Study of Stellar Populations Properties in Simulated Galaxies

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April 2022 , Friends of Friends Hybrid Meeting 2022

Abstract

In this project we aim at developing a numerical tool which allows us to mimic IFU observations. For this purpose, we studied properties of stellar populations in two simulated galaxies of the CIELO project. Synthetic spectra of the simulated populations were generated for the galaxies and per spaxel by combining the age and metallicity of simulated stellar populations with SEDs (GALAXEV). Preliminary results are shown.

1. Motivation

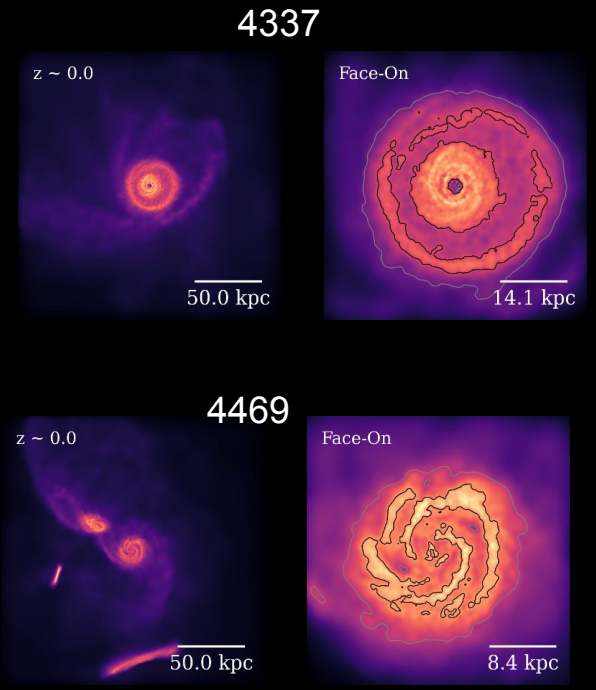
Hidro-dynamical simulations are powerful tools to probe poorly known astrophysics processes, such as the formation and evolution of galaxies. However, particular care is needed to compare simulations with observations, as observed data must also be modeled. Therefore, in this project we aim to develop a method to generate simulated IFUs which can be compared to IFU observations. In a future project, this will allow us to study the resolved fundamental properties of galaxies and compare them with the integrated relations.

2. Methodology & Simulations

For this work, we use the simulated galaxies from the CIELO project (Tissera et al in prep.) as testbeds to develop a code that allows us to mimic IFU observations. The CIELO simulations have been performed with an updated version of P-Gadget3 and includes chemical evolution following 13 elements, synthesized by Supernova II and Ia (see Pedrosa & Tissera 2015).

For this purpose and , as a first step,

- We selected the two largest galaxies of a Local Group analogue (Table1). These are the most massive galaxies within the two largest haloes of the simulated LG. The figure shows the projected stellar mass distribution of these galaxies.
  - ➢ The simulation provides the age and chemical abundances of the stellar populations, which will be used as inputs together with the stellar mass.
- The GALAXEV code (Bruzual & Charlot, 2003) was used to generate the spectra of the stellar populations which allows us to accumulate the spectral energy distributions (SEDs) of each star particle representing a single stellar populations, considering their age and metallicity (Z). In this first stage, we did not consider the effects of the interstellar medium and the presence of dust.
- IFU mock -first stage: We projected the galaxies and built a grid of N cells with side r, with r=1 kpc, for the examples shown in this poster. The cells could be squares or hexbins (hereafter they will be called spaxels). Each stellar particle is associated to a spaxel and so that, a 2D map of age, metallicity and stellar mass can be constructed. We followed the procedure applied to built the galaxy SEDs and estimated a composite SED per spaxel. This first stage does not consider the effects of dust and gas on the SEDs yet.



Figures taken from Tapia et al in prep.

3. The simulated galaxies

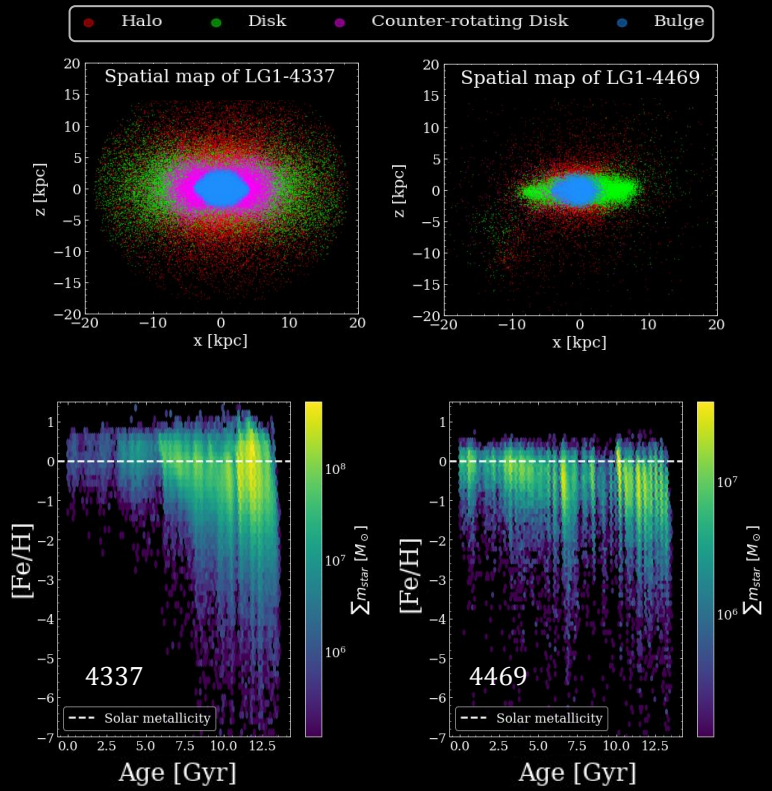
The upper panels show the edge-on projected distributions of stellar particles for galaxies 4337 (left) and 4469 (right). The red, green, magenta and blue colors represent the halo, disk, counter-rotating disk and bulge, respectively.

The bottom panels show the metallicity map ([Fe/H]) versus age weighted by stellar mass for the two galaxies respectively.

The table below displays the total stellar mass, median age and median Z of each galaxy.

Galaxy id	4337	4469
$\sum m_{\rm star}$	$5 \times 10^{10} M_\odot$	$8 \times 10^{9} M_\odot$
Median age	$11.4^{+0.6}_{-1.3}$ Gyr	$8.4^{+3.0}_{-3.8}$ Gyr
Median [Fe/H]	$-0.4^{+0.4}_{-0.5}$	$-0.6^{+0.4}_{-0.5}$

Table 1: Statistical properties of the galaxies



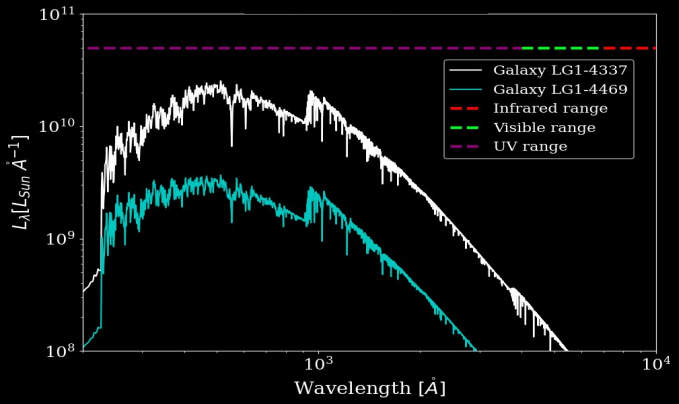
Analysis of the simulations

From the maps of [Fe/H] vs. age (lower panels) we note that the galaxy 4337 shows a concentration of stellar mass for old ages and about solar metallicities. This indicates that this galaxy underwent a big starburst event in its early stage of evolution probably forming the bulge. Then the star formation continues more quietly. On the other hand, for galaxy 4469 we notice a "fringe" pattern in the [Fe/H] vs age map, which indicates that this galaxy underwent several starburst events, but of lower intensity than the event in galaxy 4337.

Hence, galaxy 4337 is dominated by older stars, and is more massive, more metallic and in the past it experienced a big starburst compared to galaxy 4469 which is still active and more disc-dominated.

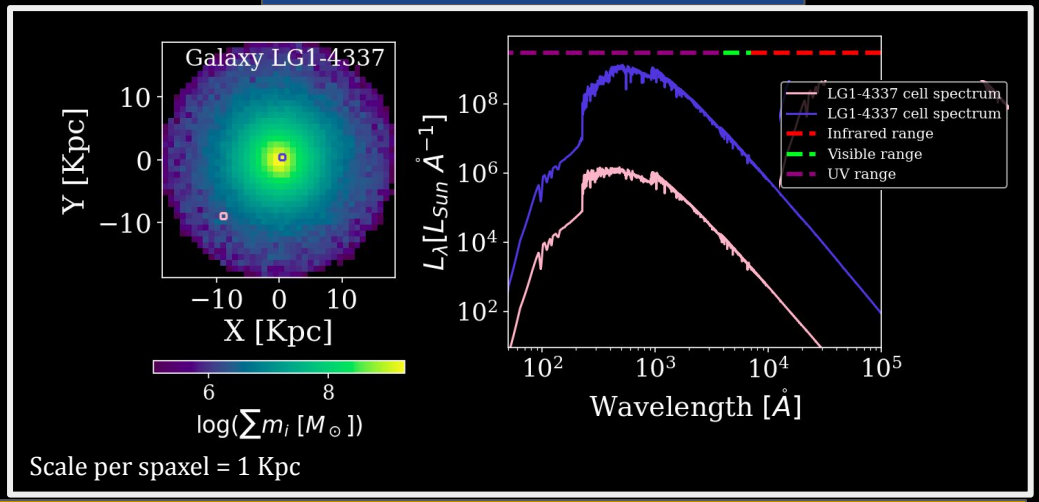
4. Preliminary results

Total spectra of galaxies



We displayed the simulated total spectra of the both galaxies (upper left panel). The SED of 4469 shows a larger contribution of young stars. In right panel we show spectra obtained for the simulated spaxels (upper right panel) for the galaxy 4337 for two regions: the central zone (blue cell) and the disk zone (pink cell). Each spaxel has a scale of 1 Kpc.

Spectra per spaxel of LG1-4337



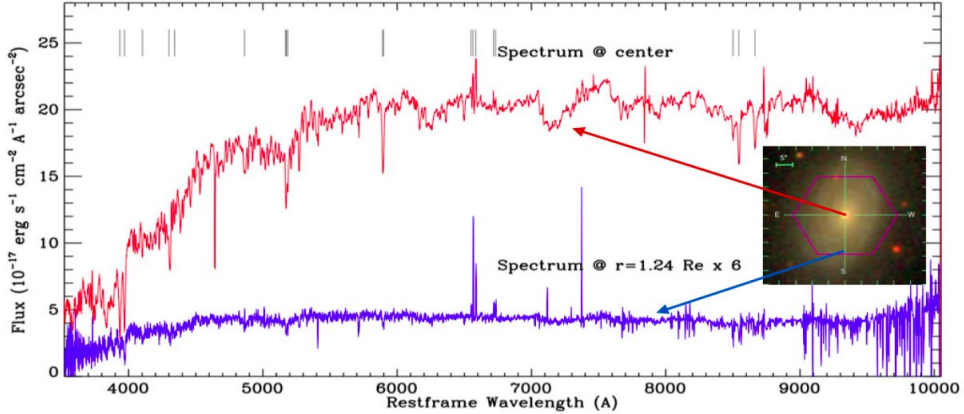
First Result

Examples of spectra per spaxel of the most massive galaxy (upper left panel). On the projected mass distribution, we show a spaxel in the bulge and one in the disc for which the SEDs are displayed on the right figure. We can notice that the central zone (blue) presents a higher luminosity and it is mainly dominated by older stellar components in comparison with the disc region that exhibits larger contributions of young stars (pink).

5. Future work

The main goal of this project is to develop a tool that allows us to mimic IFU observations. Here we showed the SEDs of different stellar populations per spaxel and the integrated spectra for two simulated galaxies. Our first results produce the composite SED per spaxel from the combined stellar populations

The next step will be to generate more realistic spectra, for which we will need to include the presence of dust, gas, among others, which directly affect the observed SEDs.



Example spectra from a typical MaNGA data cube. Taken from Albareti 2017

References:

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Bruzual, G. and Charlot, S., 2003, Monthly Notices of the Royal Astronomical Society, vol. 344, no. 4, pp. 1000–1028.

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