Building bridges between stars and galaxies

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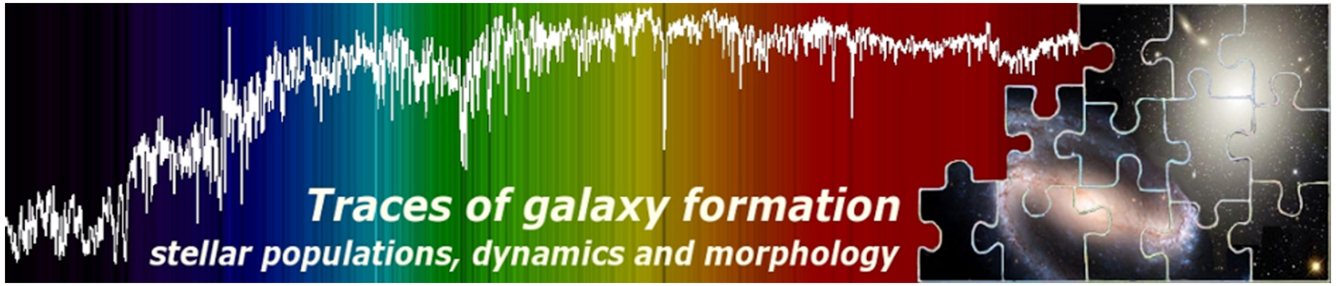
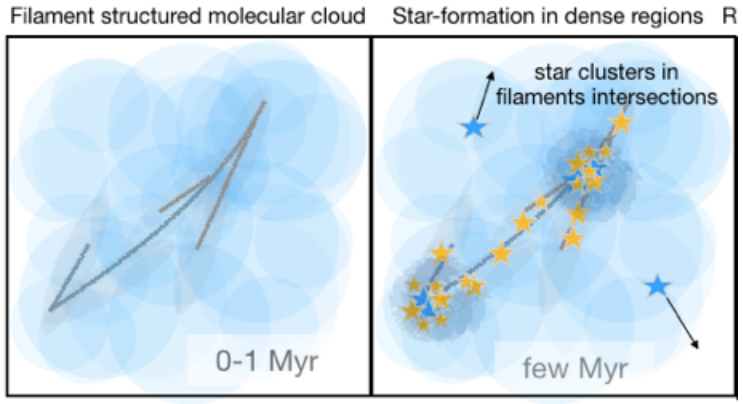
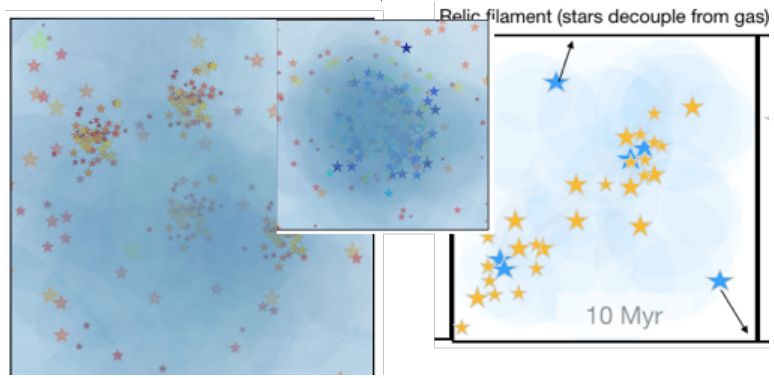


We use empirical constraints on star-formation on sub-pc scales to build-up stellar populations in galaxies.
This approach presents a link allowing to interpret galaxy-wide stellar populations in terms of individual star-forming regions. It has also the potential to constrain the physics of star-formation in distant galaxies where individual stars cannot be resolved. We developed the freely accessible code, GalIMF, that can compute and evolve stellar populations in galaxies on a star-by-star basis and self-consistently accounts for chemical enrichment. We used GalIMF to compute stellar populations in star-clusters, to understand the effect of star-formation and metallicity on the galaxy-wide stellar initial mass function in early type and ultra-faint galaxies. Recently, we applied these results to compute the cosmic star-formation rate density as based on the empirically driven variable stellar initial mass function on the embedded-cluster scale. The production of E-MILES spectra with the thusly computed galaxy-wide stellar initial mass function is in progress, will open new means of comparison with data and thus constrain the physics of star-formation and build-up of stellar populations in galaxies across cosmic time.

Stars form in embedded star-clusters within the filamentary network of dense gas (Herschel, ALMA)Lada&Lada(2003, embdeed cluster is a dense group of 35 stars), Andre+(2014), Andre+(2019), Hacar+(2017,2018)

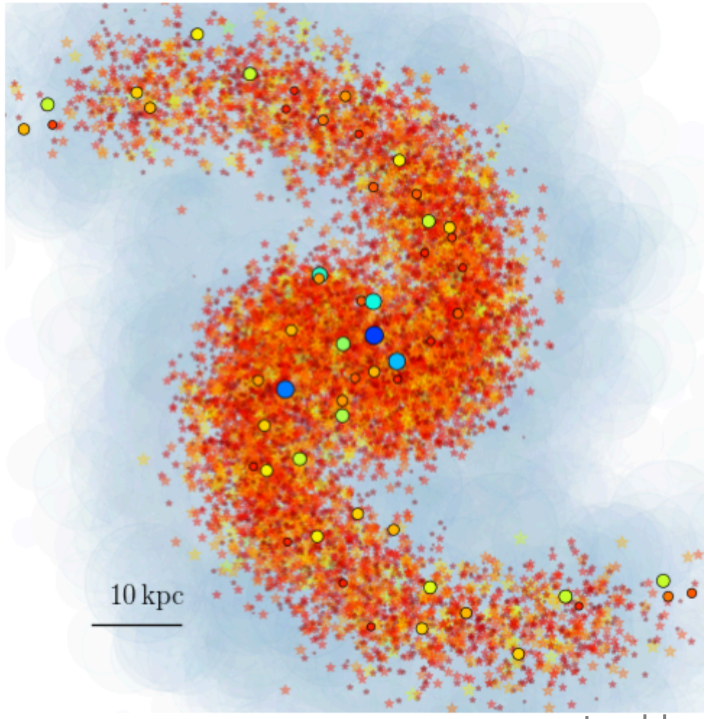




stellar feedback
stellar dynamics
stellar evolution
gas expulsion
tides and shears

“Naked” producs of star formation: star clusters, associations, relic stellar filaments in a process of dissolution into a g(G)alactic field

Jerabkova+(2019a,2019b), Beccari+(2019,2020), Pfalzner+(2019), Kuhn+(2019)



Jerabkova+2018

The physics driving star-formation is bound to sub-pc scales (dense regions of molecular clouds). These regions are forming, dissolving and becoming the galactic field over the SFH of a galaxy.

The IGIMF theory considers individual star-forming regions and links them to the observed (unresolved) galaxy-wide stellar populations.

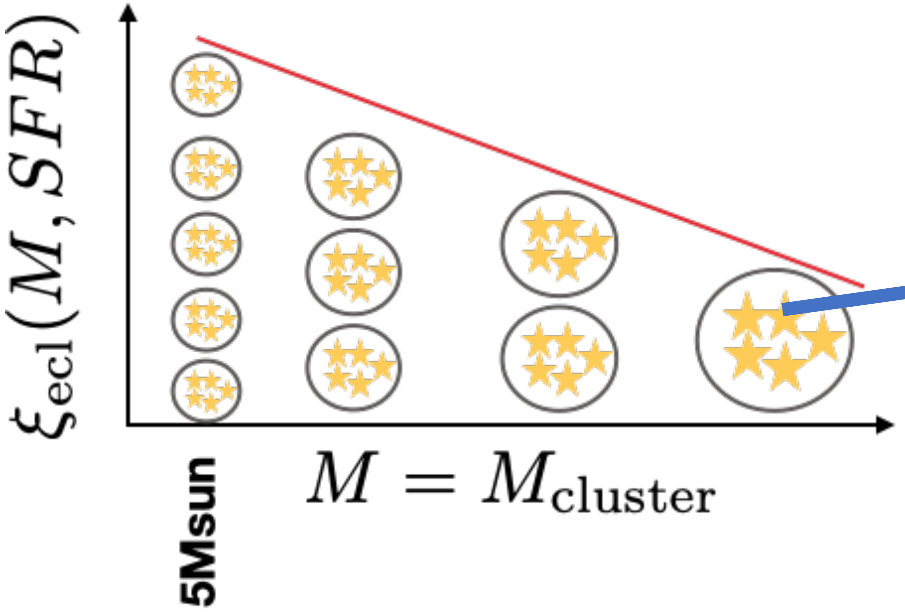
To connect star forming regions to observed galaxy-wide properties one needs to integrate over all star forming regions (spatially) and over time

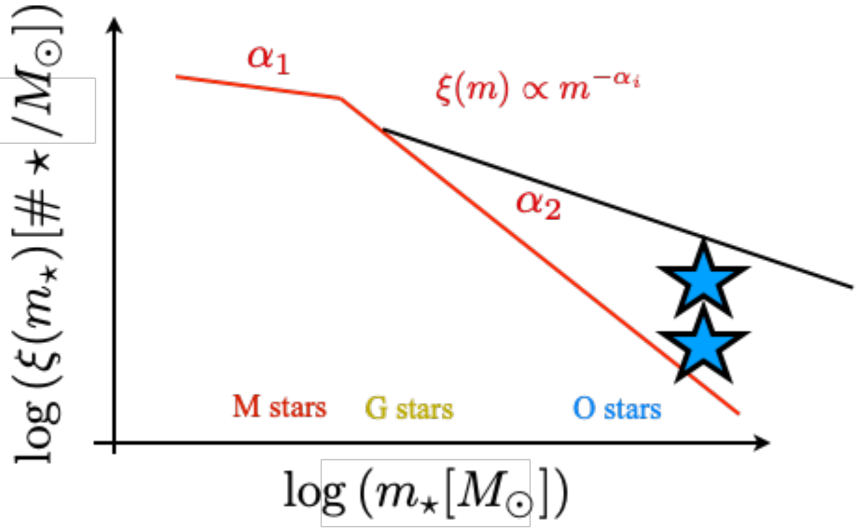
This approach is called the Integrated Galactic Initial Mass Function - the IGIMF - theory

Yan,Jerabkova+(2017,2019ab,2020), Jerabkova+(2018), first formulations: Kroupa & Weidner 2003, Weidner & Kroupa 2006, Weidner+2013

It involves the integration over all new-born stellar populations in each time-step, i.e. the integration over the embedded star clusters mass function which is empirically constrained.

Each embedded star-cluster has an IMF determined by its density and metallicity.





Remember:

The IGIMF theory is a framework that allows us to connect small-scale star formation to the galaxy-wide properties

freely availible GalIMF code: Yan, Jerabkova+(2017,2019,2020), https://github.com/Azeret/galIMF

Using current observational constraints on star formation it predicts:

Top-heavy galaxy-wide IMF at high SFR (star-formation rate): high redshift conditions e.g. Zhang+(Nat,2018)

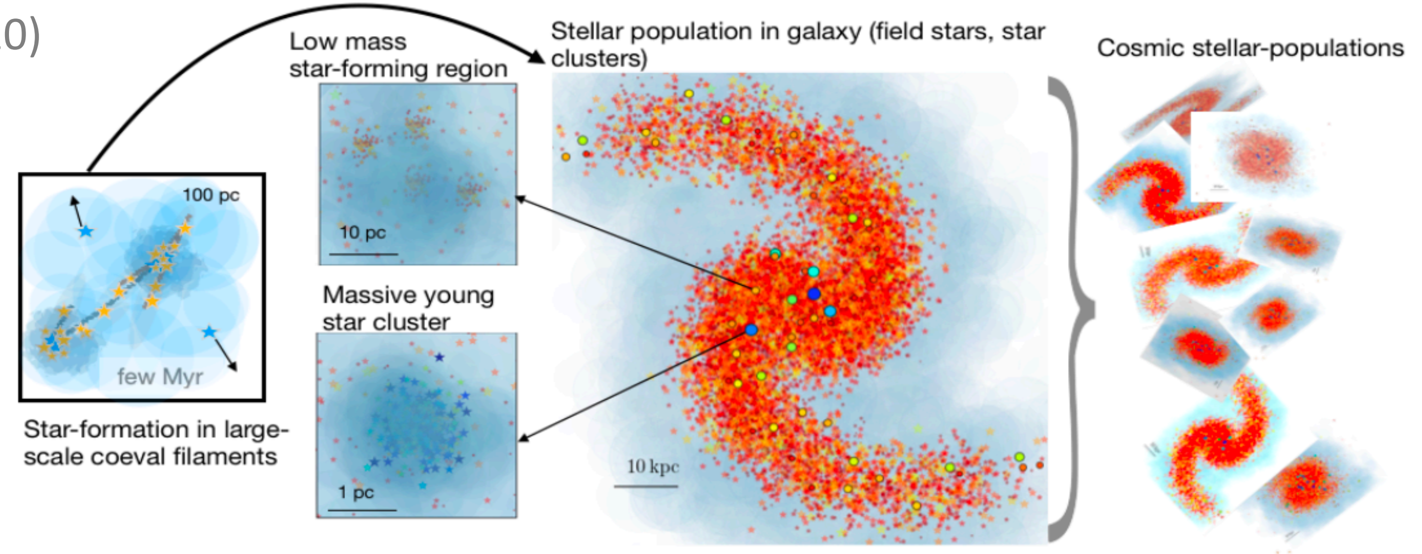
Bottom-heavy galaxy-wide IMF at super-Solar Z: bottom heavy phase in early-type galaxies once metal content is built up e.g. Martin-Navarro+(A&A,2019)

Top-light gwIMF at low SFR: dwarf galaxies, low SFR galaxies in general e.g. Watts+(MNRAS,2018)

The combination of these effects is reflected on the cosmic SFR density:

lower SFR density at high-z and higher fraction of metal poor stars in the IGIMF theory in comparison to the universal IMF

First such a study: Chruslinska, Jerabkova+(2020)

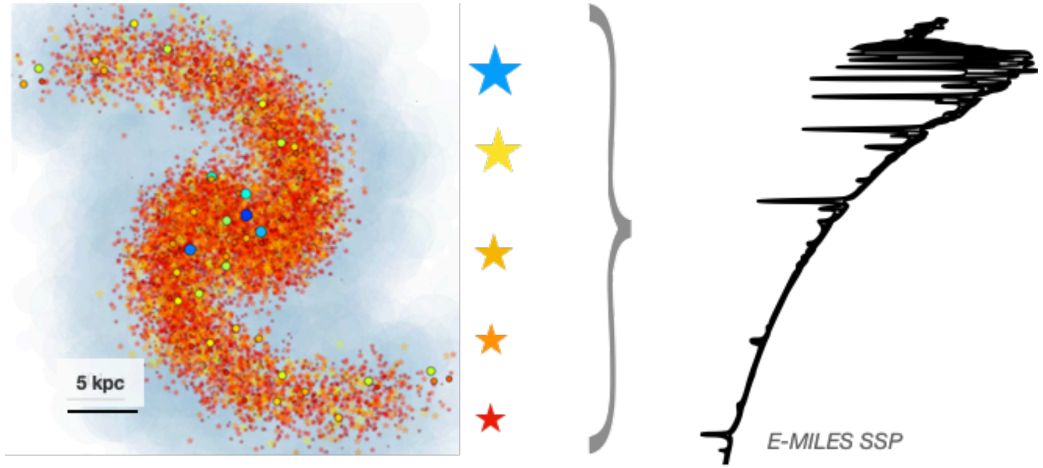


Excellent agreement with present day data!

How about the comparison with stellar populations in terms of photometry/spectroscopy?

The GalIMF code computes the build-up of stellar populations in galaxies with self-consistent chemical evolution and a given star-formation history. The code output is the galaxy-wide initial mass function and chemical element abundances.

The combination of the GalIMF code with the E-MILES spectra library will allow a direct comparison of simulated stellar populations with observed photometric and spectrocopic data! Rodríguez Beltrán + (in prep.)



From Jerabkova+(2018)

Take away:

The IGIMF theory is a framework that allows us to connect small-scale star formation to galaxy-wide properties.
Freely availible GalIMF code : Yan,Jerabkova+(2017,2019,2020)

The IGIMF theory uses empirically driven constraints to compute stellar populations in star clusters, galaxies and on cosmic scales.

Jerabkova+2017; Bekki,Jerabkova+(2017); Yan,Jerabkova+(2017); Jerabkova+(2018); Kroupa,Jerabkova+(2018); Yan,Jerabkova+(2019ab);Yan,Jerabkova+(2020); Chruslinska,Jerabkova+(2020)

For a discussion on the nature and variability of the stellar initial mass function have a look at ESO's Cosmic Duologue: https://www.youtube.com/watch?v=6Bigzy3qji4&t=2392s *(speakers: Tereza Jerabkova & Andrew Hopkins)*