Linking stellar populations and kinematics in nuclear discs of nearby galaxies of the MUSE TIMER project

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Abstract:

We use IFS data of four galaxies from the TIMER survey to explore the kinematics measured in different spectral regions that are sensitive to distinct stellar populations. We derive the velocity and velocity dispersion of both a young and an old stellar population and several stellar parameters. We report a correlation of the mean luminosity-weighted age with the difference in the kinematical parameters of the blue and red ranges of the spectrum, which are dominated by young and old stellar populations, respectively. Young stellar populations, located primarily in nuclear rings, exhibit in general higher values of velocity and velocity dispersion than the old stellar population.We also report trends with age and extinction.
Our study demonstrates that kinematic differences caused by different stellar populations can be identified in the central regions of nearby galaxies even from intermediate resolution spectroscopy.

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1. Context of the research:

Bars behave like engines of galaxy evolution, driving the distribution of angular momentum by funneling gas towards the central parts of the discs.

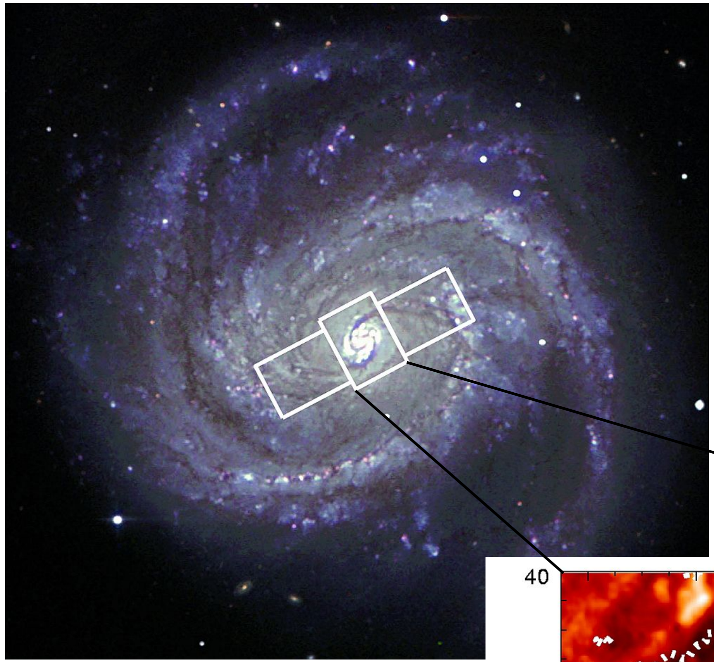
This gas can be accumulated near inner Lindblad resonances, where it shocks and leads to star formation. These stars form what we call nuclear rings.

The study of the kinematics of different stellar populations present in these structures can provide valuable information about the formation of the rings and bars.

The Integral Field Spectroscopy (IFS) provides spatial and spectroscopic data of high resolution which can be used to produce detailed maps of the gas and stellar kinematics.

The evolution of galaxies can be studied by exploring the relation between the kinematics of stellar populations and the properties related to them.

Combining these data with stellar population models allows to the study of the kinematics, age, extinction, metallicity, and color of the stellar populations.



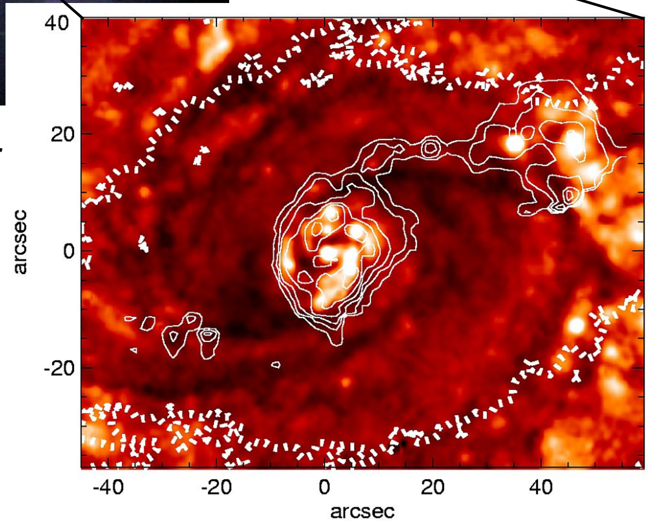


Fig. 1: M100 and its nuclear ring (Allard et al. 2005)

2. Sample and method:

For our study we selected a small sample of four SB galaxies of the MUSE TIMER (Gadotti et al. 2019) which present nuclear rings with different content of young stars. We expected to find specific relations between the kinematics and the stellar population parameters.

We use the GIST pipeline (Bittner et al. 2019) to extract the velocity and velocity dispersion of a young and an old stellar populations, traced by the Hβ (4750-5500 Å) and the Ca II triplet (8498-9000 Å), respectively (McDermid 2002), altogether with the colour and colour excess.

Additionally, we use the luminosity weighted mean age, metallicity, and fraction of young stars obtained with GIST by Bittner et al. (submitted) in the range 4750-9000 Å.

We discriminate three regions in each galaxy: disc, ring, and nucleus.

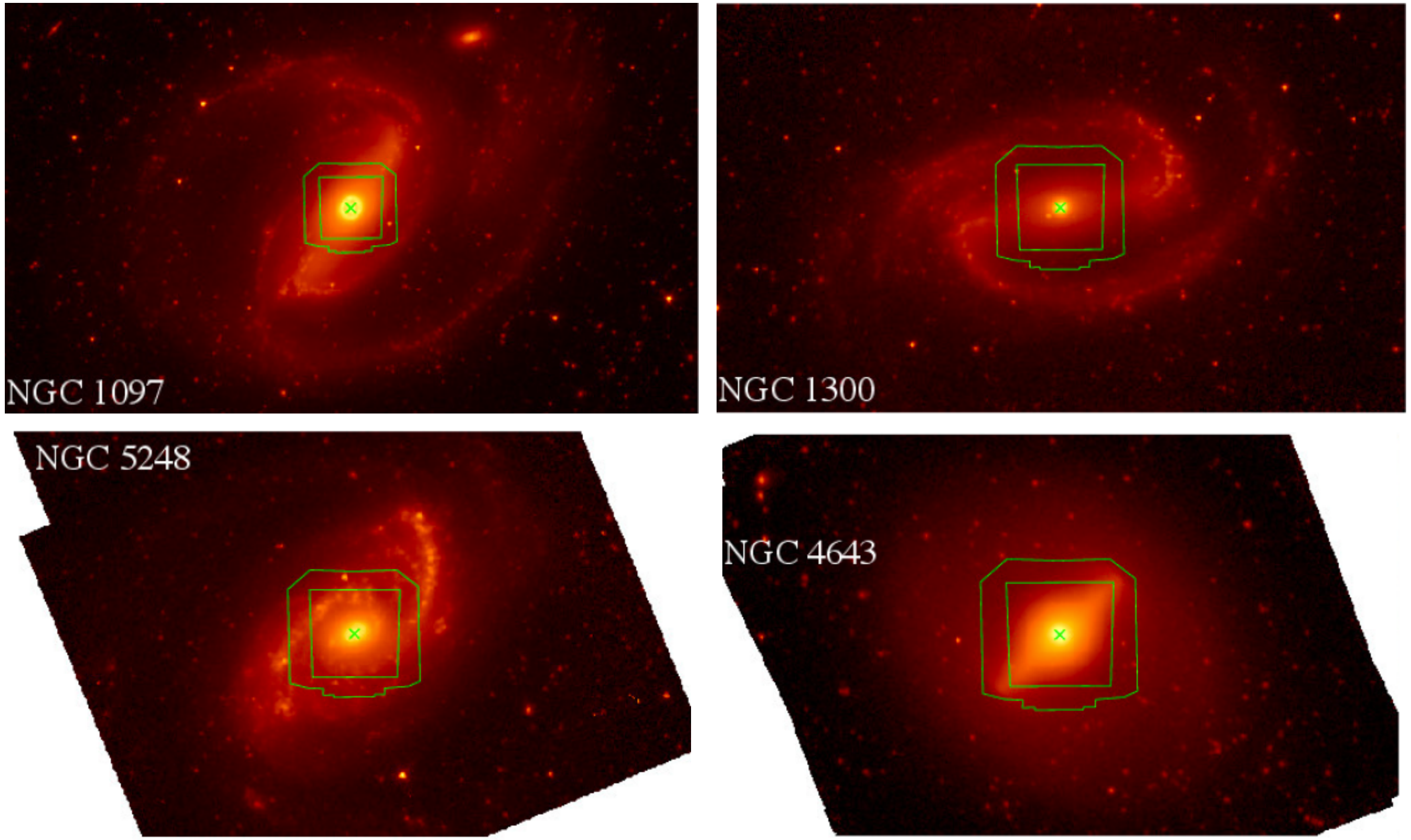


Fig. 2: S4G images at 3.6 μm of the four galaxies selected (Gadotti et al. 2019).

3.Results:

We plot detailed maps of the differences of velocity and velocity dispersion (young − old), mean age, metallicity, colour excess, and fraction of young stars.

The young stellar population presents not only a higher velocity, but also a higher velocity dispersion than the old stellar population. This is specially remarkable in the nuclear rings, where differences between both populations reach up to 60 km/s in velocity dispersion.

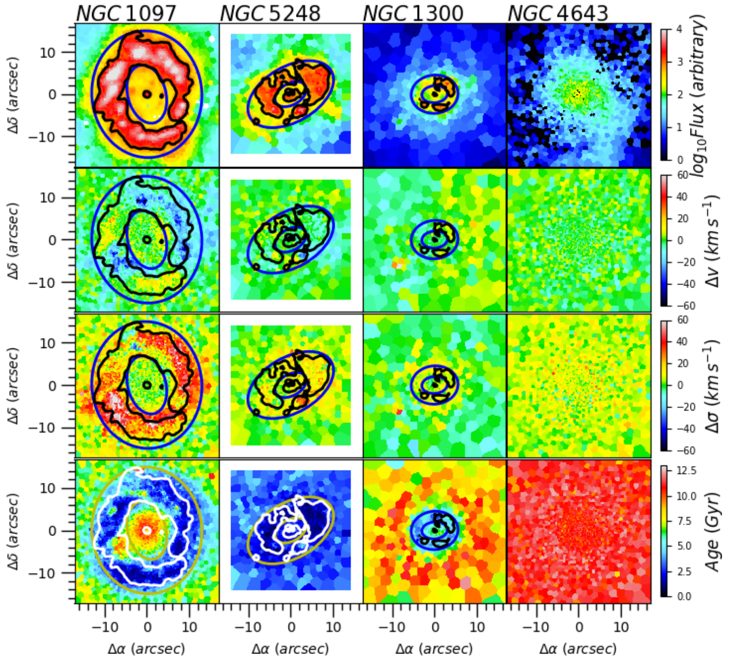
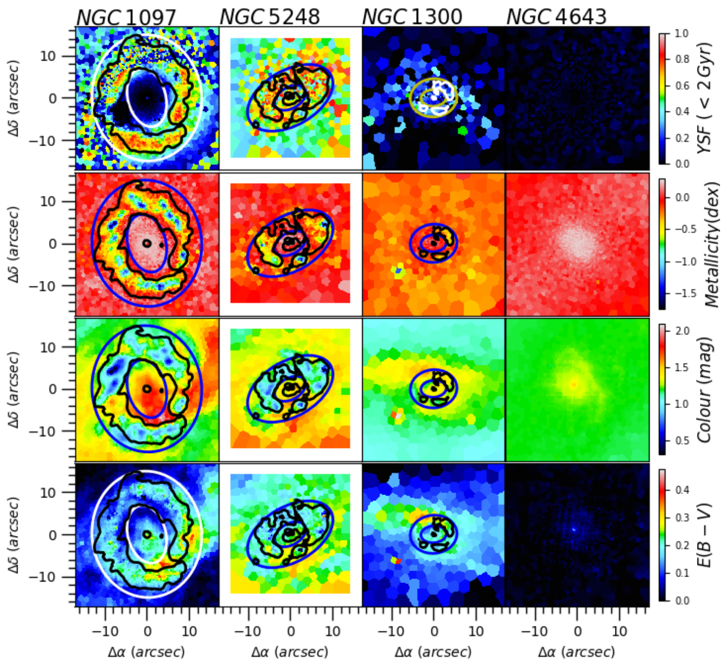


Fig. 3: Maps obtained for the Hβ line flux, Δv, Δσ, and age.



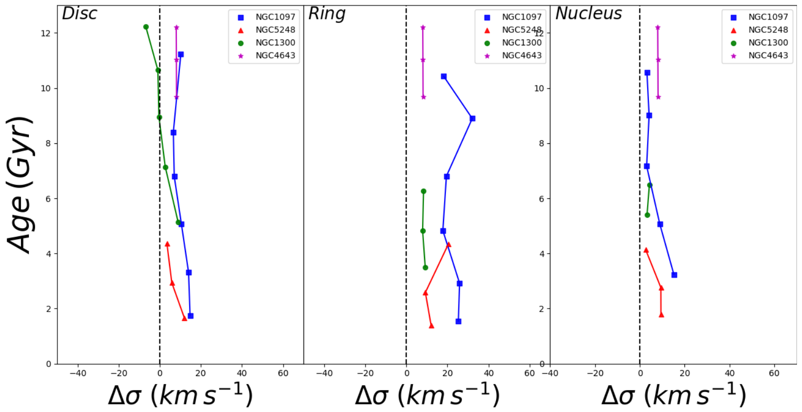
The rings are dominated by the young stellar component when compared with the disc and the nuclear region. The lower values of the metallicity are located in the circumnuclear rings.

The colour [Hβ − Ca II] seems to be dominated by the Hβ line in those parts of the rings where we find higher values of the colour excess E(B−V), revealing the presence of dust.

Fig. 4: Maps obtained for the fraction of young stars (younger than 2 Gyr), metallicity, colour, and E(B-V).

4. Analysis:
(work in progress)

We observe some trends of the difference of kinematics with the mean age. Nevertheless, in our analysis we determine that there are other relations which are more significant, in concrete, the relations with extinction and fraction of young stars.



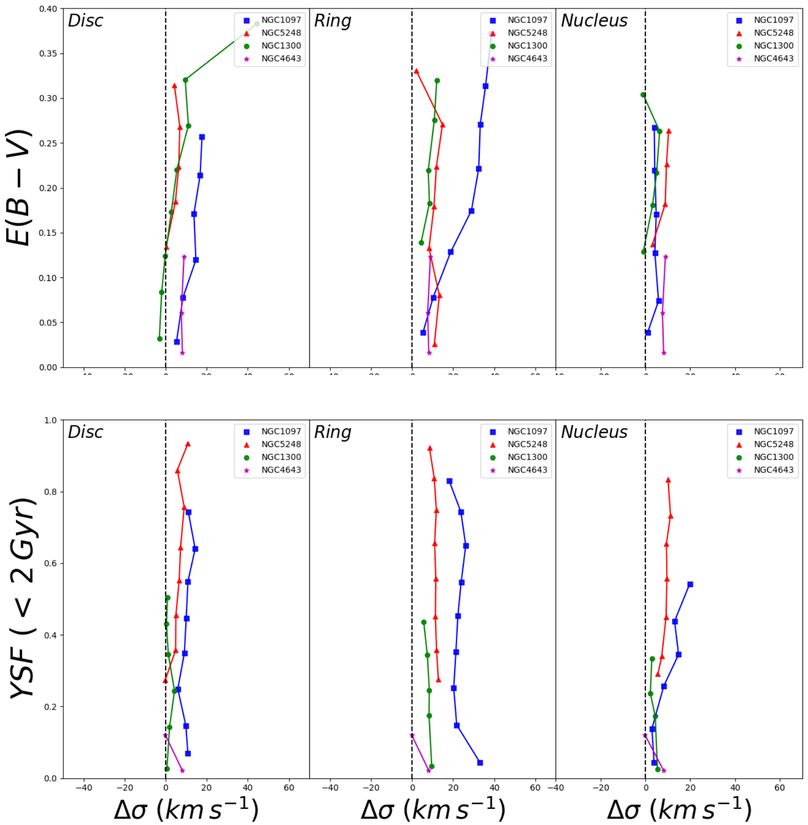
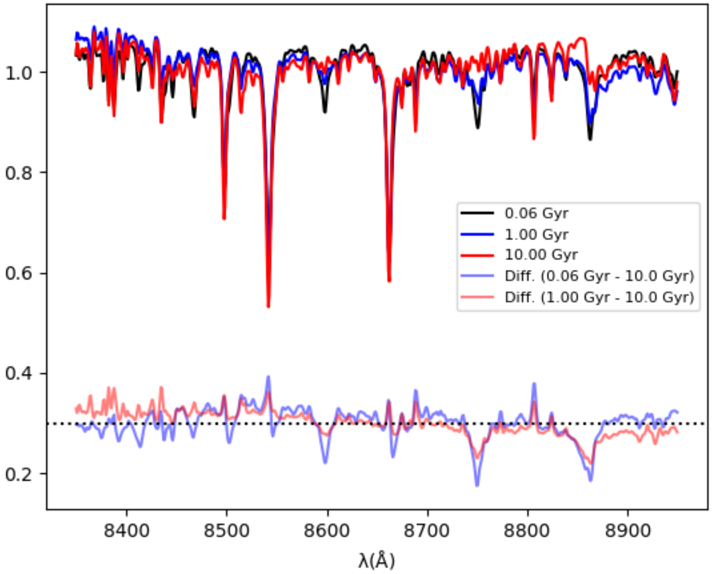


Fig. 5: Difference of velocity dispersion against age, colour excess, and fraction of young stars. The dots are the mean values of each parameter in equally spaced bins.



We try to identify the presence of different effects that may be affecting our estimation of the kinematics. The existence of a high value of the asymmetric drift or the overlapping of Paschen lines that could change the shape of the Ca II lines are ruled out.

Fig. 6: Template models for different ages used for the fitting of our data in the range of the Ca II triplet.

6. Impact of our study:

The main conclusion extracted from our analysis is that we are capable to extract the kinematics of young and old stellar populations traced by absorption lines (in our case the Hß line and the Ca II triplet). Furthermore, it is possible to identify the differences between them, at least in the most extreme cases.

These differences are observable even at the intermediate resolution offered by the current generation of IFUs. We think that with the next generation of high resolution spectrographs it would be possible to perform more detailed chemo-kinematical studies where the differences between populations could be discerned more accurately.

This study also serves as a warning against deriving kinematics from very wide spectral ranges. Specially, in cases where episodes of intense star formation are taking place.

Currently, we are carrying out a simulation exercise to validate our results. This work is in preparation and is going to be submitted for publication in the next few weeks.