Disk 'K+A' galaxies as a link between spiral and S0 galaxies in clusters

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(Rodríguez del Pino et al. 2014, MNRAS, 438, 1038)

Abstract

'K+A' galaxies had their star formation truncated 0.5–1.5 Gyr ago. Disk K +A cluster galaxies could thus represent an intermediate stage in the transformation of spiral galaxies into S0's, retaining the disk of their progenitors but with suppressed star formation. We use Integral Field Spectroscopy observations carried out with FLAMES/GIRAFFE at the VLT to analyse spatially-resolved spectra of a sample of disk K+A galaxies in a cluster at z ~ 0.3. Studying the spatial distribution and kinematics of the old and young stellar populations we learn about the processes responsible for the truncation of the star formation and morphological transformation. Galaxies in a close encounter or interaction tend to have their young stellarpopulation in the central regions of the galaxy, whereas in isolated galaxies the young starsare distributed throughout the disk. In this talk I will present these and other recent results ofour study, and will discuss the consequences for our understanding of galaxy morphologicaltransformation.

K+A galaxies and their origin

K+A galaxies are characterized by the particular features of their spectra:

- Strong Balmer absorption lines such as Hδ(4100Å) and Hγ(4135Å).

- Lack of emission lines, implying no ongoing star formation in the galaxies.

These features appear between 0.5 – 1.5 Gyr after the star formation in a galaxy is halted. The presence of type A stars (that can live up to ~ 1.5 Gyr) produces the strong Hδ feature of their spectra, that is superposed over the typical spectrum of an old 'K' population. The young population can therefore be traced by the presence of the Hδ line.
Different processes can halt the star formation in the galaxies and will leave different imprints. By studying the distribution and kinematics of the young population we can learn about what are the mechanisms responsible for the suprresion of star formation.

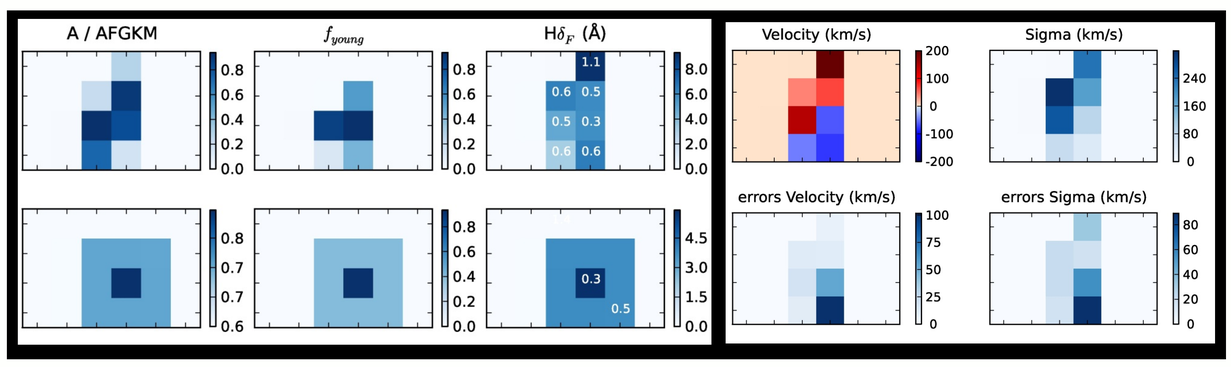
Sample and Integral Field Spectroscopy Observations

13 K+A galaxies of a cluster at z ~ 0.3 with:
- Equivalent Width (EW) Hδ > 3Å (from Couch & Sharples 1987).
- Disk morphology (from HST imaging)

Observations were carried out with the FLAMES/GIRAFFE multi-object spectrograph at the VLT (Chile). Each galaxy was observed using an individual Integral Field Unit of 20 microlenses spanning 3 x 2 arcsec^2.

Analysis

The spectral information was extracted using the software pPXF (Cappellari & Emsellem 2004). Using both stellar templates (ELODIE, Prugniel et al. 2007) and SSP models (PEGASE, Le Borgne et al. 2004) to fit the data, we obtained the kinematics and stellar composition of the individual spectra with S/N > 5. We define three different indicators of the young population:
- Strength of Hδ line
- Fraction of A stars from the fits using the stellar templates, A/AFGKM.
- Fraction of stellar populations with ages between 0.5 and 1.5 Gyr, from the fits using the SSP models, f_{young}.



Maps of the distributions of the fraction of A stars, f_{young} and Hδ in of the galaxies in the sample. Errors in Hδ are overplotted in the maps.

Maps of velocity and velocity dispersion σ for the same galaxy. In the velocity map blue means moving towards us and red moving away from us.

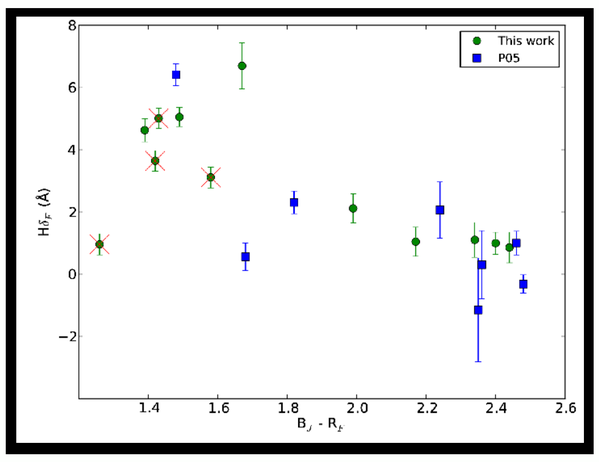
Kinematic decomposition

In order to separately measure the kinematics of the young and old stellar populations, we modified the pPXF code in such a way that it could fit two different stellar templates to one spectrum simultaneously. Although this exercise was attempted in all the galaxies, only was achieved in 6 of them.

Results

EW (Hδ) vs colour

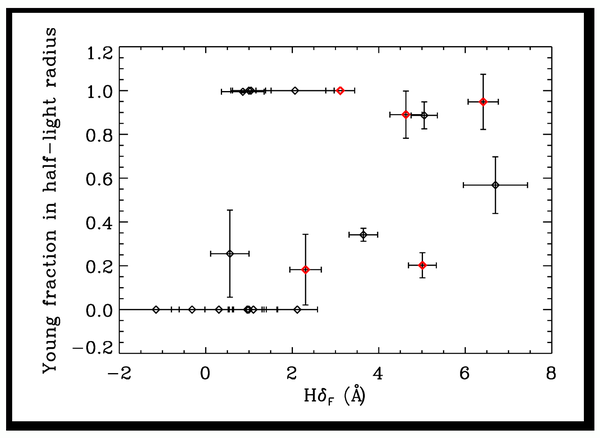
Galaxies with stronger Hδ absorption are also bluer, providing evidence of the presence of young populations in them.



Hδ versus B_J-R_F colour for our entire galaxy sample. We also show the values obtained from the analysis of some of the galaxies from Pracy et al. 2005.

Spatial distribution of the young population and influence of interactions

Assuming an exponential intensity profile for the young and old populations, we have estimated the luminosity-weighted fraction of the young stellar population within the half-light radius of the old population. Despite a large scatter, **galaxies with stronger Hδ absorption seem to show a tendency to have more centrally concentrated youngs population.**
By visual inspection of the HST images we found that 7 out of the 20 galaxies (including those from Pracy et al. 2005) show sign of recent or ongoing interaction.



Luminosity-weighted fraction of the young population within the half-light radius of the old population plotted against the integrated Hδ. A value of this fraction larger than 0.5 indicates that the young population is more concentrated than the old. Red points are interacting galaxies.

Kinematics of both populations

From the kinematic decomposition of 6 galaxies we found that the young and old populations were rotating accordingly with each other, implying an undisturbed stellar disk.

Conclusions

- Young population indicators are very consistent with each other (chances of being spurious < 1 per cent)

- Young population is more concentrated than previous generations of stars.

- No perturbation of stellar disk by the process responsible of the truncation of the star formation.

These findings point out to a gentle mechanism as responsible for the truncation of the star formation in spiral galaxies, although interactions also seem to play a role.

The last episode of star formation being more centrally concentrated in spiral progenitors would help building the bulges of the S0s.

References

Cappellari M., Emsellem E., 2004, PASP, 116, 138
Couch W., Sharples R., 1987, MNRAS, 229, 423
Le Borgne et al. 2004, A&A,425,881
Pracy M. B. et al. 2005, MNRAS, 359,1421
Prugniel et al. 2007, preprint, astro-ph/0703658