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Astrocladistics: Sixteen Years Later

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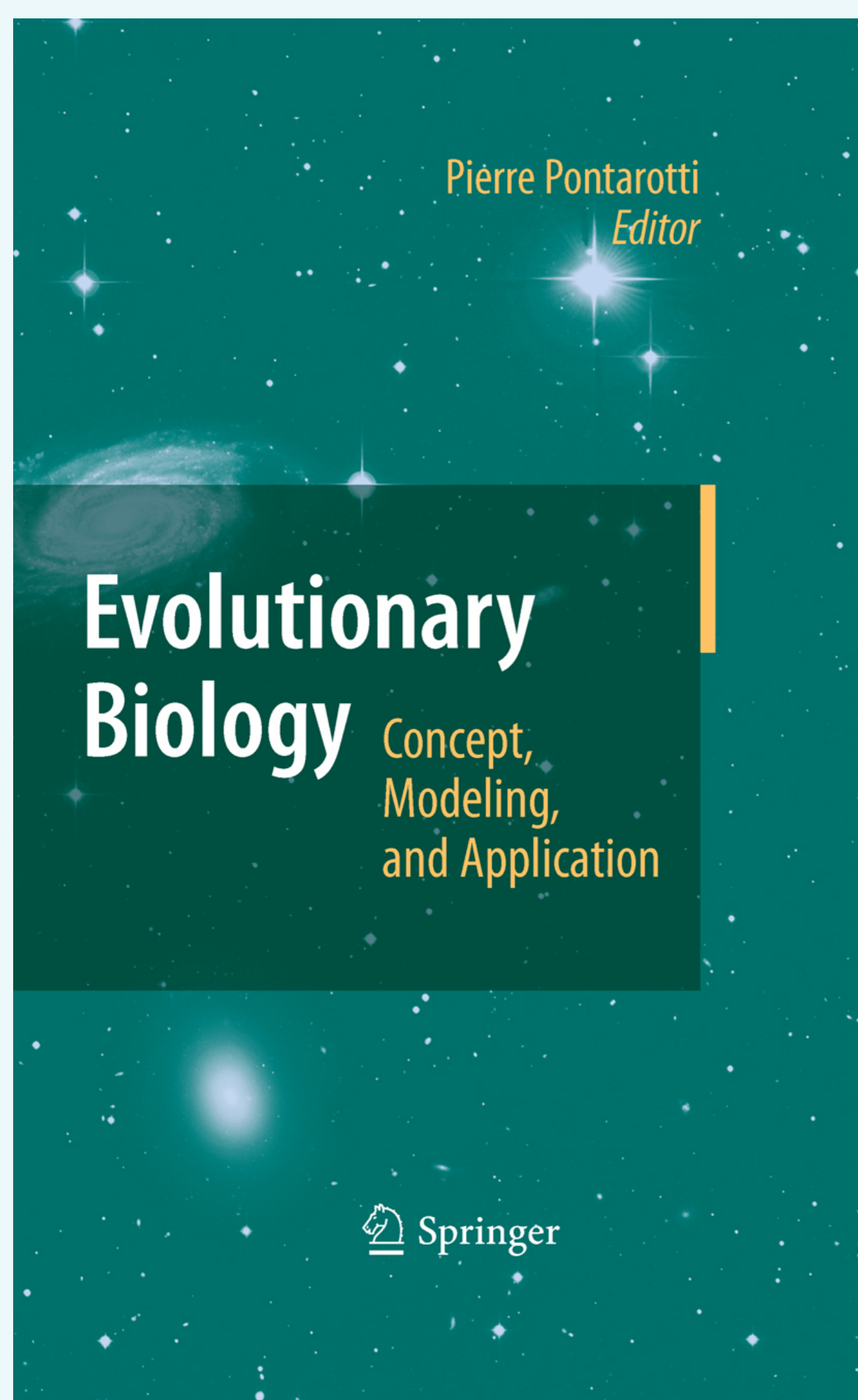
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Abstract

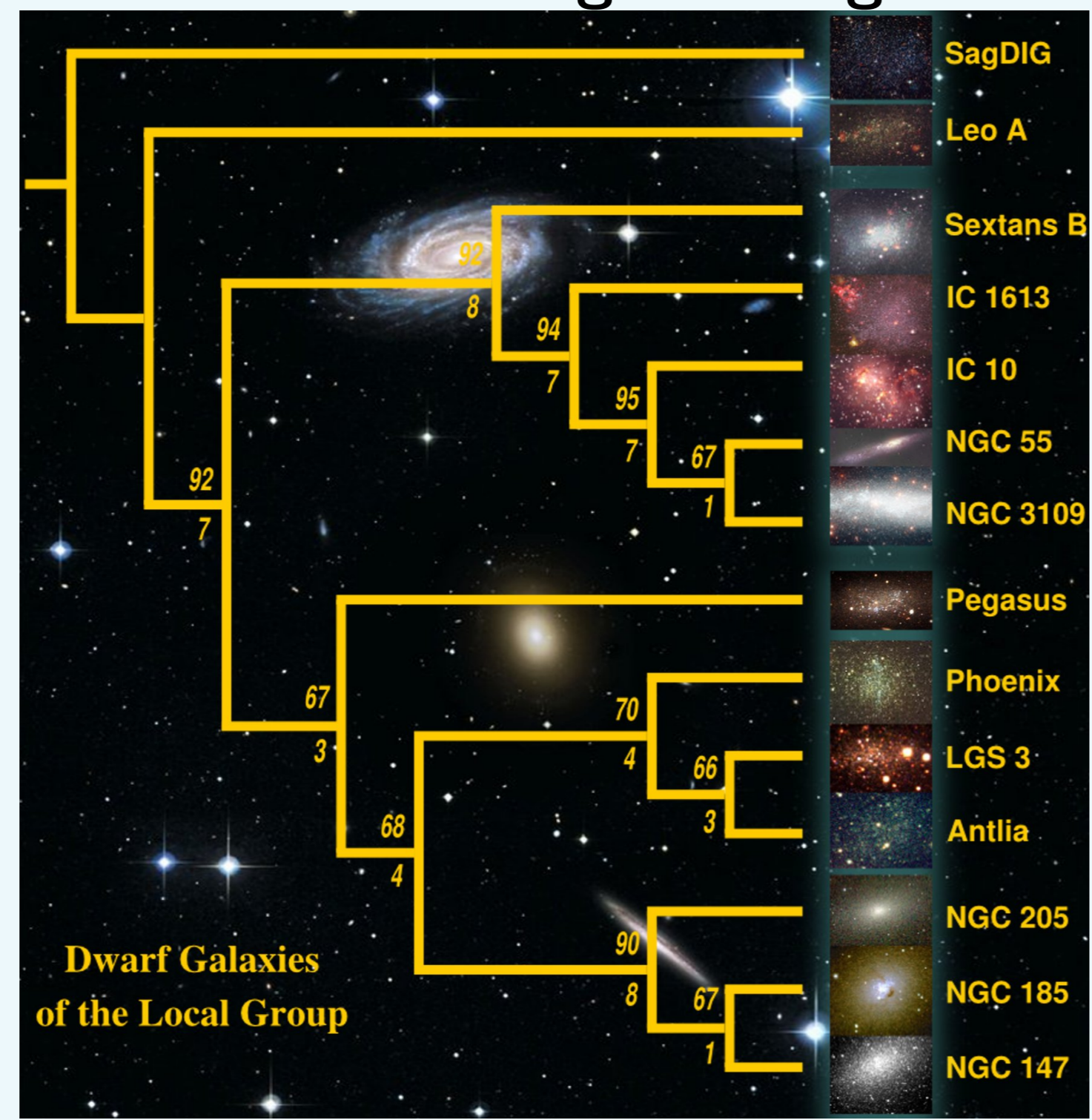
The introduction of phylogenetic tools in astrophysics started in 2001 and was presented in 2008 at the 12th Evolutionary Biology Meeting at Marseille. Many results have been obtained, essentially using Maximum Parsimony (cladistics), covering very diverse kinds of objects of the Universe : galaxies, dwarfs galaxies, gamma ray bursts, globular clusters, stellar populations, stars, jovian satellites, supernovae. These successes open some new challenges for astrocladistics.

Achievements



2008 session of the Marseille conference

First cladogram of galaxies



Fraix-Burnet, Choler, Douzery 2006

Challenges and Perspectives

Cladistics and Classification

We are now facing several important questions:

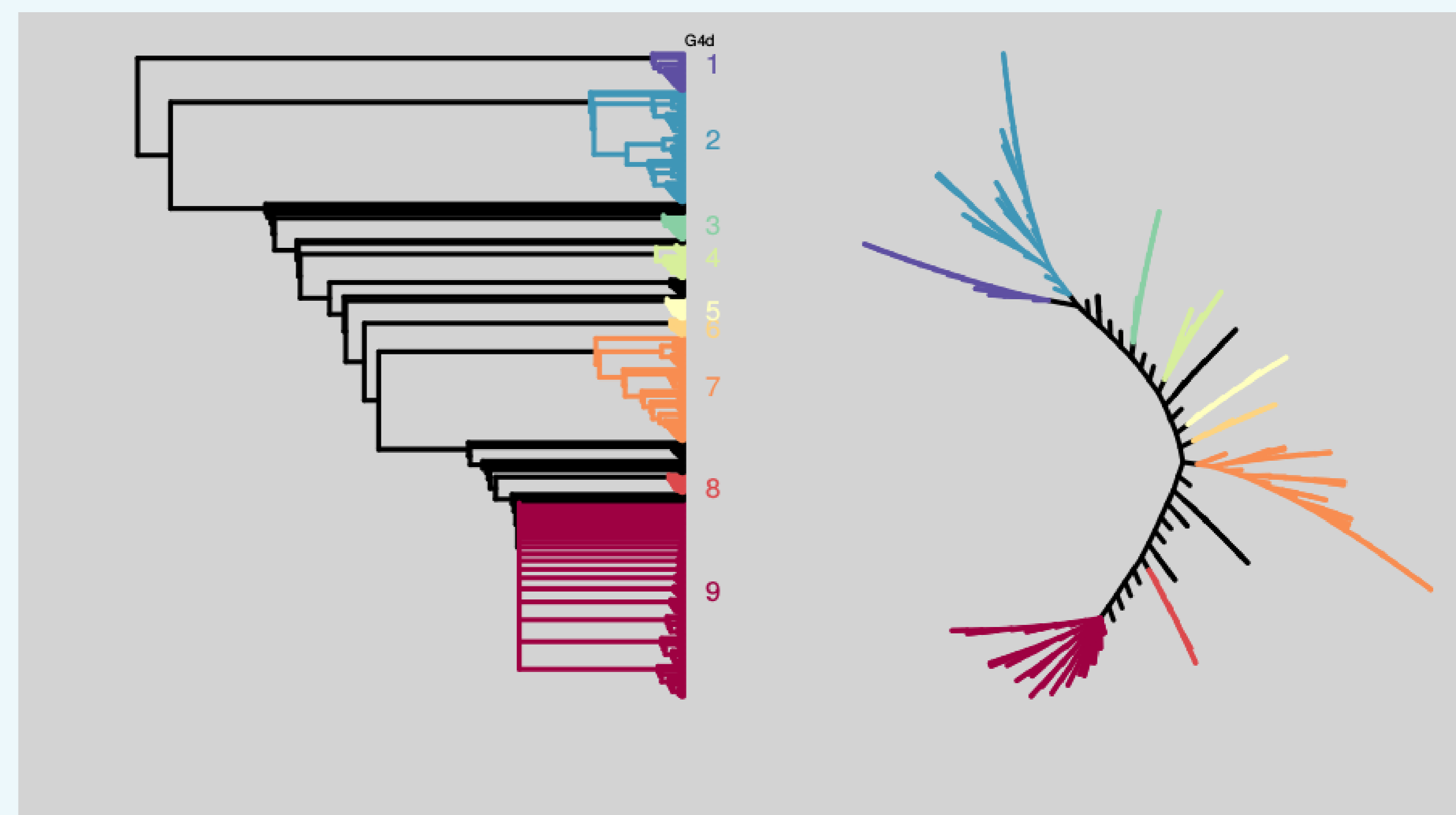
- ▶ how to **synthetise several cladograms** obtained with different traits?
- ▶ distance-based approaches and networks: **which distance?**
- ▶ **phenetic classification** first then cladistics?

The PHYLOCODE project initially inspired us, similar difficulties?

Pre-classification with Hierarchical Clustering

1494 galaxies have been pre-clustered into 300 pre-groups with a **hierarchical clustering method** followed by a **cladistic analysis**.

Eleven parameters are used: *B-V*, *logRe*, *surface brightness*, *Hβ*, *D4000*, *Mass*, *Sersic index n*, *Hα+NII*, *Gband*, *Mg* and *Na*.

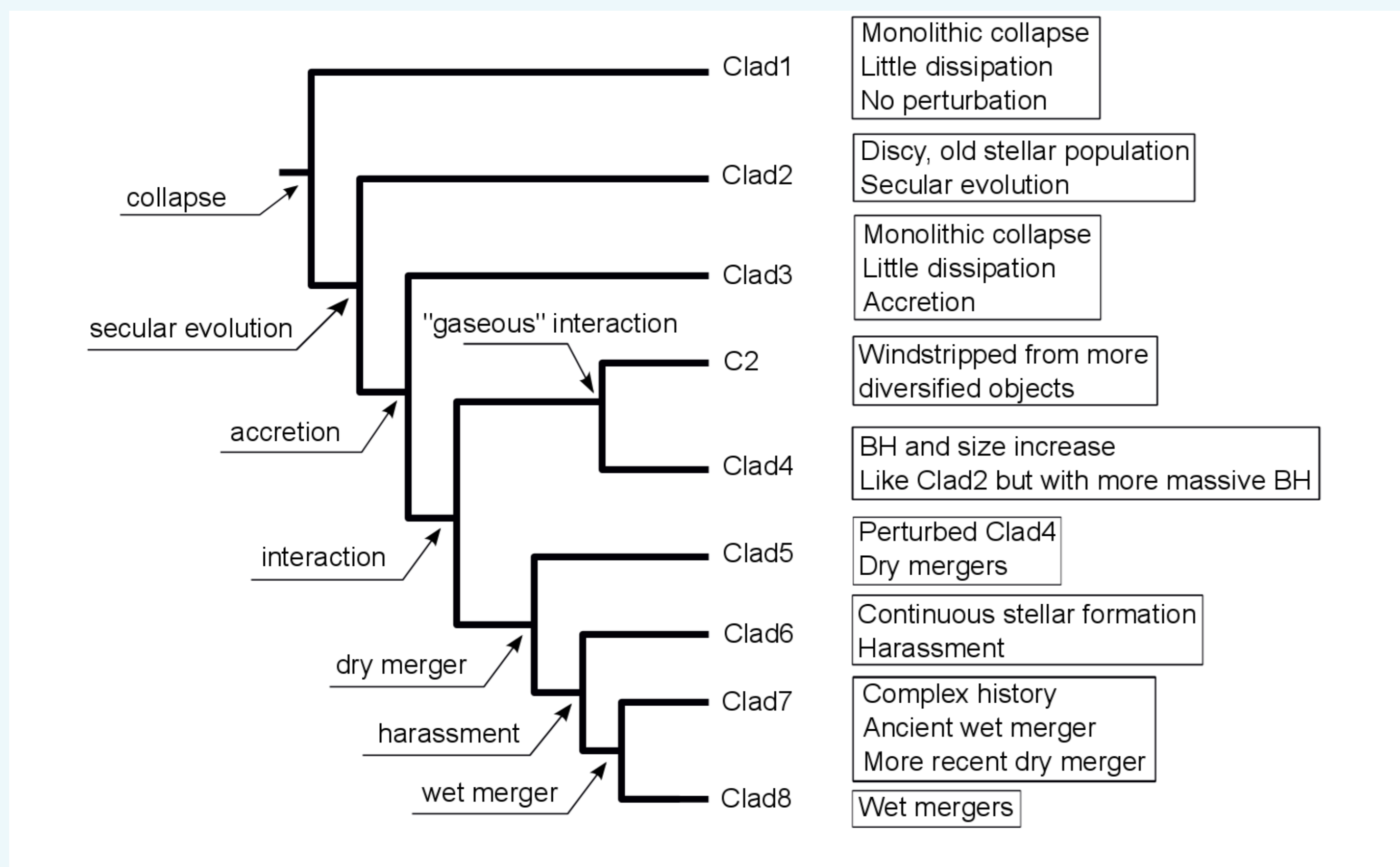


Most parsimonious tree on the 300 "pre-groups" (leaves). The nine groups ("clades") shown in colour are the larger ones with more than 30 galaxies.

Some results on galaxies

Initial motivation: renewal of the classification of galaxies.

First "general" multivariate classification of (≈1000) galaxies:

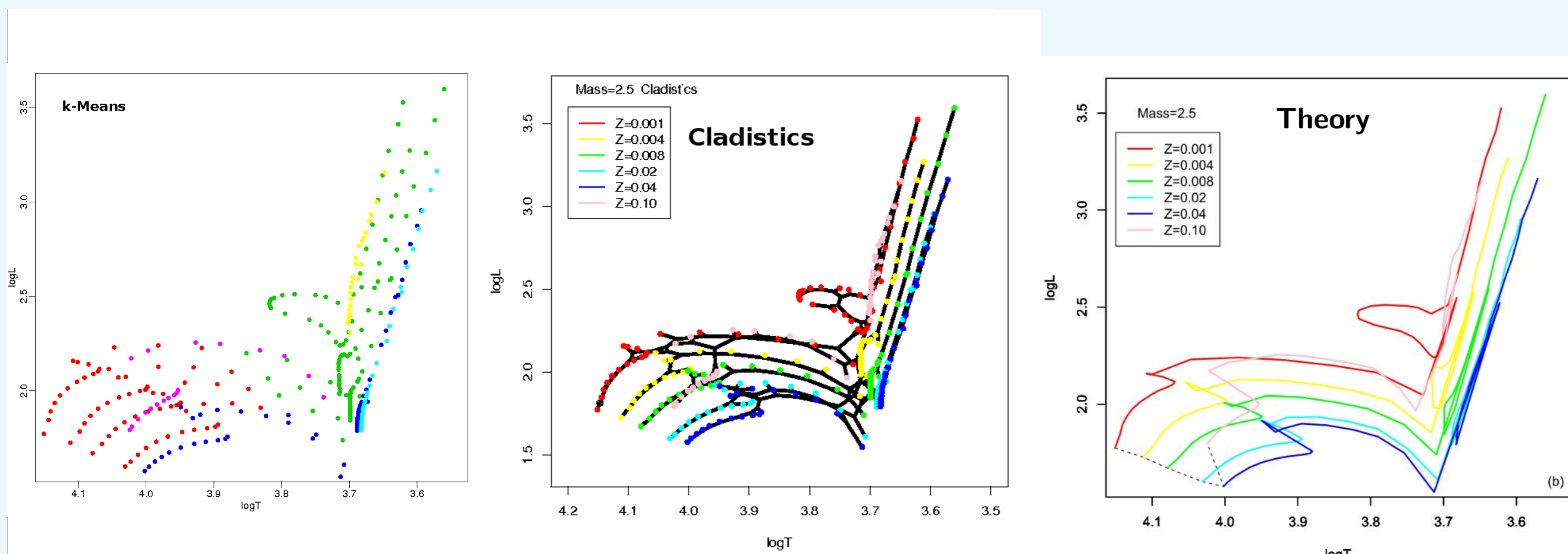


Fraix-Burnet et al 2012

But this is only for 1000 galaxies...

Why it works

Demonstration with the **evolutionary tracks of stellar evolution** using 11 parameters (traits).



Only phylogenetic tools like cladistics are able to reconstruct the families of stars related by evolution! This problem is called the **chemical tagging of stars**.

Many applications in astrophysics

- ▶ More than **16 papers** by our team
- ▶ 2 papers and 2 posters by four other teams

A blog: <https://astrocladistics.org/>



Conclusion

- ▶ Phylogenetic tools: marvelous techniques to **reconstruct evolutionary paths**, whatever the nature of evolution.
- ▶ Great **success in astrophysics**, more and more applications.
- ▶ **Connections with physical models** to be improved.
- ▶ **Still no multivariate classification of galaxies**.
- ▶ **Networks** better suited to represent galaxy diversification?