Edge-on thick discs

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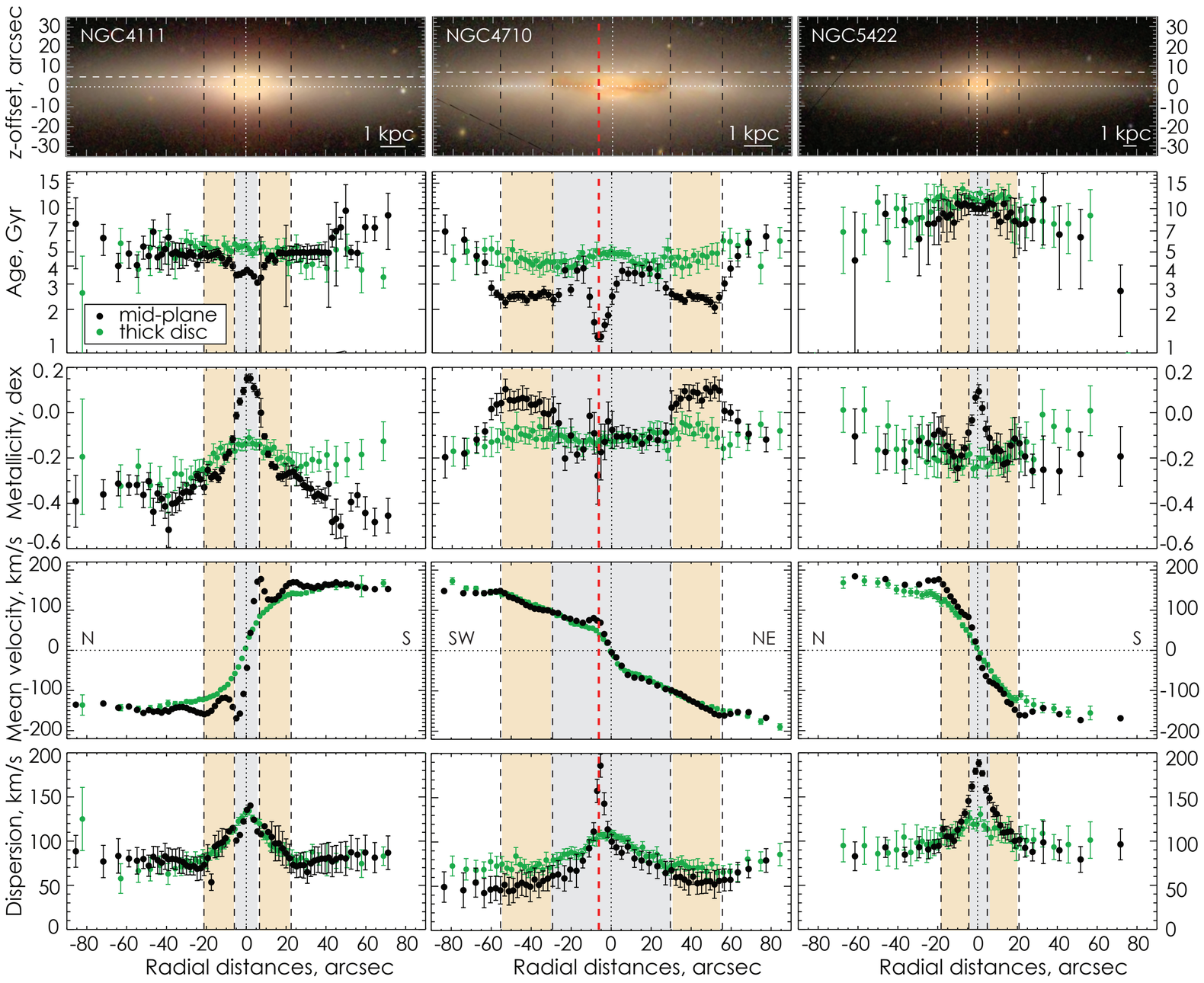


Stellar populations and internal kinematics of three edge-on galaxies. Panels (top to bottom): the slit positions overploted on SDSS color images, SSP equivalent ages, metallicities, radial velocities and line-of-sight velocity dispersions. Black and green symbols denote mid-planes and thick discs correspondingly.

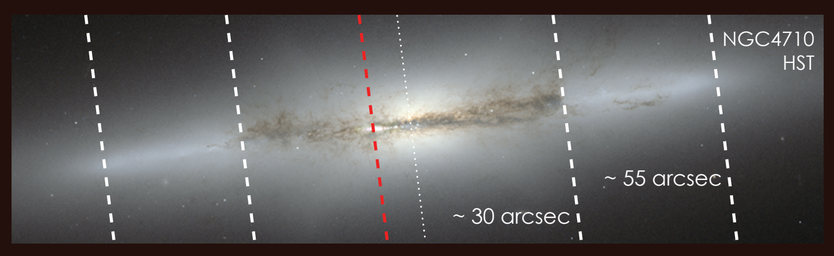
Although thick stellar discs are detected in nearly all edge-on disc galaxies, their formation scenarios still remain a matter of debate. Due to observational difficulties, there is a lack of information about their stellar populations. Using the Russian 6-m telescope BTA we collected deep spectra of thick discs in three edge-on early-type disc galaxies located in different environments: NGC4111 in a dense group, NGC4710 in the Virgo cluster, and NGC5422 in a sparse group. We see intermediate age (4 – 5 Gyr) metal rich ([Fe/H] ~ –0.2 – 0.0 dex) stellar populations in NGC4111 and NGC4710. On the other hand, NGC5422 does not harbour young stars, its only disc is thick and old (10 Gyr) and its α-element abundance suggests a long formation epoch implying its formation at high redshift. Our results prove the diversity of thick disc formation scenarios.

Long-slit spectroscopy of the sample galaxies.

NGC	Date	z-offset arcsec/pc	PA deg	Sp. range Å	T_{exp} sec	Seeing arcsec
4111	21/05/09	0/0	150	4825–5500	8400	1.3
4111	24/04/15	5/364	150	3600–7070	5600	1.0
4710	24/04/15	0/0	27.5	3600–7070	3600	1.2
4710	24/04/15	7/560	27.5	3600–7070	7200	1.1
5422	24/04/12	0/0	151.4	3600–7070	3600	2.5
5422	25/04/15	7/1049	151.4	3600–7070	8400	1.5

We present the first results of our observational program on three S0-a galaxies. We are convinced that with the sample expansion, the quality of this data will allow us to draw the general conclusions about the origin of these structures in the different types of galaxies.

Several processes may act simultaneously during the formation of structures that we observe as thick discs. Presently, we see hints about key processes in these galaxies. So, only N5422 is consistent with model of the rapid turbulent thick disc formation by Bournaud et al. (2009). But we cannot clearly assess the importance of other thick disc formation mechanisms, such as minor mergers or accretion events, for all three galaxies. As for the models of the stellar radial migration, it is difficult to test the relevance of the radial migration scenario from observations. One of the reasons is that depending on the initial distribution of the radial metallicity, very different radial profiles of stellar population parameters can emerge. Nevertheless, we do not see notable negative age gradients in thick discs predicted by Minchev et al. (2015).

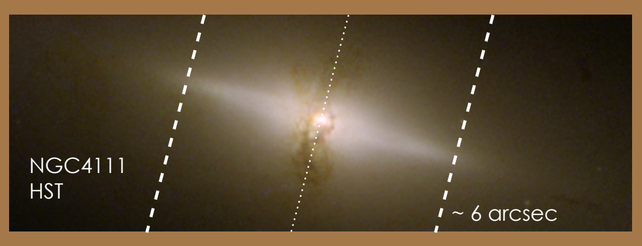


A slight asymmetry within the central region corresponds to the bright spot distinctly seen on optical images of NGC 4710 south-west of its centre. It is probably a giant star formation region that shines through unevenly distributed dust.

NGC4111

It is a member of the Ursa Major galaxy group that is known to contain a common extended HI envelope. The distances from N4111 to the nearest neighbours are about 30 – 40 kpc.

Our data extend out to 6.2 kpc from the centre that corresponds to 10.0 and 2.7 thin and thick disc scale-lengths respectively. Nevertheless, we do not see significant differences of stellar populations in the outer regions of discs. The [Mg/Fe] values for both disc components are about +0.15 dex and consistent within 0.03 dex. Stellar ages of the two layers are almost identical ~5 Gyr. Moreover, the stellar velocity dispersion profiles are similar too. With the exception of the central region where our mid-plane data probes the bulge, we see a completely flat age profile. Metallicity has a slight negative gradient and decreases from [Fe/H] = –0.2 dex at r = 15 arcsec to –0.4 dex in the outer regions of both discs.



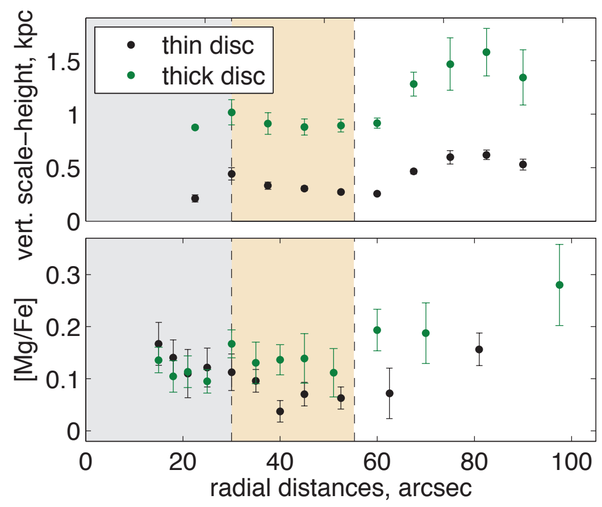
Kasparova, A. et al., 2016, MNRASL, 460, L89

NGC4710

It is located in the Virgo cluster outskirts. Its projected distance to M87 is about 5.4 deg or 1.6 Mpc. A dusty disc is observed in the central 2 kpc region dominated by an X-shaped structure (that is traditionally explained as an edge-on bar). There are statistically significant differences in [Mg/Fe] abundance ratios between the thin and thick disc components and we see its radial gradients.

Thin disc. Outside the dusty region (30 < r < 55 arsec) – young and metal-rich component. Outside 55 arcsec the stellar age abruptly becomes significantly older while the metallicity decreases.

Thick disc (at 560 pc above the mid-plane) possesses significant gradients neither in age nor in metallicity, which coincide with the values in both outer and inner regions in the mid-plane.



The apparent multi-component structure in the mid-plane of N4710 suggests a complex evolution history. We believe that we should see a similar end-product, if an initially thick disc had been forming and growing until low redshift (z = 0.5 in this case) similarly to N4111, and then the thin disc growth was fueled by additional gas in much larger amounts than in N4111, which caused intense star formation and self-enrichment. Later, the ram pressure stripping by the hot intracluster gas near the Virgo cluster center strips the outer part (r > 55 arcsec) of the thin gaseous disc and quenches the star formation. The disc flaring would quickly occur beyond this radius because there will be no more gas and dynamically cold stars forming in the mid-plane – exactly as we observe in N4710.

NGC5422

For comparison with the mid-plane of NGC 5422 we placed a slit at 7 arsec (~ 1050 pc) above it. Our profiles of kinematics and stellar population parameters extend to 70 arcsec (10.5 kpc). Not surprisingly, in those regions our analysis demonstrates stellar population properties and stellar velocity dispersion radial profiles consistent within uncertainties. N5422 is the only galaxy were we see an old thick disc ~ 8...11 Gyr with slightly subsolar ~ –0.2 dex metallicity and a moderate α-enhancement ([Fe/H] ~ 0.15). The age and metallicity gradients in NGC 5422 are not statistically significant.

The rapid turbulent thick disc formation by Bournaud et al. (2009) looks plausible only for N5422. This galaxy has a moderately α-enhanced very old stellar population in its only one thick disc that correspond to the duration of the star formation epoch of 1.5 – 2 Gyr, if it had started to form at z ~ 3 and was finished by z ~ 1.5.