The spatially resolved star formation history of mergers:

A comparative study of the LIRGs IC1623, NGC6090, NGC2623, and Mice

Cortijo-Ferrero+2017

2017A&A...607A..70C

arXiv: 1707.05324

Presenter: K.Kushibiki

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Abstract

Spatially resolved star formation history of four local mergers with IFU data (CALIFA, PMAS in LArr mode)

- Early-stage mergers: IC1623, NGC6090, Mice
- More advanced merger: NGC2623

→ Spatially resolved mass growth, Σ_{SFR} and sSFR history over 3 timescales (30, 300 Myr, 1 Gyr)

For 3 LIRGs, major phase of SF in timescales of 10^7 yr to few 10^8 yr with enhancement of x~2-6

Early-stage mergers

- Enhancement in the last 30 Myr
- Spatially extended: factors of 2-7 both in center and disk

More advanced merger

- Extended SF on a longer timescale ~ 1 Gyr: a factor of ~2-3, relic of the first pericenter
- Enhancement in the last 30 Myr: Only in the center by a factor of 3

Mice

- Not enhanced but inhibited SF
- Smaller gas fraction and its almost prograde orbit → challenge for the models

1. Introduction

Burst by galaxy interaction may be shorter than duration of the interaction
→ Directly observe merger-induced SF in mergers of gas rich disks (LIRGs&ULIRGs)

- SFR increased in mergers in modest (not only for LIRGs, consistent to simulations)

Spatial scale of the SF in mergers

- Low resolution merger simulation
  → SF is concentrated toward the central region and suppressed in the outskirts
  Underestimate the spatially extended SF observed (intersection of spiral/tidal structure)
- High resolution models (shocks & parsec scale physical process)
  → Extended SF is important in the early stages of merger and nuclear starburst
  in the advanced stages (Barnes2004, Teyssier+2010, Hopkins+2013, Renaud+2015,2016)

U/LIRGs are unique laboratories for physical process triggered by galaxy mergers

- Quenching of SF
- Morphological transformation
- Observational characterization of SF in mergers at different stage → merger simulations

Goal of this paper

- Spatially resolved SFH of mergers (Early-stage: Mice, IC1623, NGC6090, Advanced: NGC2623)
  → Enhanced SF? Its time scale and spatial extent

2. Sample

4 mergers (Part of CALIFA survey, except for IC1623)

- Early-stage mergers: Mice, IC1623, NGC6090
- More advanced merger: NGC2623

Mice (Wild+2014)

- Stellar population of both galaxies > several Gyr
- Younger stellar population ~0.6 Gyr
  only in northern tidal tail and NE arm of NGC4676B
- Stellar mass contributed by stars < 140 Myr ~ 5%
  ↔ ~30% in the nuclear of NGC4676A and tidal arm of NGC4676B
- Excess of light from intermediate age stars
  in western half of NGC4676A, inter-galaxy, NE bar of NGC4676B
  ← Consistent with SF at the first passage ~ 170 Myr ago(dynamic instabilities / shocks)

Fig. 1 Upper-left

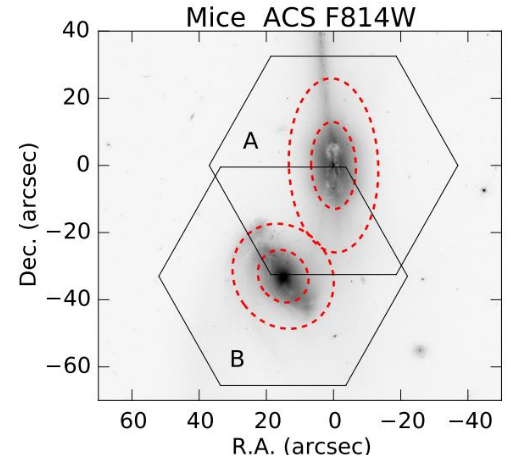


Table 1

Property	Mice	IC 1623	NGC 6090	NGC 2623
CALIFA ID	577 (A); 939(B)	-	2945	213
RA	12 46 10.7	01 07 46.3	16 11 40.8	08 38 23.8
DEC	+30 43 38	-17 30 32	+52 27 27	+25 45 17
Interaction stage	IIIa	IIIb	IIIb	IV
z	0.022049	0.020067	0.029304	0.018509
Scale (kpc/″)	0.47	0.42	0.61	0.39
HLR (kpc)	4.6 (A); 3.8 (B)	2.8	4.2	3.3
Stellar mass ($M_\odot$)	1.2×10^{11}(A), 1.5×10^{11}(B)	3.9×10^{10}	6.8×10^{10}	5.4×10^{10}
$\log(L_{IR}[L_\odot])$	10.62	11.65	11.51	11.54
$SFR_{30\ Myr}$ ($M_\odot$/yr)	3(A), 2(B)	20	51	8

2. Sample

IC1623 (Cortijo-Ferrero+2017a)

- Merger-induced SF is extended and recent
- W progenitor
  - Average light-weighted age ~ 50Myr,
  - Older ~300Myr in the center than surrounding ~30Myr
    ← Induced in previous stage of the merger
  - Light is dominated by younger stellar populations everywhere
    >> 10-20% (tyipical value of Sbc/Sc)
  - Extinction ~0.2mag and flatter profile than Sbc/Sc
  - Stellar metallicity ~ 0.6 Zsun and flat or positive radial profile
  - SFR(t<30Myr) ~ 6 x MS
- E progenitor: Much higher level of extinction (2-6 mag)

NGC6090 (Cortijo-Ferreo+2017a)

- Merger-induced widespread clusters
  with average light-weighted age ~ 50-100Myr
- Age profile: flatter than Sbc/Sc → General rejuvenation
- Average stellar extinction: NE~1.3mag, SW ~ 0.5 mag,
  both flatter profile than Sbc/Sc
- Stellar metallicity ~ 0.6 Zsun and flat or slightly positive profile
- SFR(t<30Myr) ~ 9 x MS

Fig. 1 Upper-right

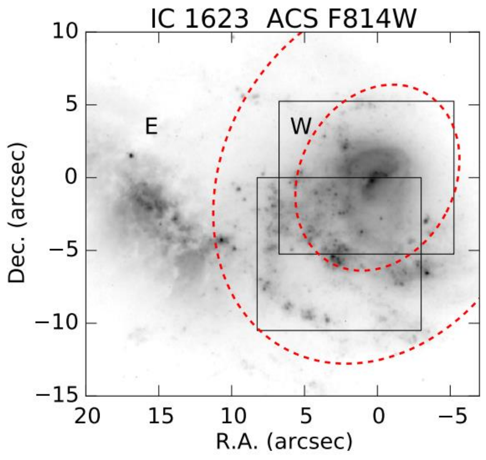
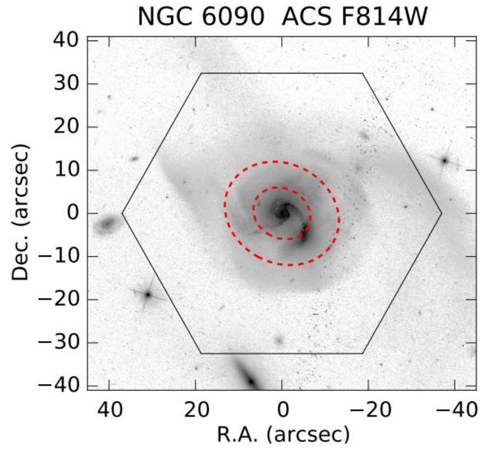


Fig. 1 Lower-left



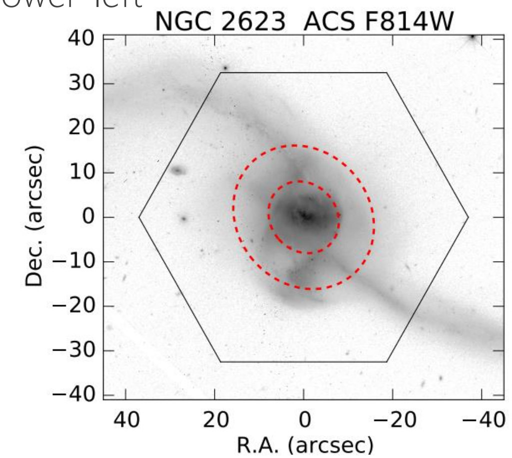
2. Sample

NGC2623 (Cortijo-Ferrero+2017b)

- Two period of merger-induced SF
  - Recent episode traced by young stellar population < 140Myr in the innermost (<0.5 HLR ~ 1.4kpc)central region
  - Some isolated clusters in north tidal tail and in south SF knots

  → Traced by intermediate stellar population 140Myr – 1.4Gyr
- Center (<0.2HLR) ~ 500Myr < ~900Myr at 1HLR
- Stellar extinction is high in the inner 0.2HLR ~1.4mag and steeper negative gradient than Sbc/Sc
  → In the last stage of a merger, most of the gas and dust is concentrated in the mass center

Fig. 1 Lower-left



3. Observations and data reduction

At Calar Alto observatory (CAHA) with 3.5m telescope and PMAS (optical IFU)

For IC1623 (not included in CALIFA survey)

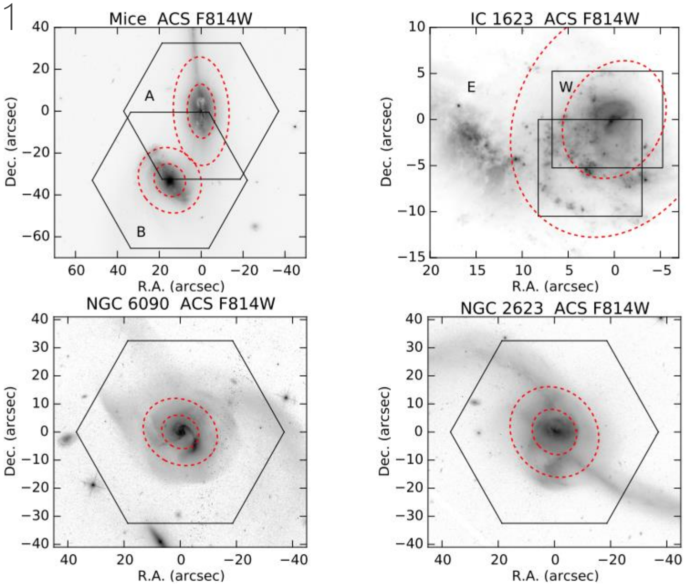
- Lens Array (LArr) configuration
    - 0.75″ /lens → 0.75″/spaxel
    - 12″ x 12″ FoV
    - Two pointing for western galaxy

For the others

- PPaK mode: Fiber bundle
    - 382 fibers of 2.7″ diameter → 1″/spaxel
    - 74″ x 64″

Both cover ~3700-7100 AA

Fig. 1



Half light radius (HLR)

= semi-major axis length containing half of the total light at 5635 AA

HLR = 4.6 (Mice A), 3.8 (Mice B), 2.8 (IC1623 W), 4.2 (NGC6090), 3.3 (NGC2623) kpc

cf.) HLR ~ 5.0 and 4.1 kpc for Sbc and Sc controls

Reduction: Cortijo-Ferrero+2017a, and CALIFA papers

4. Spatially resolved star formation histories

4.1. Method of analysis

Full spectral synthesis technique

- Data binning and criteria
  - CALIFA data: Coadding spaxels into Voronoi zones to get S/N>20
  - LArr data: Use the individual spaxels if the S/N > 5
- STARLIGHT code (Cid Fernandes+2005)
  - Linear combination of SSPs: Vazdekis+2010 for ages > 63Myr
    & Gonzalez Delgado+2005 for younger ages
    → 156 spectra: 39 ages (1Myr-14Gyr), 4 metallicities (0.2, 0.4, 1, 1.6 Zsun)
  - Calzetti+2000 reddening with Rv=4.5 for all the SSPs
  - PYCASSO software

Non-parametric SFH approach to predict correctly the contribution of the young and/or old stellar population of U/LIRGs

Control Sbc/Sc galaxies

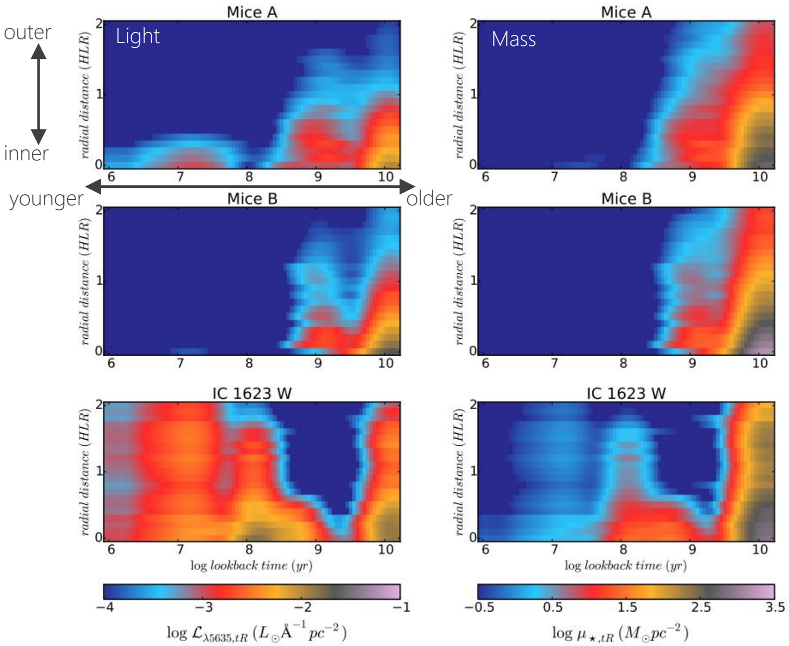
- The same mass range as the mergers
- 70 Sbc and 14 Sc
  ← The progenitors of the galaxy mergers are gas-rich spirals without significant bulges

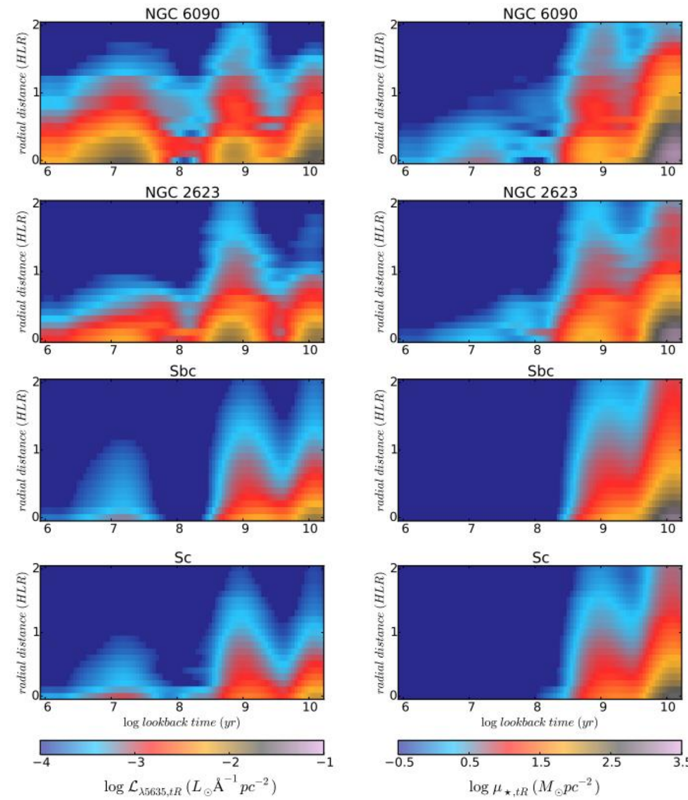
4. Spatially resolved star formation histories

4.2. SFH: The 2D R x t maps

Visualize the spatially resolved SFH of galaxies

Fig. 2





Note: Smoothed in log t with 0.5dex Gaussian filter,
Value of < 30Myr is the average of the values younger than that age

LIRG-mergers show prominent spatial and temporal distortions, specially for < 1Gyr

4. Spatially resolved star formation histories

4.2. cont'd

Binning with 4 age scales

1. < 30Myr: youngest ionizing stellar populations
2. ~ 300Myr: young population emitting UV up to early type A stars
3. ~ 1Gyr: intermediate age dominated by A and F stars
4. > 1Gyr

Binning with 3 spatial scales

1. < 2HLR: the whole galaxy
2. Central 0.5 HLR: Bulge component
3. 1-1.5 HLR: Disk of spirals

Uncertainty

- Propagating the dispersion due to slight age (±1 SSP) and radial variations (±0.1/0.5 HLR) → Too small
- Main uncertainty is caused by choice of model and extinction law → Still a few – 10 % uncertainties

Table 2

0.0 – 0.5 HLR							
Light (%)	Sbc	Sc	Mice A	Mice B	IC 1623 W	NGC 6090	NGC 2623
SSPs ≤ 30 Myr	8.0(0.2)	13.3(0.2)	13.5(0.7)	1.4(0.1)	20.5(2.7)	49.2(0.8)	21.7(0.6)
SSPs ≤ 300 Myr	8.4(0.2)	17.7(0.1)	17.1(0.7)	1.4(0.1)	57.1(0.9)	52.20(0.02)	29.9(0.3)
SSPs ≤ 1 Gyr	19.0(2.0)	32.4(2.9)	27.0(0.9)	4.2(0.4)	70.9(0.9)	67.5(0.9)	64.7(1.1)
Mass (%)	Sbc	Sc	Mice A	Mice B	IC 1623 W	NGC 6090	NGC 2623
SSPs ≤ 30 Myr	0.061(0.004)	0.133(0.006)	0.13(0.02)	0.007(0.002)	0.6(0.1)	0.66(0.02)	0.4(0.1)
SSPs ≤ 300 Myr	0.09(0.01)	0.27(0.01)	0.3(0.1)	0.007(0.002)	4.2(0.3)	0.92(0.01)	1.1(0.1)
SSPs ≤ 1 Gyr	2.2(0.5)	4.3(0.9)	2.5(0.4)	0.5(0.1)	7.4(0.3)	6.5(0.4)	10.6(0.7)
1.0 – 1.5 HLR							
Light (%)	Sbc	Sc	Mice A	Mice B	IC 1623 W	NGC 6090	NGC 2623
SSPs ≤ 30 Myr	16.7(0.2)	15.2(0.4)	2.9(0.1)	8.4(0.3)	57.7(0.5)	33.1(1.7)	10.2(0.5)
SSPs ≤ 300 Myr	22.7(0.4)	24.2(0.4)	5.1(0.4)	9.5(0.4)	79.7(0.3)	43.9(1.0)	17.8(1.1)
SSPs ≤ 1 Gyr	42.5(3.1)	52.8(3.6)	17.8(0.6)	28.1(3.7)	79.7(0.3)	66.2(1.6)	60.9(2.1)
Mass (%)	Sbc	Sc	Mice A	Mice B	IC 1623 W	NGC 6090	NGC 2623
SSPs ≤ 30 Myr	0.23(0.01)	0.30(0.02)	0.026(0.001)	0.072(0.004)	1.37(0.01)	0.7(0.1)	0.28(0.02)
SSPs ≤ 300 Myr	0.7(0.1)	1.1(0.1)	0.2(0.1)	0.15(0.02)	3.8(0.1)	1.8(0.1)	1.5(0.3)
SSPs ≤ 1 Gyr	7.6(1.3)	13.2(1.8)	2.6(0.2)	3.9(0.8)	3.8(0.1)	11.0(0.9)	23.1(1.7)
0.0 – 2.0 HLR							
Light (%)	Sbc	Sc	Mice A	Mice B	IC 1623 W	NGC 6090	NGC 2623
SSPs ≤ 30 Myr	10.5(0.2)	14.0(0.2)	10.2(0.4)	2.9(0.1)	35.5(2.1)	46.8(0.8)	19.3(0.6)
SSPs ≤ 300 Myr	12.2(0.3)	19.4(0.2)	13.5(0.4)	3.2(0.2)	65.6(1.6)	51.1(0.1)	28.3(0.4)
SSPs ≤ 1 Gyr	25.3(2.3)	37.9(3.2)	25.6(1.1)	8.1(1.0)	73.6(0.4)	66.9(1.0)	62.6(1.2)
Mass (%)	Sbc	Sc	Mice A	Mice B	IC 1623 W	NGC 6090	NGC 2623
SSPs ≤ 30 Myr	0.144(0.007)	0.22(0.01)	0.062(0.005)	0.034(0.003)	1.0(0.1)	0.7(0.1)	0.3(0.1)
SSPs ≤ 300 Myr	0.36(0.03)	0.6(0.1)	0.2(0.1)	0.08(0.02)	3.7(0.1)	1.2(0.1)	1.3(0.2)
SSPs ≤ 1 Gyr	4.8(0.9)	8.3(1.4)	2.9(0.3)	1.5(0.3)	4.9(0.2)	8.1(0.7)	13.4(0.9)

4. Spatially resolved star formation histories

4.2.1. SFH: Mice A and B

- Dominated by the old stellar population (74% and 92% in luminosity)
- Younger than 1 Gyr = 25.6% (Mice A) and 8.1% (Mice B) (luminosity)
- Younger population in 1-1.5 HLR vs Central 0.5 HLR (luminosity)
    - Mice A: 17.8% vs 27%
    - Mice B: 28.1% vs 4.2%

4.2.2. SFH: IC1623

- Younger than 300Myr = 65.6% (luminosity)
  Similar in the inner 0.5 HLR (57.1%) and significant higher in 1-1.5HLR (79.7%)
- Younger than 30Myr = 20.5% (0.5HLR) and 57.7% (1-1.5HLR)
- Old population < 26% in luminosity but >95% in mass

4.2.3. SFH: NGC6090

- Dominated by very young stars (t<30Myr): 46.8%
  49.2% in the central 0.5HLR and 33.1% in the 1-1.5 HLR
- Between 30Myr and 300Myr: Only ~20%
- Old population: ~34% in luminosity and 91% in total mass

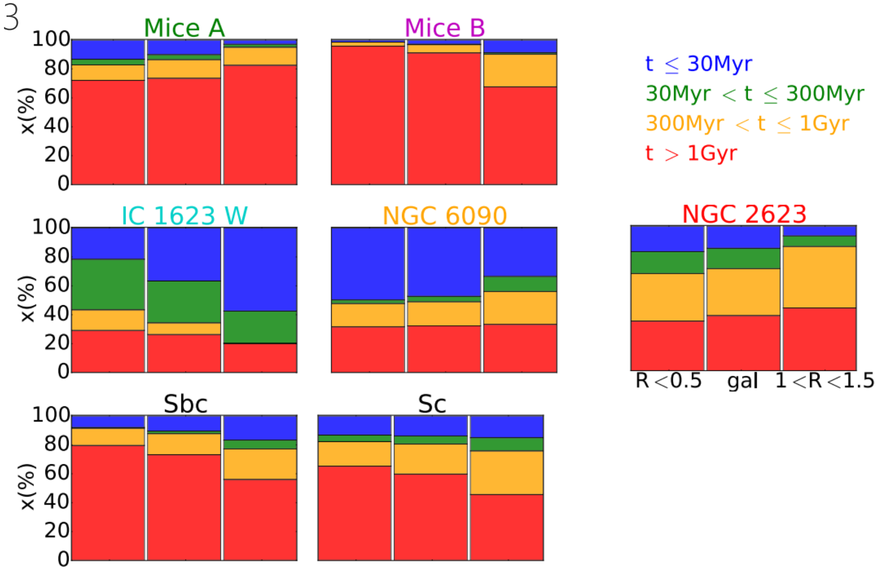
4. Spatially resolved star formation histories

4.2.4. SFH: NGC2623

- Young (t<30Myr) and intermediate (30Myr-1Gyr): 19.3% and 43.3%
    - 21.7% and 43.0% in the central 0.5HLR
    - 10.2% and 50.7% in 1-1.5HLR
- Old population > 1Gyr: ~37% in luminosity and 86% in mass
  For mass, 89% in the central 0.5HLR and 77% in the disk

4.3. SFH: Light fraction

Fig. 3



LIRG-mergers

- Larger light fraction in <1Gyr than Sbc/Sc
    - Evident in <0.5HLR for the 3 LIRGs
    - Also in outer region (1-1.5HLR) for the premerger LIRGs (IC1623, NHC6090)

→ Experience starburst in the last 1Gyr

Mice

- More similar to Sbc/Sc
- Outer regions of Mice A, B seem to have suppressed the SF in the last 1Gyr

4. Spatially resolved star formation histories

4.3. cont'd

How much enhanced/suppressed contribution of light relative to Sbc(Sc)

Inner 0.5HLR

	< 30 Myr	< 300 Myr	< 1 Gyr
IC1623W, NGC6090, NGC2623	x3(2), 6(4), 3(2) higher	x7(3), 6(3), 4(2) higher	x 4-3(2) higher
Mice A, Mice B	x2(1) higher, x6(13) lower	Similar, Suppressed	Similar, Suppressed

- < 1Gyr of 3LIRGs: x~2 less than the value of < 300Myr
  → SF has not been continuous in the last 1Gyr

1-1.5HLR

<table>
<tr><th></th><th>< 30 Myr</th><th>< 300 Myr</th><th>< 1 Gyr</th></tr>
<tr><td>IC1623W, NGC6090</td><td>x ~4, ~2 higher</td><td>x3, 2 higher</td><td rowspan="2">Not enhanced
(or very slightly enhanced)</td></tr>
<tr><td>NGC2623</td><td>x 0.6 (0.7)</td><td>Comparable</td></tr>
<tr><td>Mice A, Mice B</td><td colspan="3">x0.3-0.4 , x0.3-0.5</td></tr>
</table>

- NGC: In the last 30Myr, enhanced in central region, not in the disk

Global < 2.0HLR: Intermediate between the above two results

→Two early stage merger LIRGs: Enhanced in the last 30, 300Myr both in the center and disk
NGC2623: Enhanced in the last 20, 300Myr in the center, comparable in the outer part
Mice A, B: No enhanced SF, suppressed in disk of A and both in the disk and center of B

4. Spatially resolved star formation histories

4.4. SFH: Mass assembly

- Young stellar population (<1Gyr) contributes little to the mass
- Population older than 2Gyr are the main contributors
- Older than 10Gyr
    - Contribute with ~73% for Sbc/Sc
    - Also in mergers: ~66% for NGC2623 to ~92% for IC1623

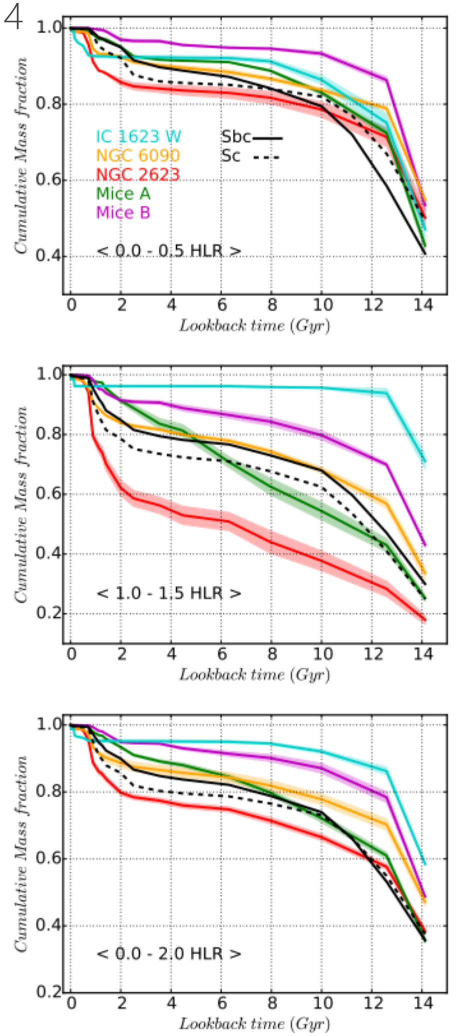
Diversity and interesting difference/similarities to the spirals

A) Mass growth was very fast (Also in Sbc/Sc), mergers have grown faster or at similar rate as Sbc/Sc (Exception: Outer region of NGC2623)

B) Mass is assembled faster in the inner parts than in the outskirts (Except for IC1623) → Inside-out growth

t_{80}: Lookback time when roughly ~80% of the present stellar mass had been assembled

Fig. 4



4. Spatially resolved star formation histories

4.4. cont'd

Inner 0.5HLR

Formed at similar epoch to Sbc/Sc

	Sbc(Sc)	Mice A	Mice B	IC1623 W	NGC6090	NGC2623
t_{80}	9.7(10.5) Gyr	10.7 Gyr	12.9 Gyr	11.4 Gyr	12.0 Gyr	9 Gyr

Mass contribution of SSPs < 1 Gyr

- Two early-stage mergers: a factor ~2 higher than Sbc/Sc
- More advanced merger NGC2623: a factor ~3 higher
- Mice A: comparable, Mice B: suppressed by a factor 8

1-1.5 HLR

Early-stage mergers formed earlier than Sbc/Sc

	Sbc(Sc)	Mice A	Mice B	IC1623 W	NGC6090	NGC2623
t_{80}	3.3(1.7) Gyr	4.7 Gyr	9.8 Gyr	13.5 Gyr	4.4 Gyr	0.9 Gyr

Mass contribution of SSPs < 1 Gyr

- Comparable in NGC6090 and factor 3 less in IC1623 than Sbc/Sc
- 2 times more mass fraction in NGC2623
- Mice a and Mice B, a factor 5 and 2 less

4. Spatially resolved star formation histories

4.4. cont'd

Global < 2.0 HLR

Similar and intermediate between the values in the center and the disk

	Sbc(Sc)	Mice A	Mice B	IC1623 W	NGC6090	NGC2623
t_{80}	7.3(3.9) Gyr	7.8 Gyr	12.1 Gyr	12.9 Gyr	8.9 Gyr	1.9 Gyr

Mass contribution of SSPs < 1 Gyr

- Two early-stage mergers: Comparable or even lower than Sbc/Sc
- More advanced merger NGC2623: a factor ~2 higher

→Most of the mass was assembled very early, similarly to the same epoch of early type spiral and massive galaxies

Mass formed in the last 1Gyr relative to Sbc/Sc

- Early-stage merger LIRGs: 2 times larger in the center but comparable in the disks
- NGC2623: 3 times in the center and 2 times in the outer region larger
- Mice A(B): A factor 2(4) less mass fraction

5. Spatially resolved recent star formation rates

Radial structure of the Σ_{SFR} and the local sSFR

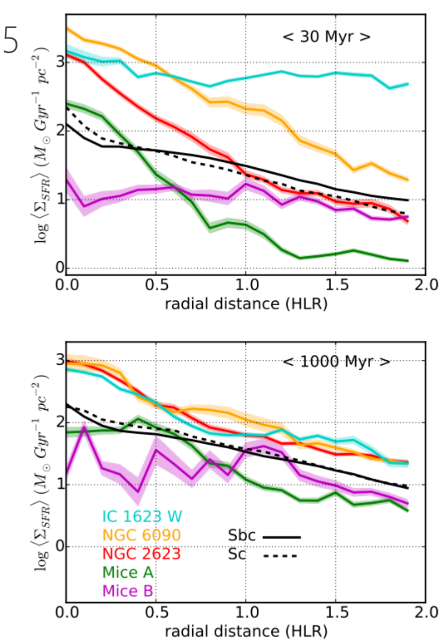
5.1. Choices for the star formation time scale

t_{SF}: the age of the oldest stars to be included to compute recent SFR

- t_{SFR} = 30Myr: Coincides with the lifetime of O and early type B stars, Hα estimate
- t_{SFR} = 300Myr: Young populations emitting UV up to early type A stars, UV estimate
- t_{SFR} = 1Gyr: Intermediate age populations dominated by A and F stars, FIR estimate

5.2. The intensity of the star formation rate, ΣSFR

Fig. 5



t_{SF} = 30Myr

- LIRG-mergers: Enhanced with respect to spirals
- Mice: Significant depression

t_{SF} = 1Gyr

- LIRG-mergers: Some enhancement but radial structures are more similar to each other and spirals
- Mice A: Declining profile and similar to spirals in the center
- Mice B: Variable and depressed in the center

5. Spatially resolved recent star formation rates

t_{SF} = 30Myr: Enhancement/Supression with respect to Sbc(Sc)

	< 0.5 HLR	1-1.5 HLR
IC1623W, NGC6090	1.15(1.05) dex, 1.38(1.28) dex	1.50(1.63) dex, 0.69(0.82) dex
NGC2623	0.83(0.72) dex	-0.16(-0.03) dex
Mice A, Mice B	0.16(0.06) dex, -0.74(-0.84) dex	-1.00(-.087), -0.30(-0.17) dex

- Two early-stage mergers LIRGs: Enhanced both in the inner and outer regions
- NGC2623: Enhanced in the center, but similar or slightly decreased in the outer part
- Mice: Significantly decreased in the disk of Mice A and the whole of Mice B
- Steepness: Mice A(-1.77dex/HLR), NGC2623(-1.74)<NGC6090(-1.18)<IC1623 W(-0.40), Mice B(-0.06)

t_{SF} = 1Gyr

	< 0.5 HLR	1-1.5 HLR
IC1623W, NGC6090, NGC2623	0.64(0.57) dex, 0.74(0.67) dex, 0.73(0.65) dex	0.40(0.37) dex, 0.42(0.39) dex, 0.28(0.24) dex
Mice A, Mice B	-0.07(-0.15)dex, - 0.65(-0.73) dex	-0.50(-0.53), - 0.07(-0.10) dex

- Mergers LIRGs: Enhanced in the centers and slightly enhanced in the outer parts
- Mice: Decreased in the disk of Mice A and the whole of Mice B
- Steepness: Except for Mice B (flat), negative gradient similar to or steeper than spirals

5. Spatially resolved recent star formation rates

5.3. sSFR

LIRG-mergers: Flatter than spirals
Above or equal to 0.1 Gyr^{-1}
~ Threshold between SFGs and quiescent

Mice: Significantly below 0.1 Gyr^{-1}

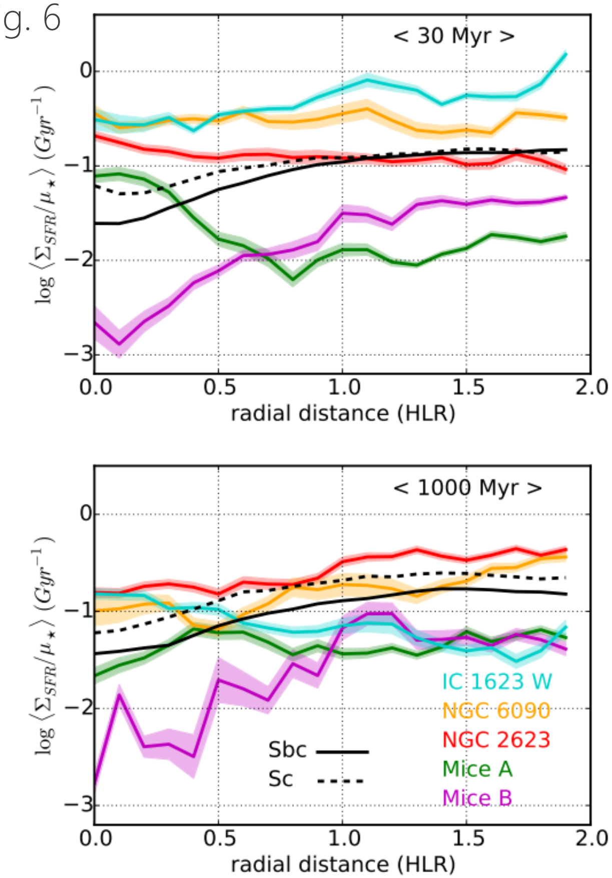
t_{SF} = 30Myr (Comparison with Sbc(Sc))

	< 0.5 HLR	1-1.5 HLR
IC1623W, NGC6090	0.93(0.67) dex, 0.94(0.68) dex	0.69(0.68) dex, 0.36(0.33) dex
NGC2623	0.65(0.38) dex	-0.04(-0.07) dex
Mice A, Mice B	0.15(-0.12) dex, -1.03(-1.30) dex	-1.04(-1.07) dex, -0.57(-0.60) dex

Gradient in the inner 1HLR

- Flat in NGC6090 and NGC2623
  → Forming stars more actively than past
- Positive in IC1623 W → Less SF in the center
- Negative in Mice A → Enhancement in the nucleus
- Positive, steeper in Mice B

Fig. 6



5. Spatially resolved recent star formation rates

5.3. cont'd

t_{SF} = 1Gyr

	< 0.5 HLR	1-1.5 HLR
IC1623W, NGC6090, NGC2623	0.43(0.18) dex, 0.31(0.06) dex, 0.55(0.30) dex	-0.42(-0.61) dex, 0.07(-0.12) dex, 0.38(0.19) dex
Mice A, Mice B	-0.08(-0.33)dex, - 0.94(-1.19) dex	-0.56(-0.75), -0.36(-0.55) dex

- sSFR gradient in the inner 1HLR is from positive to negative

sSFR as the inverse of a time scale for the SF: τ

t_{SF} = 30Myr

- τ for LIRGs (IC1623W~2.7Gyr, NGC6090~3.2Gyr, NGC2623~7.0Gyr) << spirals

t_{SF} = 1Gyr

- τ for early stage mergers ~ spirals (~10Gyr)
  → Enhancement of SF in these objects occurs in times scales of a few 100 Myr
- τ of NGC2623 ~ 5Gyr
  → SFH of it more extended in time

6. Discussion

6.1. Global enhancement of the star formation in mergers

In previous studies (Guo+2016, Pereira-Santaella+2015)

- ULIRGs: Above 1σ of the MS
- LIRGs: Not always true. Depending on SFH and timescale of SFR tracer

For 3 merger-LIRGs

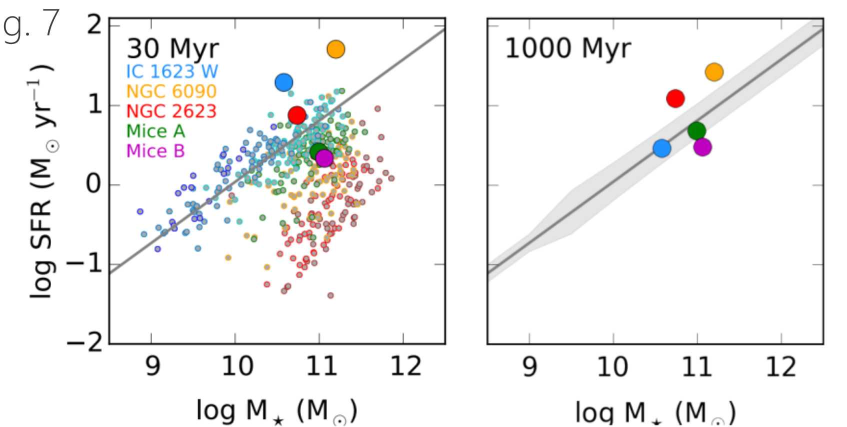
- Enhancement in the t_{SF}<30Myr (IC1623W~x6, NGC6090~x6, NGC2623~x2)
- In 1Gyr timescale, IC1623W is on MS and NGC6090 is enhanced but less than in 30Myr timescale NGC2623 show a slight increase in this timescale

→Major phase of SF in the merger LIRGs: 10^7 to a few 10^8 yr (Consistent with previous studies)
Longer timescale of NGC2623 is also in agreement with Alonso-Herrero+2010

For Mice

- Seen after first passage and probably the least advanced merger
  → SF is still not enhanced

Fig. 7



6. Discussion

6.2. The extent and relevance of the different phases of star formation

With sSFR

	30 Myr		1 Gyr	
	<0.5HLR	1-15.HLR	<0.5HLR	1-15.HLR
IC1623W	x6 enhanced	x5 enhanced	x<2 enhanced	x3-4 decreased
NGC6090	x7 enhanced	moderate (x2)	x<2 enhanced	similar to spirals
NGC2623	x3 enhanced	similar to spirals	x2 enhanced	x2 enhanced
Mice A	similar to spirals	x11 decreased	similar to spirals	x3-4 decreased
Mice B	x14 decreased	x4 decreased	x11 decreased	x3-4 decreased

With the amount of mass formed in each periods, reach totally consistent results

Recent SF of three LIRGs is enhanced, but the amount and spatial extension of enhancement depends on timescale and the galaxy

- Significant on short timescale in the three systems
  but on longer timescale only relevant in the advanced merger

SF in Mice is mostly inhibited especially for Mice B
← Lack of gas in the progenitor (~6%) ← Negative feedback from the AGN at the center

6. Discussion

6.3. Evolutionary scheme

Hydrodynamic simulations (Teyssier+2010, Powell+2013)

- Extended starburst arise spontaneously after the first pericenter passage
- Nuclear-starburst is also present but occurs later, after the second pericenter passage

Most advanced merger NGC2623 , already passed coalescence

- Extended SFR enhancement about <1Gyr ago (First pericenter passage)
- Current SFR enhancement located in the center

Two pre-merger LIRGs IC1623 W and NGC6090 after first pericenter and prior to coalescence

- SFR enhancement in the last 30Myr and spatially extended

Mice passed the first pericenter passage about 170Myr ago

- No evidence of an enhanced SFR, SF is mainly inhibited
  → Least evolved merger and the lack of gas in Mice B
  → Many factors determine when, where, and with which intensity the starburst occurs (Morphology, gas, orbital characteristics, etc.)