ARC 2021 Poster Competition

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Understanding the Evolution of Galaxies from 6 billion years old Universe: Connecting Past to Present

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Timeline of our Universe

TODAY (DEAD GALAXIES)

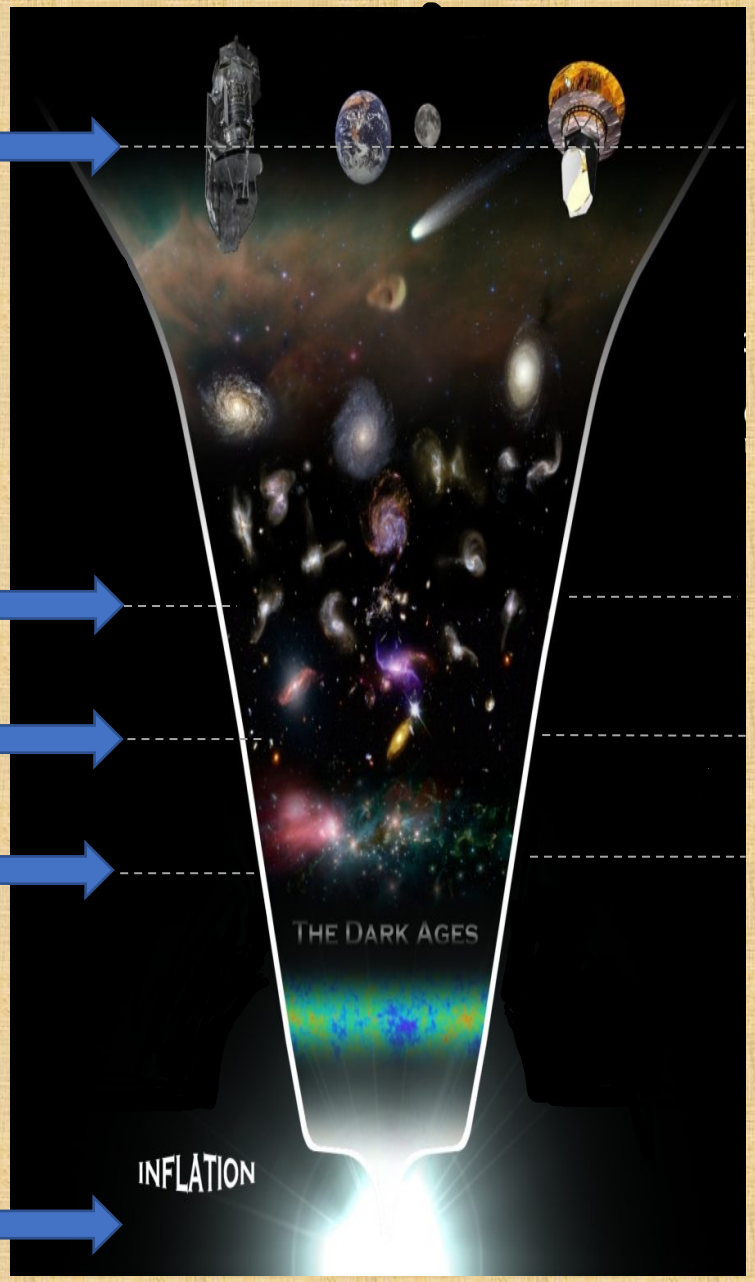
(ALIVE GALAXIES)

OUR SAMPLE

FIRST GALAXIES

FIRST STARS

BIG BANG



13.8 Billion Years

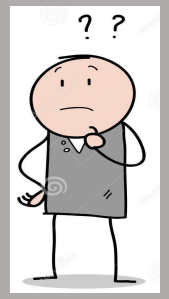
6 BYr

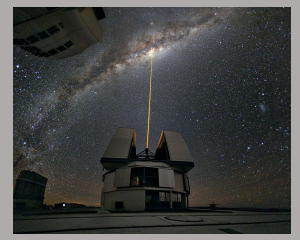
1 BYr

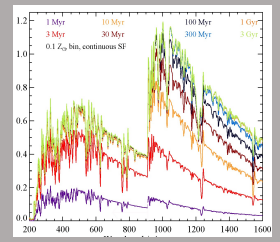
400 MYr

Time = 0

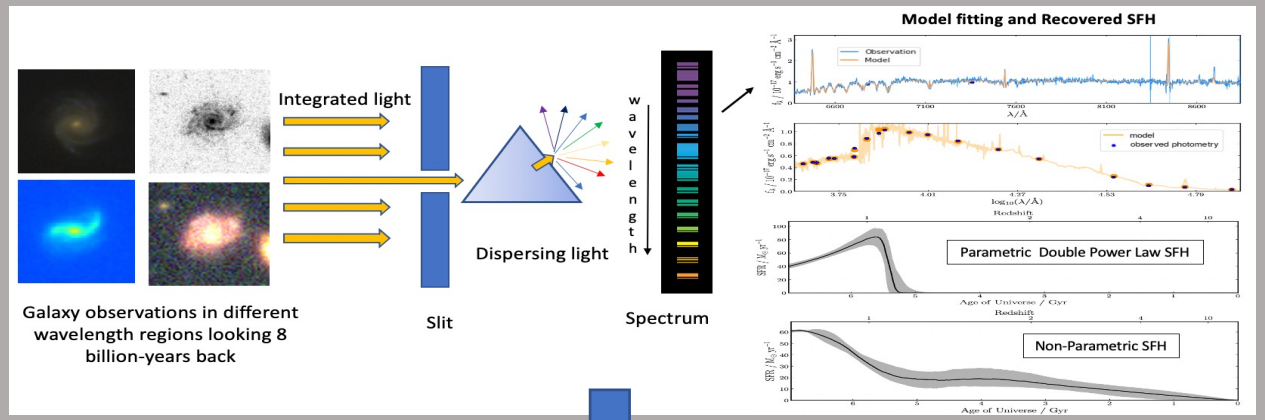
Curious Human + Telescope + Supercomputer + Models



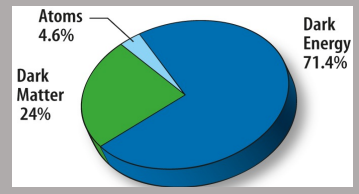




Recovering PAST (t=0 to t=6 BYr) activities from the spectrum



- How galaxies form and evolve?
- What is their chemical composition? (Carbon, Oxygen required for life!)
- Why and how they *suddenly* stop forming stars?
- How their age, mass, star-formation rate, gas + dust content relate to their environment and nuclear activity?
- Connecting the known to the UNKNOWN !!



Understanding the Evolution of Galaxies from ~6 billion years old Universe: Connecting Past to Present

Abstract

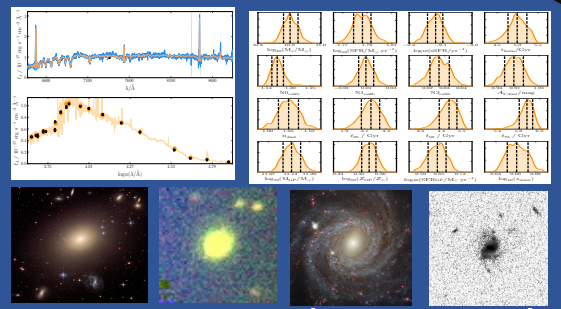
Our project aims at studying the interplay between stellar population parameters, environment and star-formation histories of the early universe galaxies and connect that to present day structures. My focus has been on utilizing sophisticated Bayesian Stellar Population Synthesis (SPS) Modeling to obtain constrains on parameters in 16-dimensional space. We compare our results with previous studies of smaller sample **(<80)** (Gallazzi+14), younger universe (Carnall+17,18) and studies of local universe (Gallazzi+06) to obtain evolution of correlations in properties with time.

Dataset : LEGA-C

Large Early Galaxy Astrophysics Census (LEGA-C) is a high resolution (0.6x 10^{-10} meters) 130-night spectroscopic survey of **3000** galaxies from the time when universe was just 6 billion years old. Each galaxy was observed for **20 hours** (unlike ~1 hour for typical redshift surveys) to obtain high signal-to-noise (S/N > 20) accurate measurements of spectral features that define the physical conditions of the system including type of stars present, their chemical composition, amount of dust and the history of star-formation.

Modelling Method : BAGPIPES

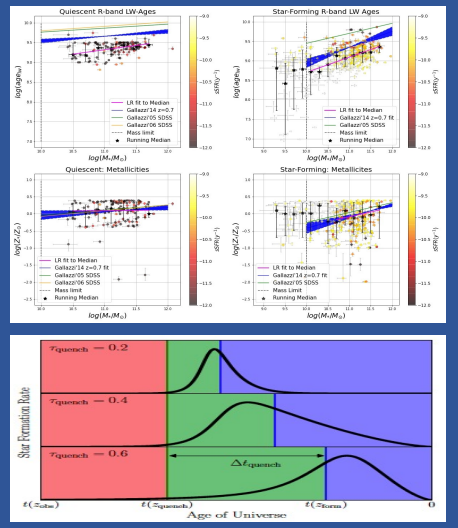
Bayesian Analysis of Galaxies for Physical Inference and Parameter EStimation (BAGPIPES) is a Bayesian state-of-the-art parametric spectral fitting code that models galaxy's photon emission from far-ultraviolet to microwave regime using the MultiNest nested sampling algorithm.



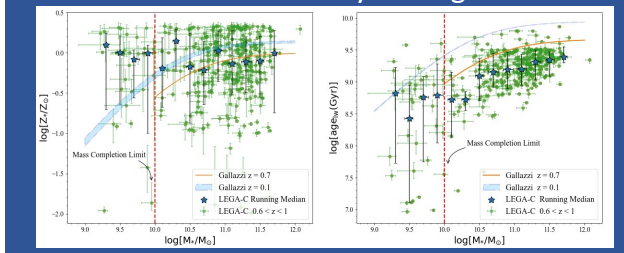
A (elliptical) B (spiral)

Initial Results

A B

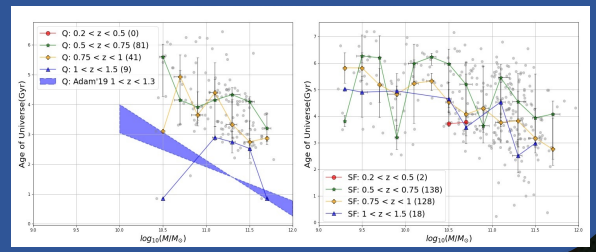


Metallicity and Ages



Time of formation with lookback time

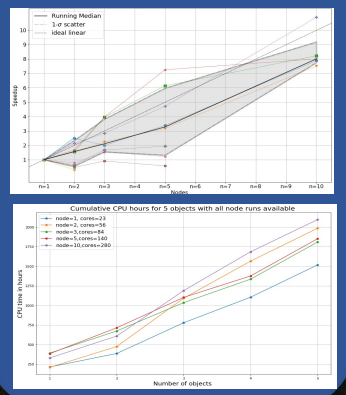
Carnall et al 2017



Computational Resources: CRC and Penn State

This Bayesian modeling is computationally intensive requiring ~450 CPU hours per galaxy per Parametric star-formation history with most optimum parallelization. We got **proposal approved for 3.5 million CPU hours** last year at Pitt CRC and now we can use 14 nodes (392 cores) simultaneously with close to ideal Speedup. This summer, we will be running more complex and computationally demanding Non-Parametric star-formation histories models with collaborators at Penn State (Prof. Joel Leja)

Speedup t_1/t_N



References

1. Gallazzi A. et.al, 2006, arXiv:astro-ph 0506539 , MNRAS, Volume 370,
2. Gallazzi A. et.al, 2014, ApJ 788 72, doi:10.1088/0004-637X/788/1/72
3. Carnall A. et.al, 2017, arXiv:1712.04452v2 , MNRAS, Volume 480, Issue 4
4. Carnall et.al, 2019, arXiv:1903.11082v2 , MNRAS, Volume 490, Issue 1

Conclusions and Future work

- At any epoch of time, less-massive galaxies have younger stellar populations than their massive counterparts.
- More heavy metal chemical enrichment (C, O, N, Fe etc.) for massive galaxies than less massive ones.
- At a fixed stellar mass, a trend towards *lower* average formation time is found with *decreasing* observed time.
  Reasons : 1. Mergers
  2. Periods of rejuvenated star- formation
- Use more sophisticated tool (*Prospector*) to perform Non-Parametric SFH modeling this summer in collaboration with Prof. Joel Leja (Penn State)