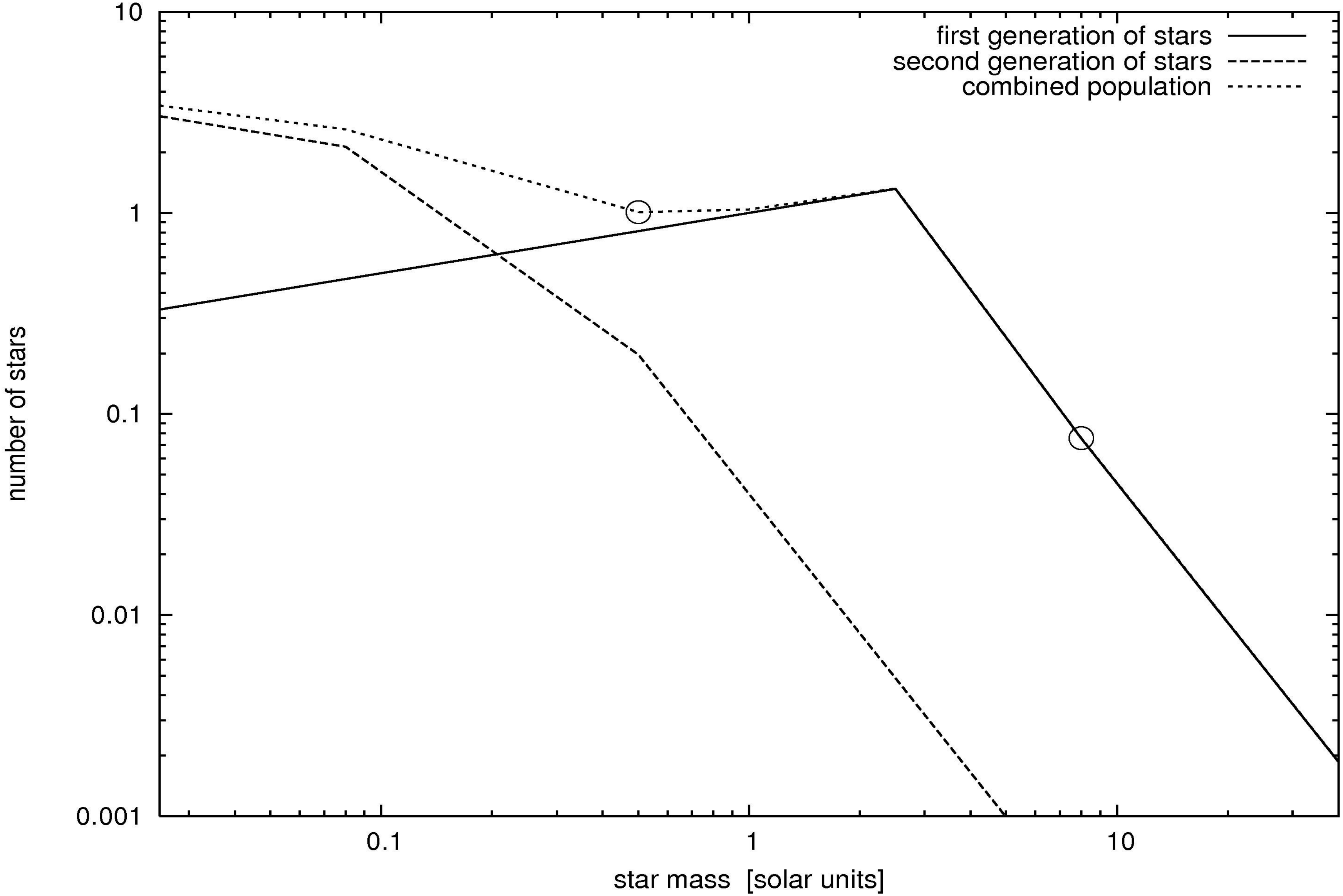
high mass IMF-slope of the model population for observed UCDs, remnant population: white dwarfs only



We are facing a problem within this model: the stability of the stellar systems is questionable for the obtained high mass IMF slopes.

Therefore we now move on to a more complicated model based on and inspired by the work of D'Antona, Mazzitelli and Caloi.

The more complicated model



Working it out...

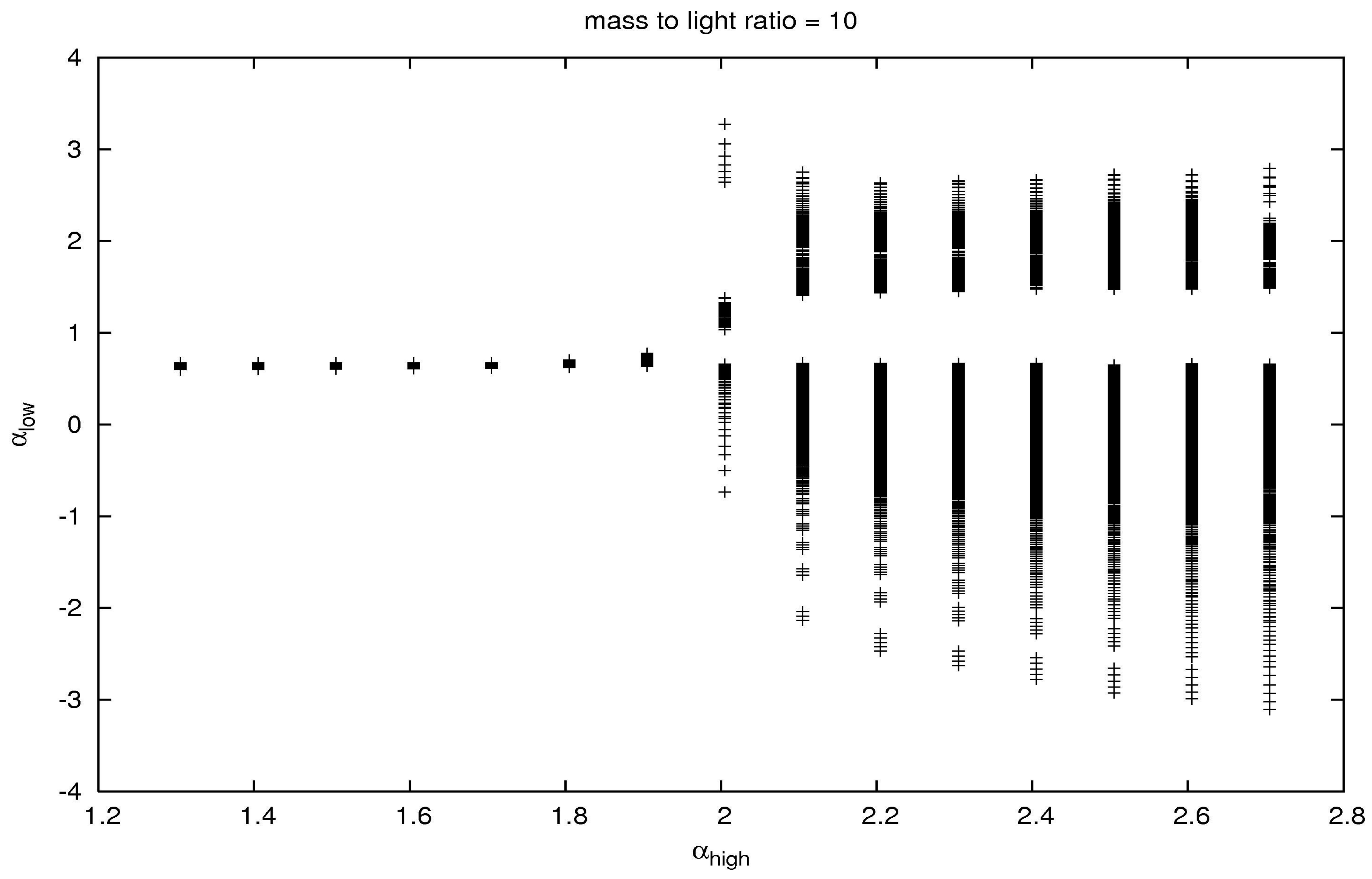
- Again, we have to solve

$$\frac{m(\alpha, \ldots)}{l(\alpha, \ldots)} - \frac{M}{L} = 0$$

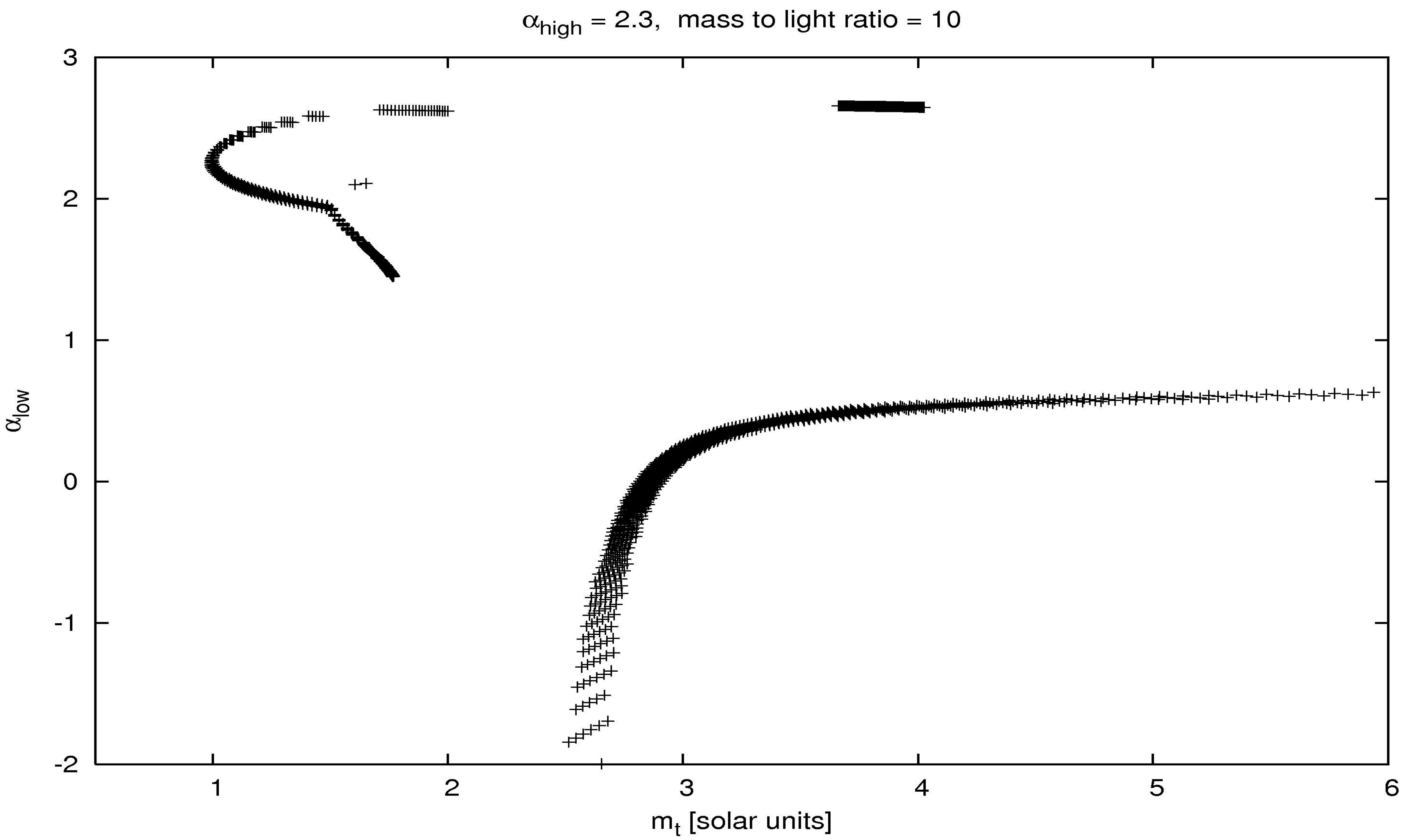
under a number of secondary conditions.

- For a given mass to light ratio, we try different numbers of stars at two fixed star masses as well as different high mass slopes and check for a solution.

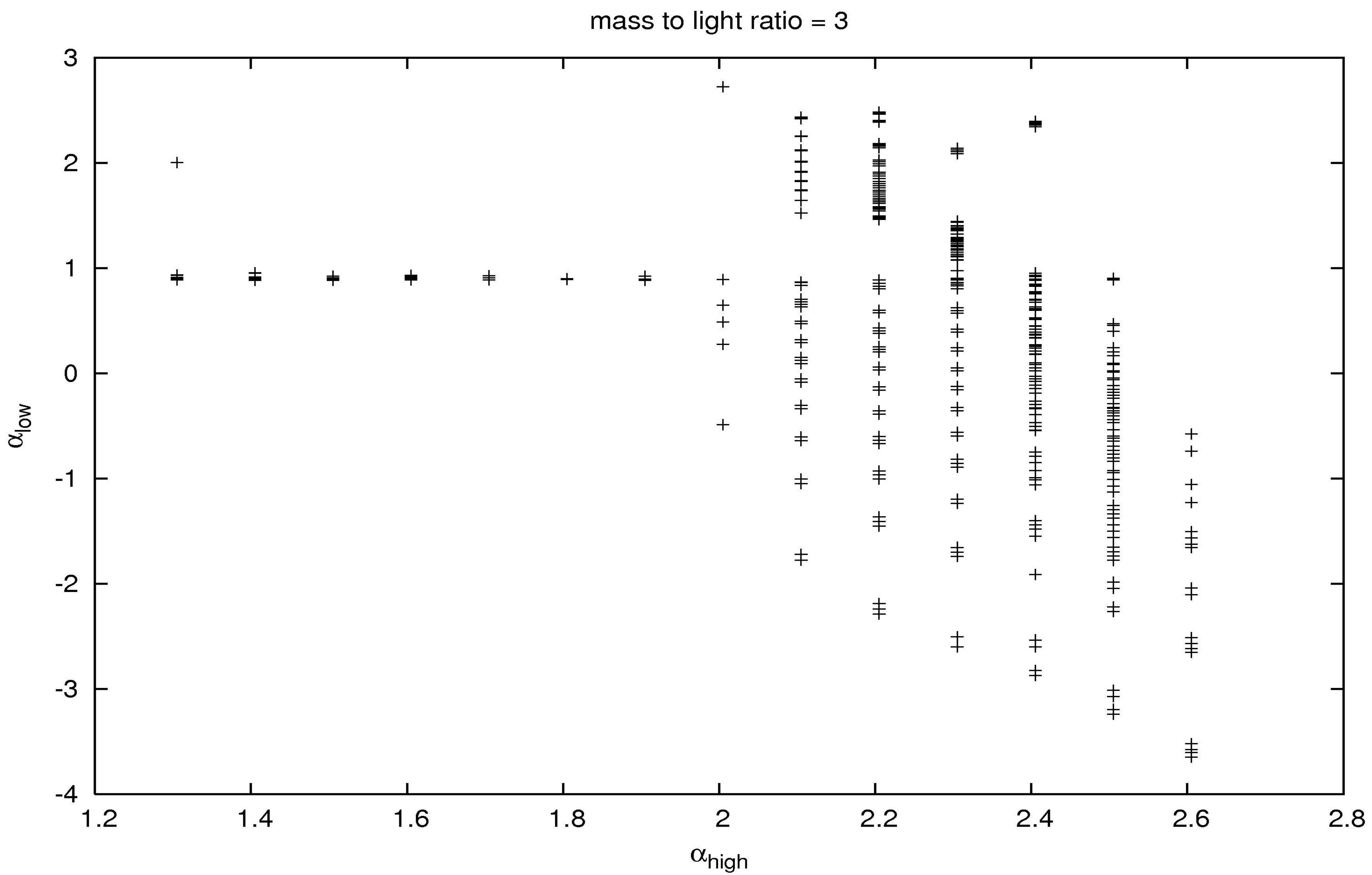
possible IMF-slopes for the first population of stars at a mass to light ration of 10



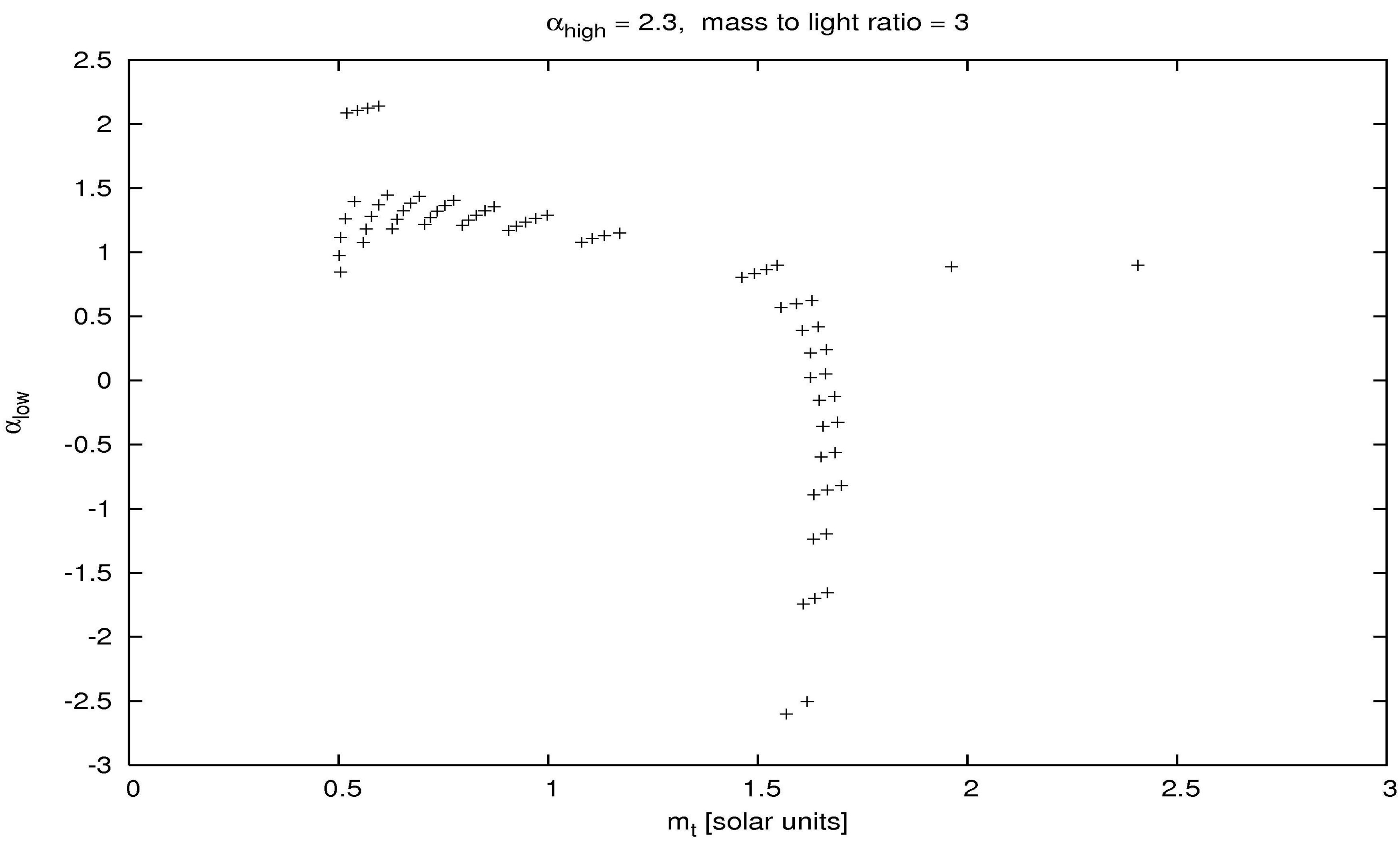
Low mass IMF-slope of the first population of stars against transition mass at a mass to light ratio of 10



possible IMF-slopes of the first population of stars at a mass to light ratio of 3



Low mass IMF-slope of the first population of stars against transition mass at a mass to light ratio of 3



Conclusions

- UCDs are a new type of stellar systems (although possible related to other, better known ones).
- UCDs have an enhanced mass to light ratio.
- models of stellar populations explaining the high mass to light ratio can be constructed.

Thank you for your attention