Star formation in counter-rotating galaxies.
Observations and Simulations

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Morelli, Coccato, Corsini, Dalla Bontà, Fabricius, Saglia, Debattista
Summary

- MUSE spectroscopic Observations
  – results
- Modelling the counter-rotation with simulations
  – results
- **Counter-rotation**: when in one galaxy components with opposite spin co-exits (see review by Corsini 2014)

- Stars vs. Gas
- Stars vs. Stars

- **Stars vs. (Stars + Gas)**

- whole galaxy
- inner/outer region

- About 15% of S0 counter-rotates  Pizzella et al.(2004)
- We can detect up to a fraction of 20% (in luminosity) counter-rotating stars
Reconstructed image spaxel 0.2”x0.2”, seeing~1.4”
IC 719

Ca Triplet region

MUSE@VLT  $\Delta \lambda = 2.5\,\text{Å}$  $R=2000-3500$ ;  $\sigma = 65 - 35\,\text{km/s}$
IC 719: full spectral fitting

Stellar templates eMiles-MIUSCAT (Vazdekis et al. 2012)

pPXF (Cappellari & Emsellem 2004) based code (Coccato et al. 2011)
MUSE@VLT - IC 719: full spectral fitting
For each of the two stellar components we can measure:

- kinematics: *velocity* and *velocity dispersion*
- line strength → *age* and *metallicity*
- the luminosity ratio Main/secondary → *spatial shape*
IC 719 kinematics - Velocity field

Main component

Secondary component

Ionized gas

Main = 70% of total light

1' x 1'
IC 719 kinematics - Velocity dispersion

Main component

Secondary component

1'x1'

Ionized gas
Major Axis

Velocity

Velocity dispersion
IC 719 2d maps: Lick Indices

Hβ

Mgb

Main

Secondary
MUSE - IC 719  Narrow band imaging

- Hβ
- Hα
- [NII]658nm
- [SII]671nm
Observational Results

- Secondary component: same *kinematics* and same *spatial distribution* as the ionized gas.

- Secondary component: *younger* and *metal poor* in comparison with the main component (see also Katkov, Sil’chenko et al 2013)

- There is *Star formation* associated to the secondary component

- Secondary component: *thinner* \((q<0.15)\) than the main component \((q=0.2-0.3)\)
Observations - Conclusions

- The counter-rotating stellar component originated from a gaseous disk.

- The cold gas, acquired from outside, settled onto the galaxy plane and formed the counter-rotating stars than now form a young, star forming thin disk.
IC 719 one of the ETG in the sample with the brightest and more extended HI emission (Grossi et al. 2009)
We now need models to compare with

Goals: test observational limits – understand the processes

THE MODEL: Number of stars particles=1,838,606; Total Mass=5.683e10 Msun; Spatial resolution=50pc. Stars of different ages: stars older than 6 Gyr represent 2/3 of the total mass of the galaxy and we assume are the prograde stellar component (Debattista in prep.).

We used the code SYNTRA (Portaluri+ 2017 MNRAS 467, 1008)

→ simulated MUSE datacube
RESULTS: the machine is working. We successfully recovered the original velocity field of both the pro-grade and counter-rotating components.

NEXT STEPS:

Measurements: the minimum percentage of counter-rotating stars we can detect recovering the kinematics, age and metallicity of the stellar populations;

Science: the astrophysical process that brings to the formation of such galaxies.
Summary

- The counter-rotating disk is cold, thin, metal poor and young.

- The counter-rotating stellar component originated from the gaseous disk that formed from the acquisition of a gas cloud.

- We started modelling the formation of such galaxies to properly test observational limits and better understand the acquisition mechanism.
- **Counter-rotation**: when in one galaxy components with opposite spin co-exits (see review by Corsini 2014)

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Distribution of ages

n. of Prograde star particles
6-->8 Gyr=213,355
8-->11 Gyr=1,002,081

n. of Counter-rotating particles
0-->2 Gyr=213,858
2-->4 Gyr=257,693
4-->6 Gyr=151,619
IC 719 kinematics - Velocity field

Main stellar component

Main = 70% of total light

Secondary component

Ionized gas

1' x 1'
IC 719 ages and metallicities of stellar populations