Astrocladistics: Sixteen Years Later
Didier Fraix-Burnet

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Astrocladistics: Sixteen Years Later
Didier Fraix-Burnet
Univ. Grenoble Alpes, CNRS, IPAG, 38000 Grenoble, France (didier.fraix-burnet@univ-grenoble-alpes.fr)
http://ipag.osug.fr/public/fraixbud/

Abstract

The introduction of phylogenetic tools in astrophysics started in 2001 and was presented in 2008 at the 12th Evolutionary Biology Meeting at Marseilles. 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

Some results on galaxies

Initial motivation: renewal of the classification of galaxies.

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

- Monolithic collapse
- Little dispersion
- No perturbation

- Occasional collapse
- Stellar population
- Secular evolution

- Monolithic collapse
- Little dispersion
- Accretion

- Winds stripped from more
- Dwarfs or more

- BrH and BrII interaction
- Like Clad2 but with more mass
- Mass increase

- Turned off
- Dry mergers

- Continuous star formation
- Harassment

- Complex history
- Ancient wet merger
- More recent dry mergers

- Wet mergers

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/

Challenges and Perspectives

Cladistics and Classification

We are now facing several important questions:

- how to synthesise 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, HzJ, 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 properties of the nine main groups.

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?