

Star formation activity in interacting galaxies: numerical studies



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A gallery of galaxy interactions

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Interacting Galaxies • Arp 87



Whirlpool Galaxy • M51



NASA, ESA, S. Beckwith (STScI), and The Hubble Heritage Team (STScI/AURA) • Hubble Space Telescope ACS • STScI-PRC05-12a

Hubble
Heritage

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Interacting Galaxies • Arp 87

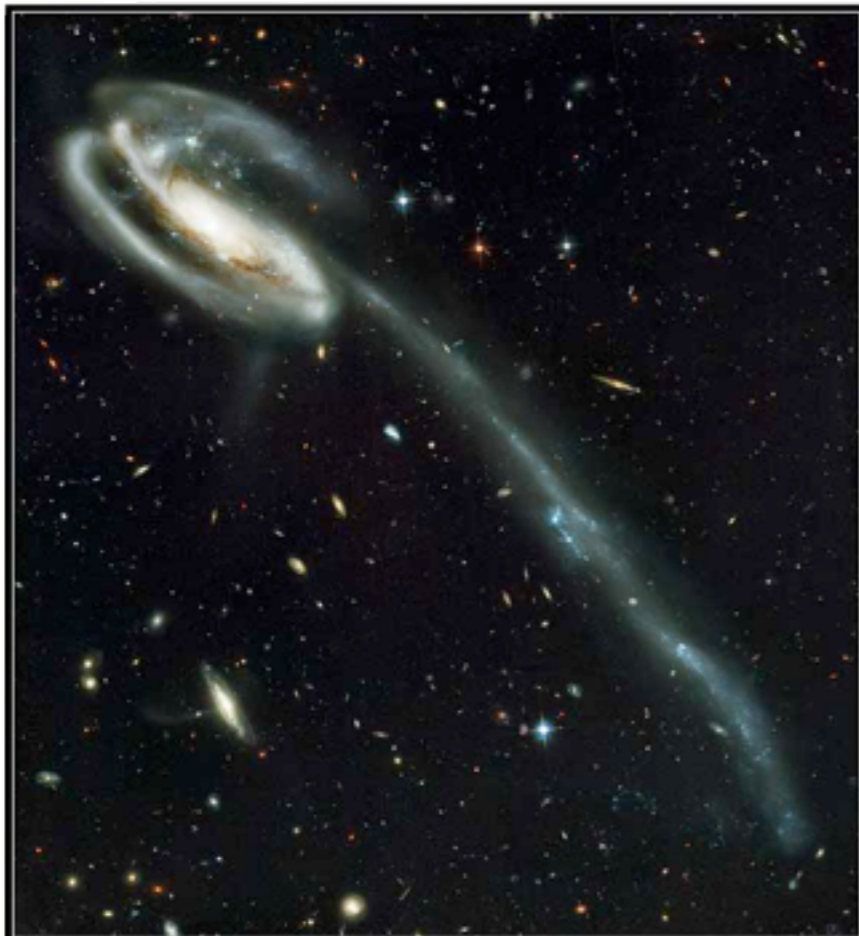


Whirlpool Galaxy • M51



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Tadpole Galaxy • UGC 10214

HST • ACS

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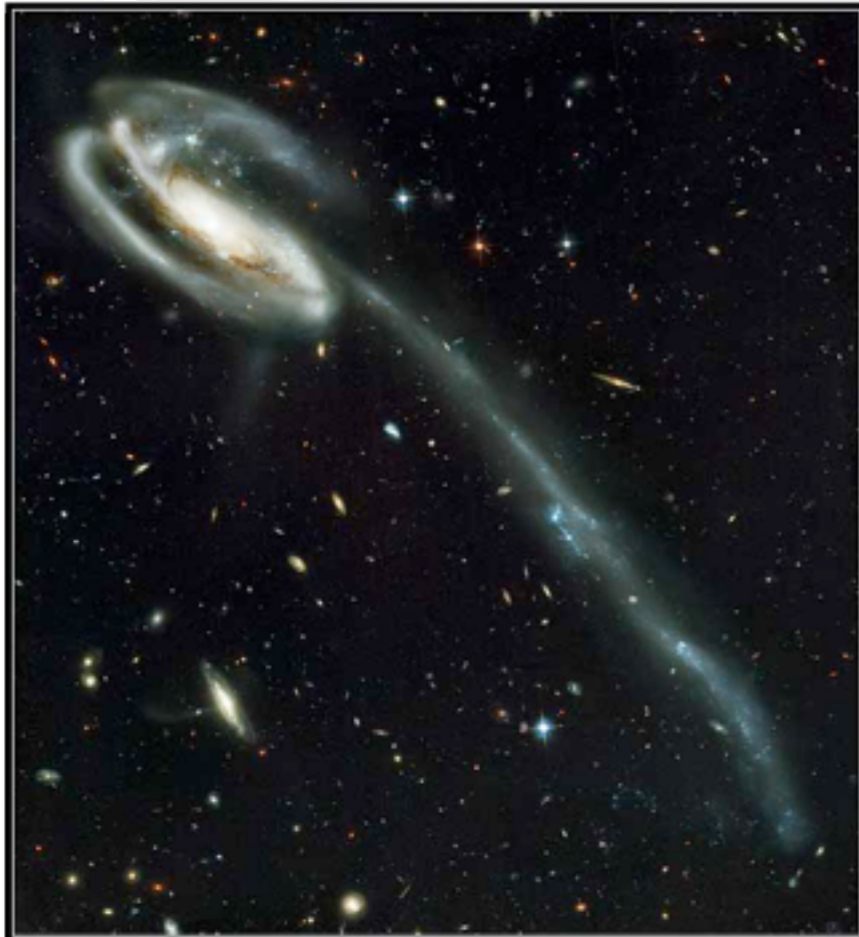
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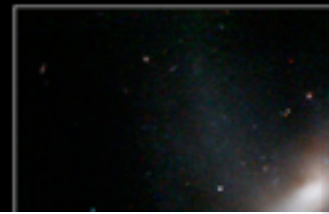


Colliding Galaxies NGC 4038 and NGC 4039 HST • WFPC2

PRC97-34a • ST ScI OPO • October 21, 1997 • B. Whitmore (ST ScI) and NASA

A gallery of galaxy interactions

Interacting Galaxies • Arp 87



Active Galaxy M82



Hubble



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Tadpole Galaxy • UGC 10214

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Colliding Galaxies NGC 4038 and NGC 4039

HST • WFPC2

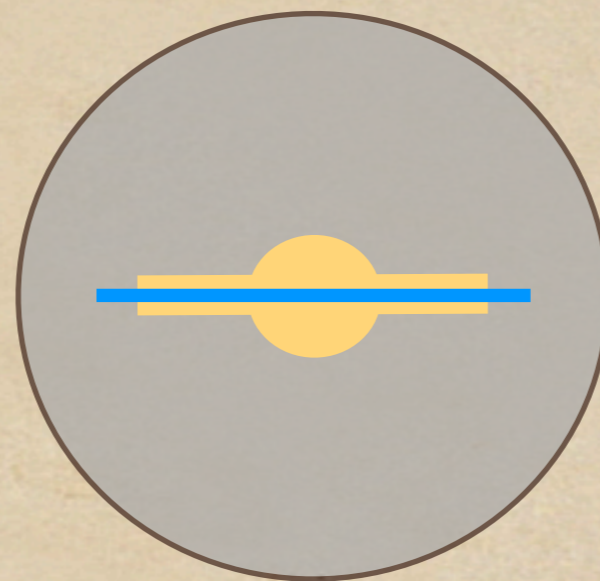
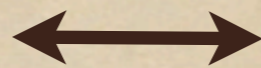
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Interactions and star formation

- ◆ What is the relationship between interactions and star formation?
- ◆ How ubiquitous are massive starbursts in interacting galaxies?
- ◆ What is the range of responses of galaxies to tidal interactions?
- ◆ How are the SFRs related to the morphological properties of the interacting galaxies and to the dynamical properties of the interaction?

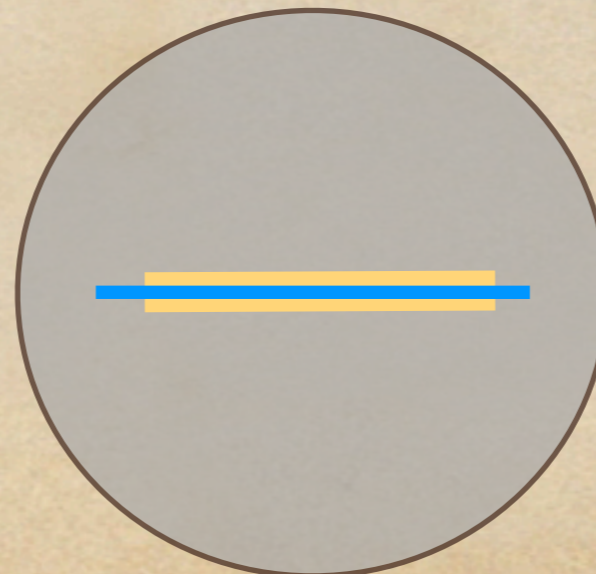
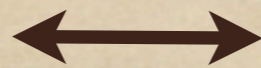
Interactions and star formation: simulations of major mergers (1)

Dark halo



- ◆ **Early-type galaxies interactions**

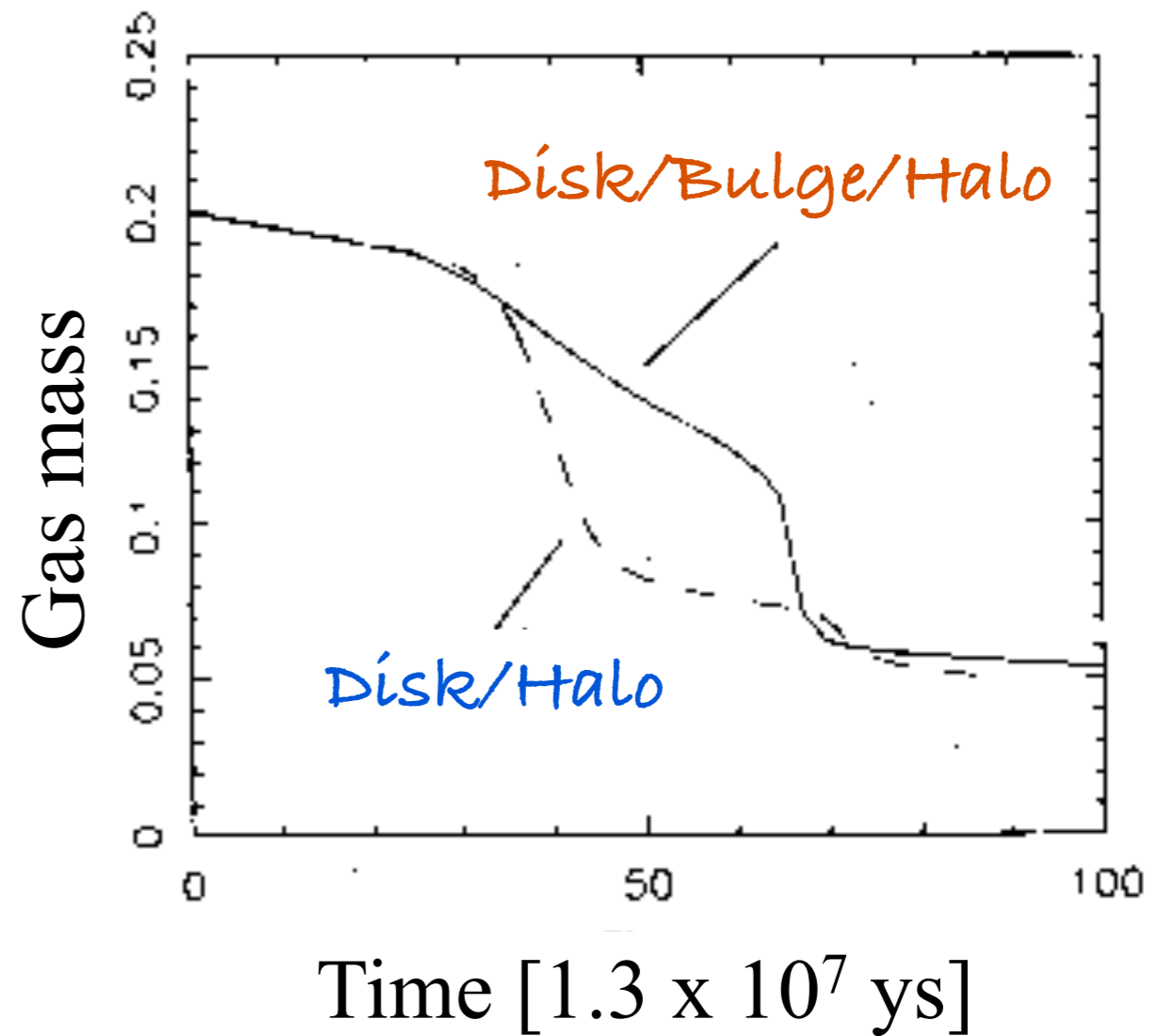
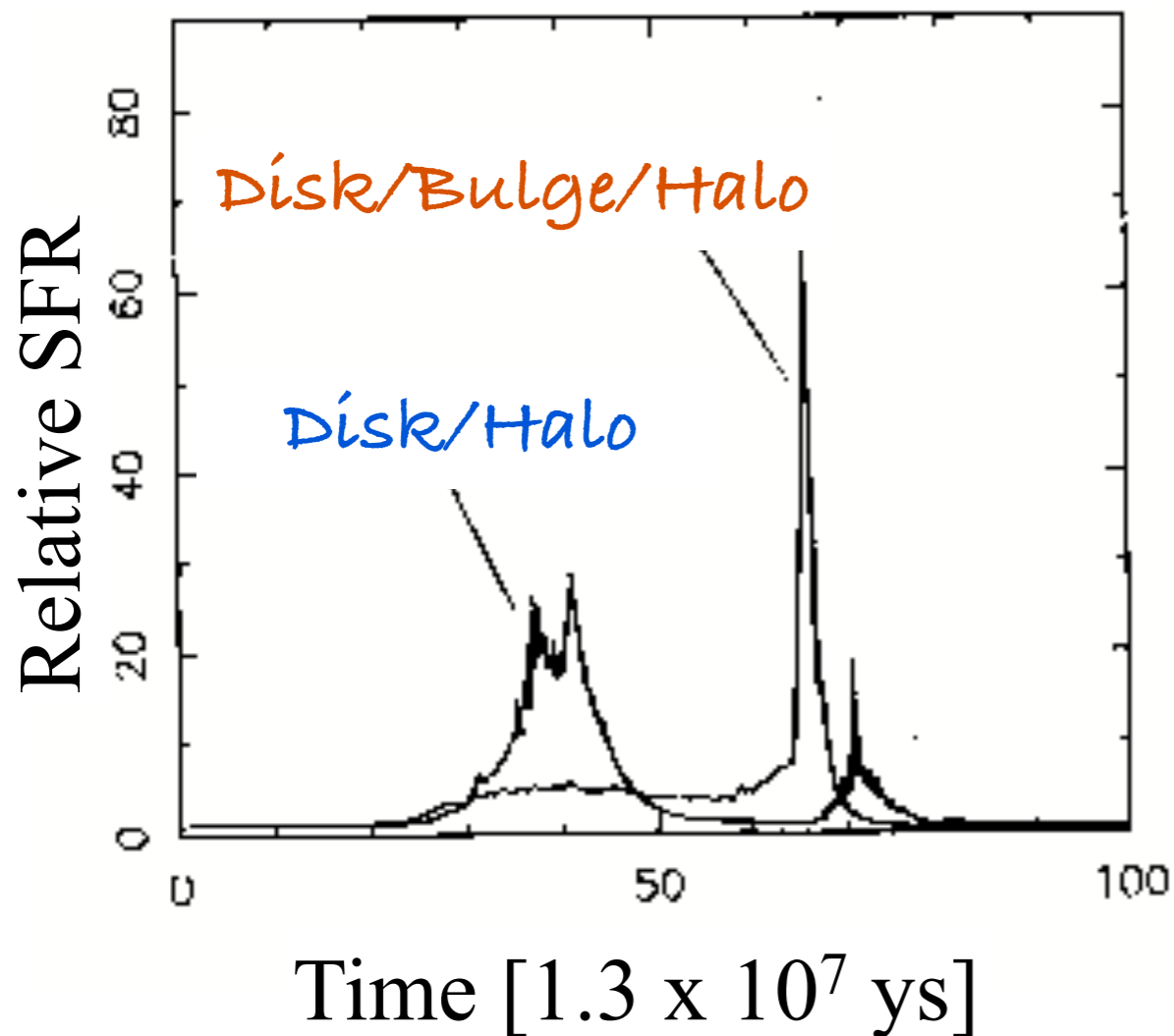
Dark halo



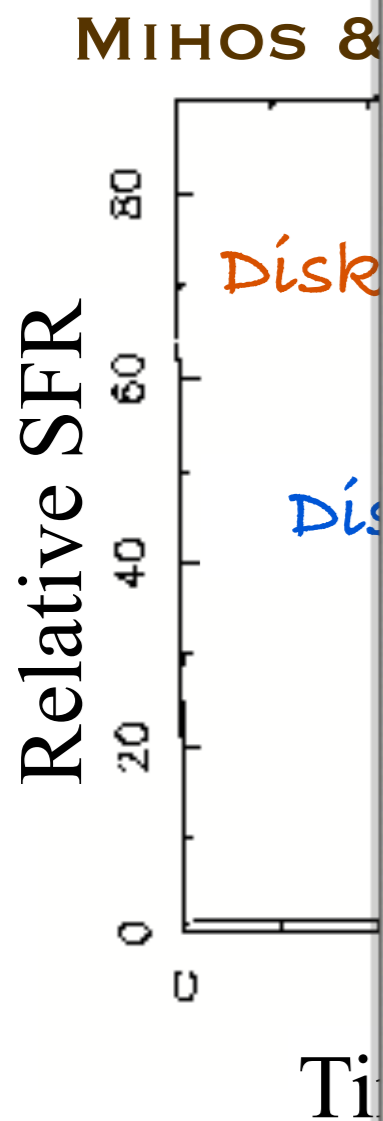
- ◆ **Late-type galaxy interactions**

Interactions and star formation: simulations of major mergers (2)

MIHOS & HERNQUIST, 1994



Interactions and star formation: simulations of major mergers (2)



- ◆ Ultra-luminous starbursts in major mergers
- ◆ The structure of the merging galaxies determines the nature of the starburst event
- ◆ The presence of a bulge stabilizes the disk against bar formation, suppressing gas inflow and the starburst until the final phases of the merger

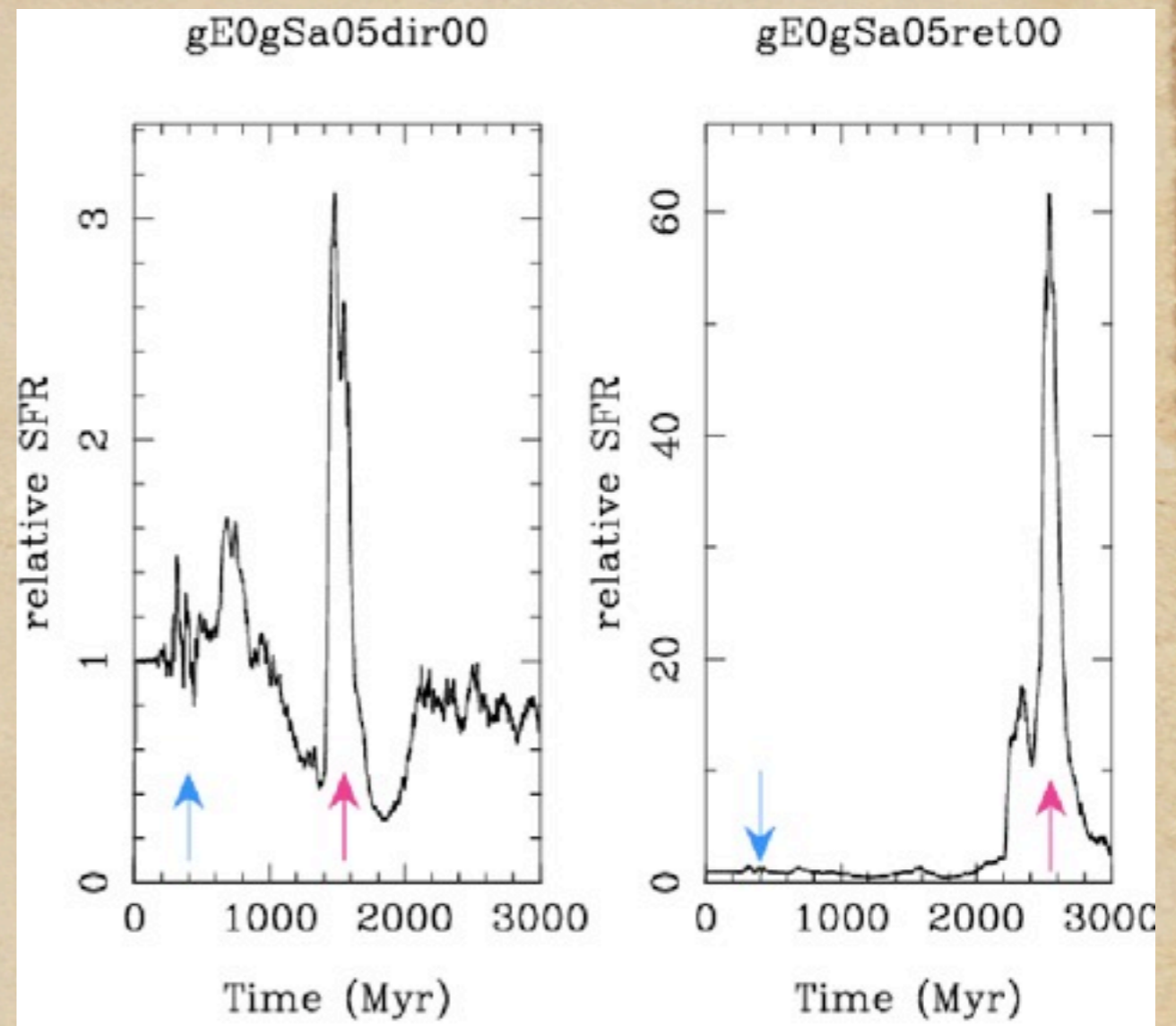
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Interactions and star formation: simulations of major mergers (3)

~120 simulations of
interacting pairs

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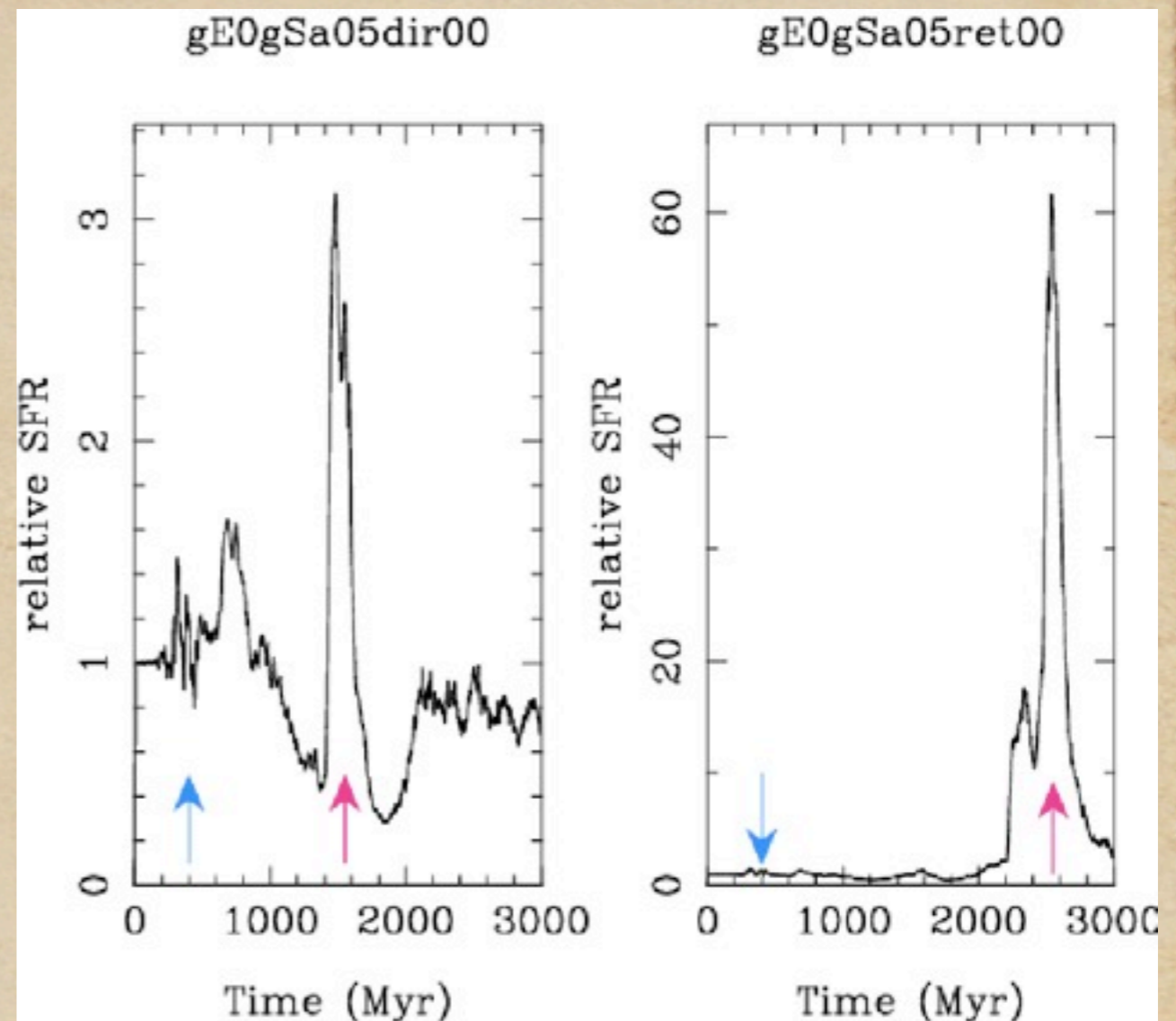


**DI MATTEO, COMBES, MELCHIOR &
SEMELIN, 2007**

Interactions and star formation: simulations of major mergers (3)

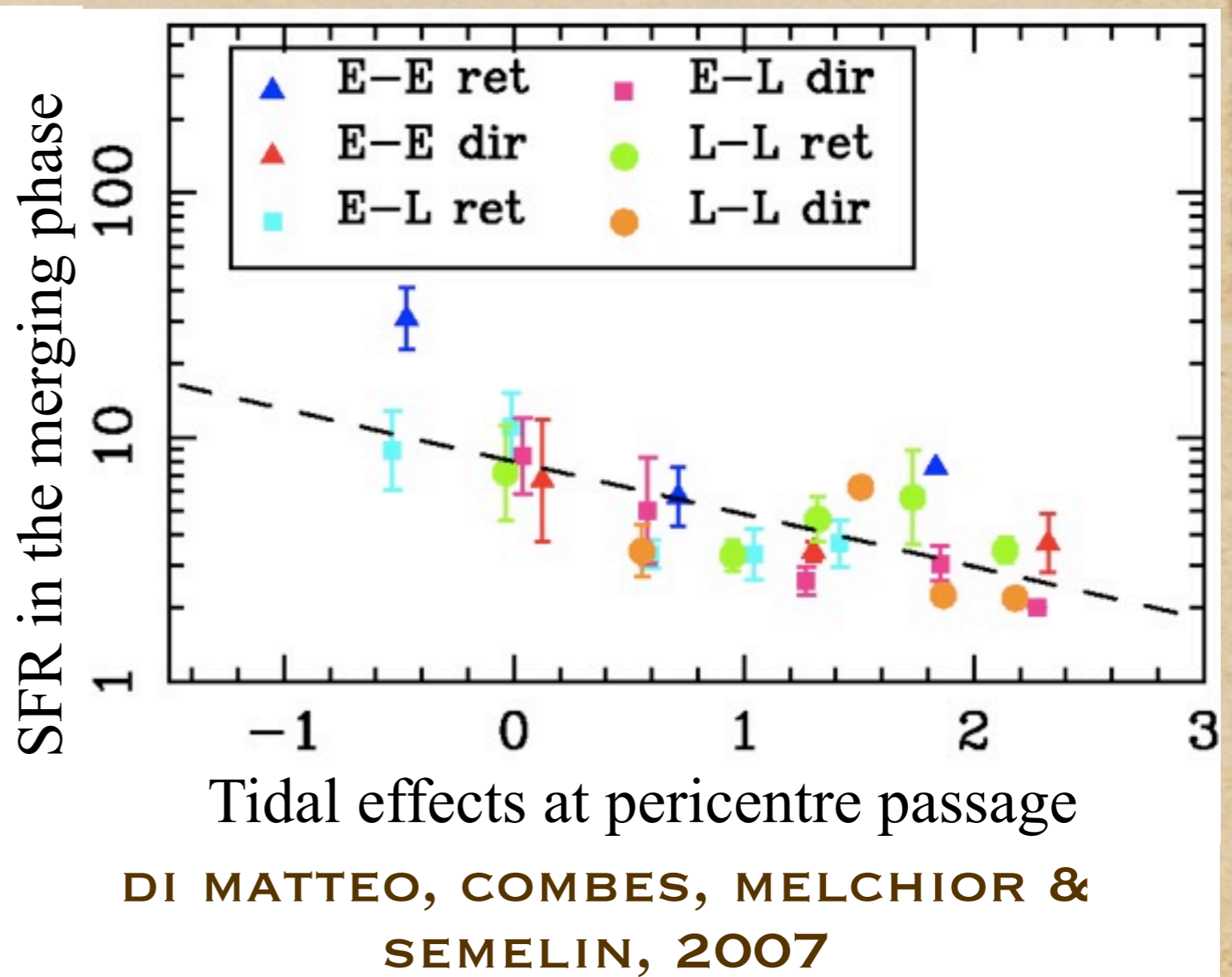
~120 simulations of
interacting pairs

A variety of SF
histories can be
found, from starburst
galaxies to low SF
enhancements



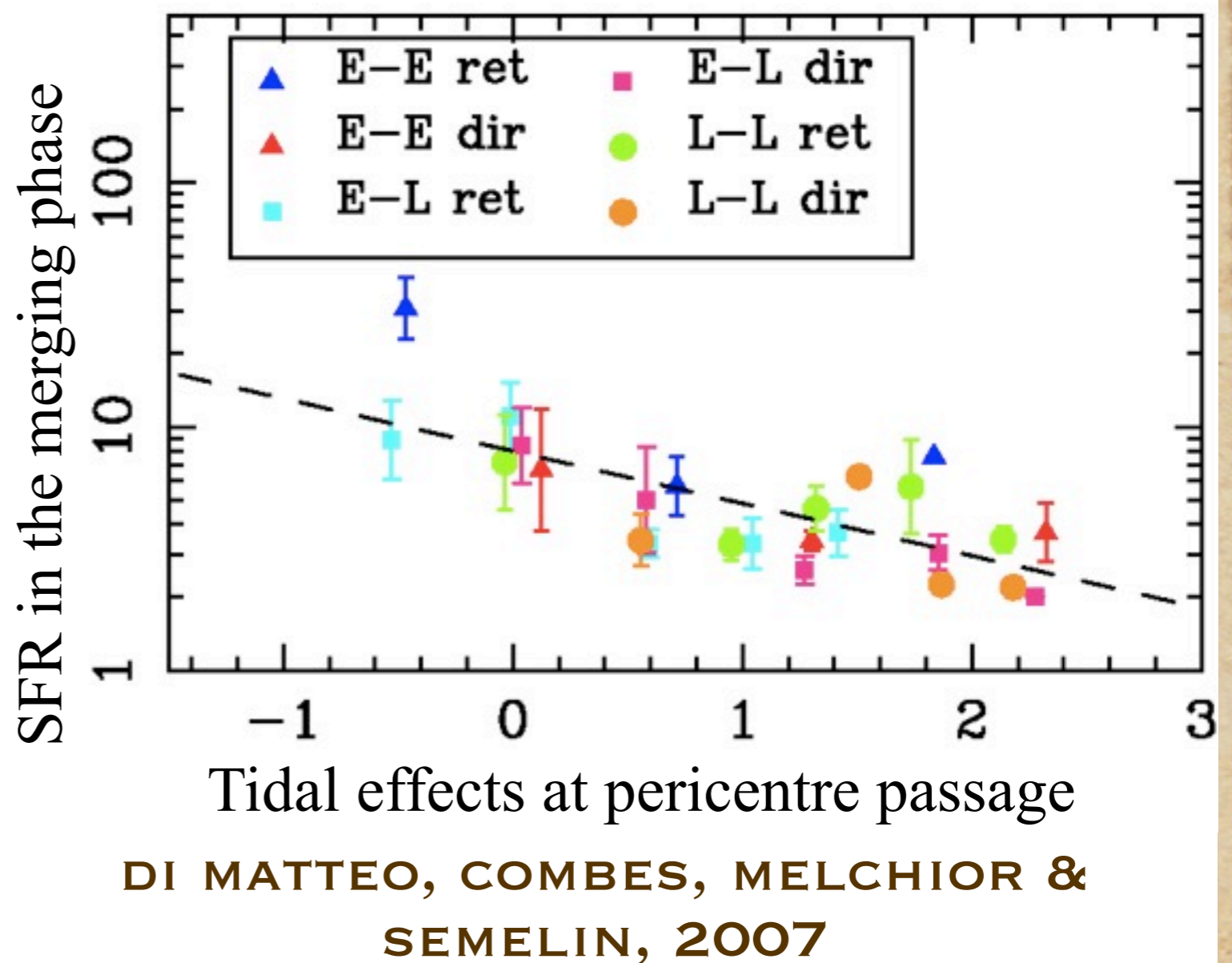
DI MATTEO, COMBES, MELCHIOR &
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Interactions and star formation: simulations of major mergers (4)



Interactions and star formation: simulations of major mergers (4)

The stronger the tidal effects at the first pericenter passage, the lower the SF enhancement in the merging phase



Interactions and star formation: simulations of major mergers (5)

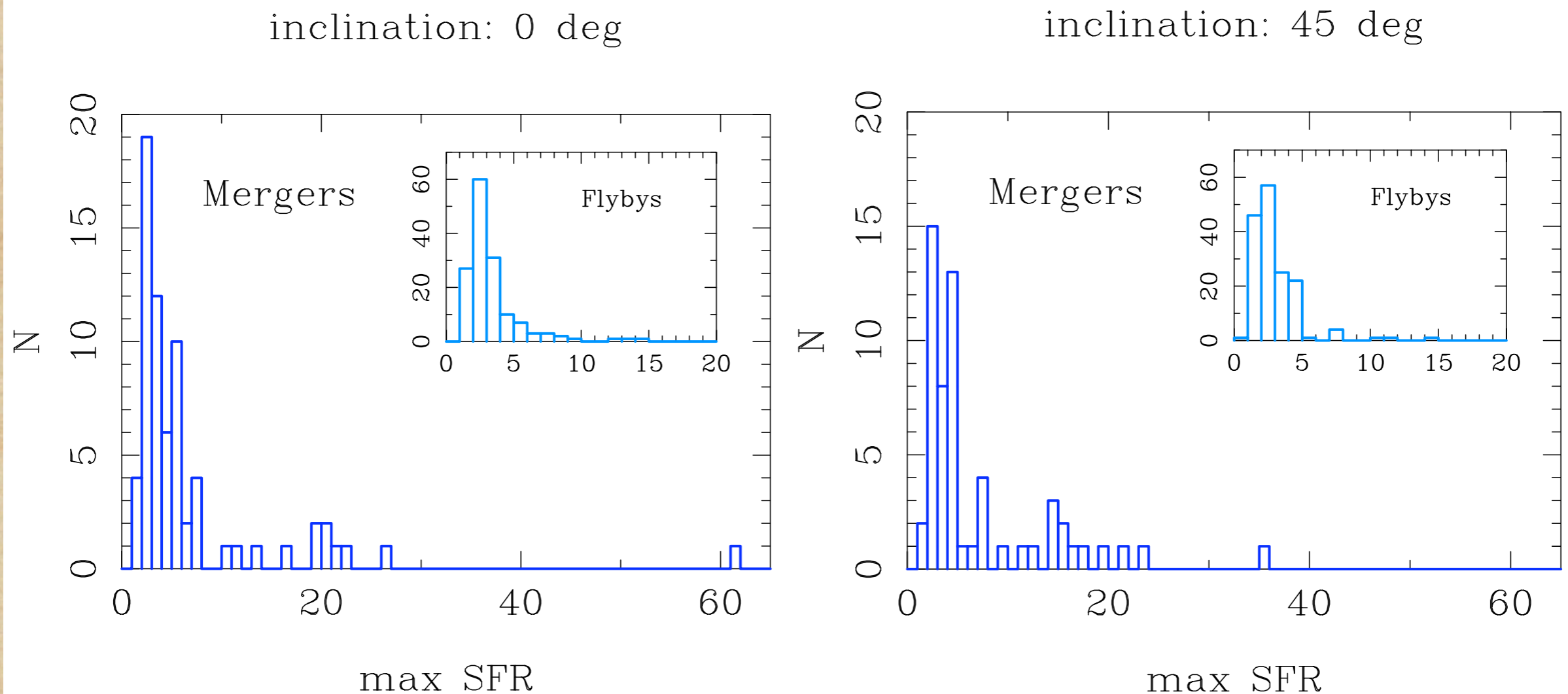
~1000 simulations of interacting
pairs

DI MATTEO, BOURNAUD,
MARTIG ET AL. 2008

Interactions and star formation: simulations of major mergers (5)

~1000 simulations of interacting
pairs

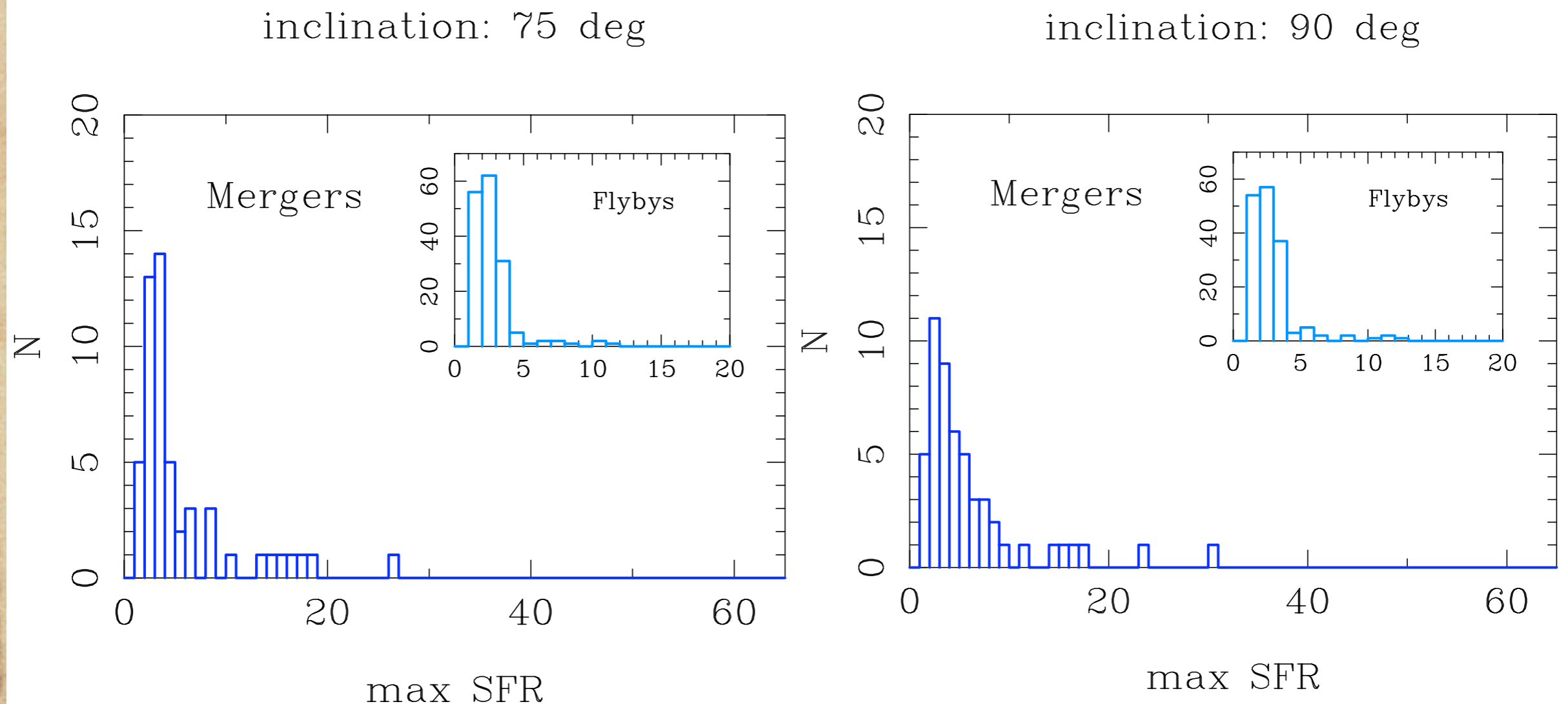
Interactions and star formation: simulations of major mergers (5)



~1000 simulations of interacting
pairs

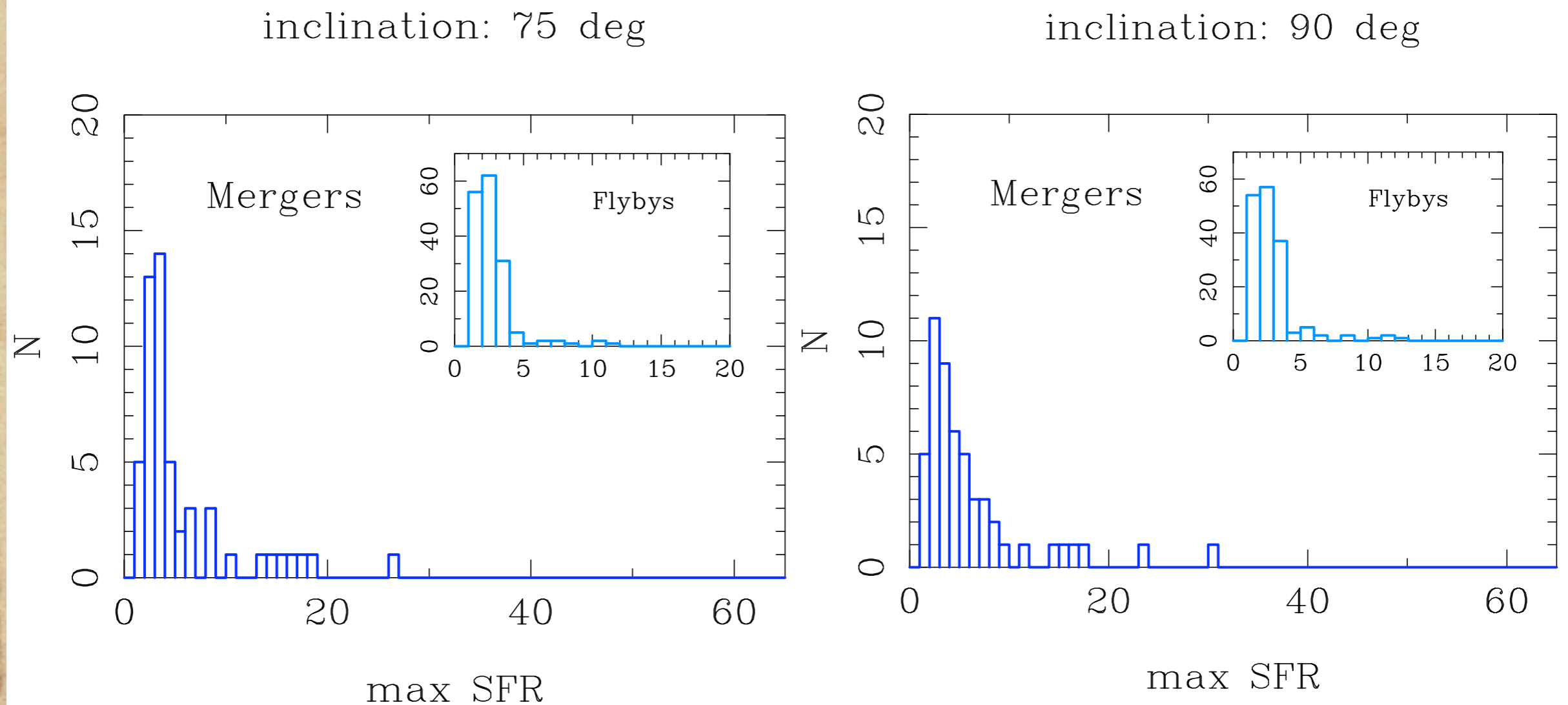
DI MATTEO, BOURNAUD,
MARTIG ET AL. 2008

Interactions and star formation: simulations of major mergers (6)



DI MATTEO, BOURNAUD, MARTIG ET AL. 2008

Interactions and star formation: simulations of major mergers (6)

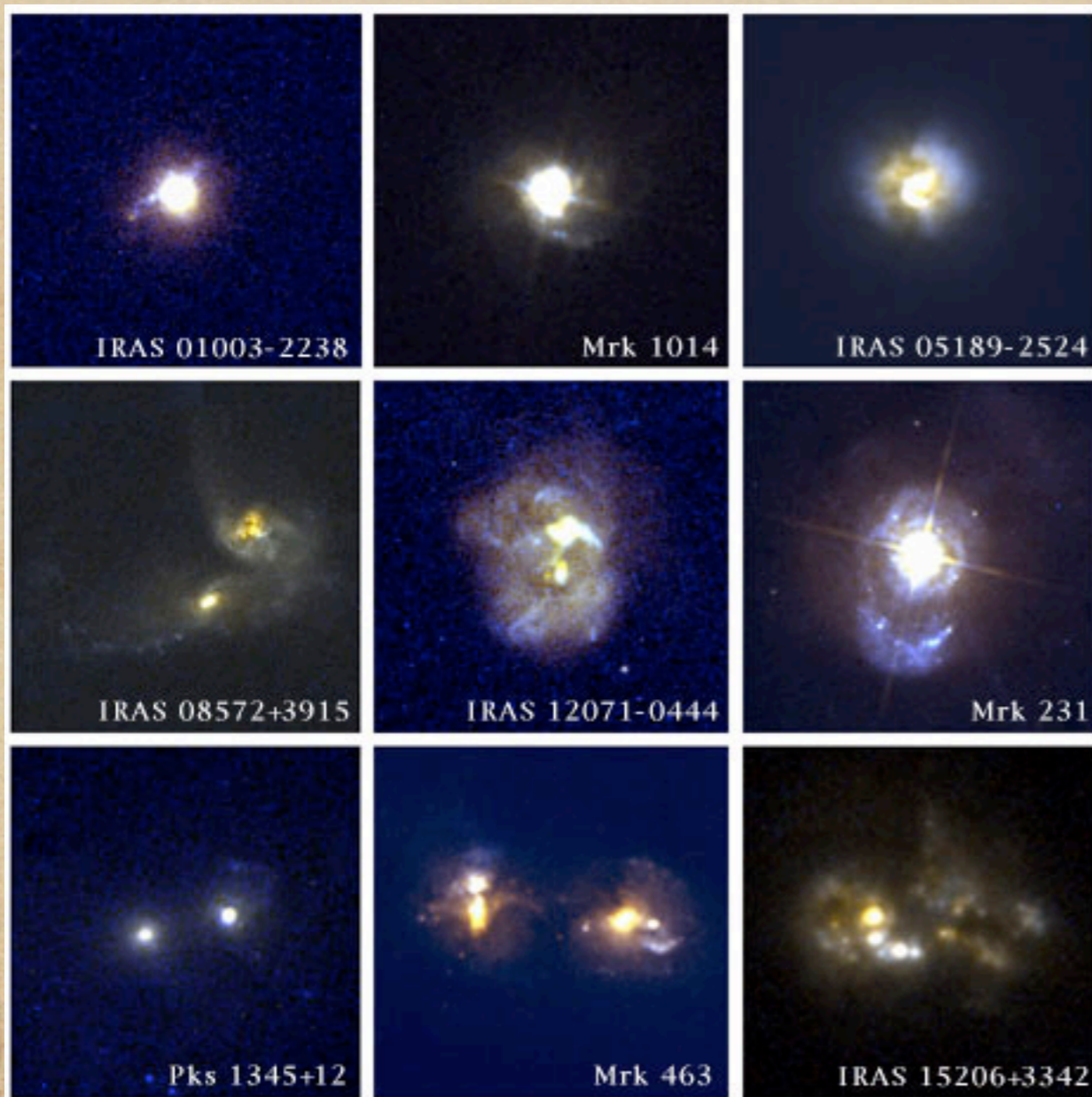


Interactions and star formation:
simulations of major mergers (7)

Interactions and star formation: simulations of major mergers (7)

- ◆ **Galaxy interactions rarely trigger starbursts!**
- ◆ The majority of the encounters ($\sim 85\%$) produces a SF enhancement less than a factor of 5
- ◆ Typical duration of a few 10^8 yr

Interactions and star formation: comparison with observations (1)



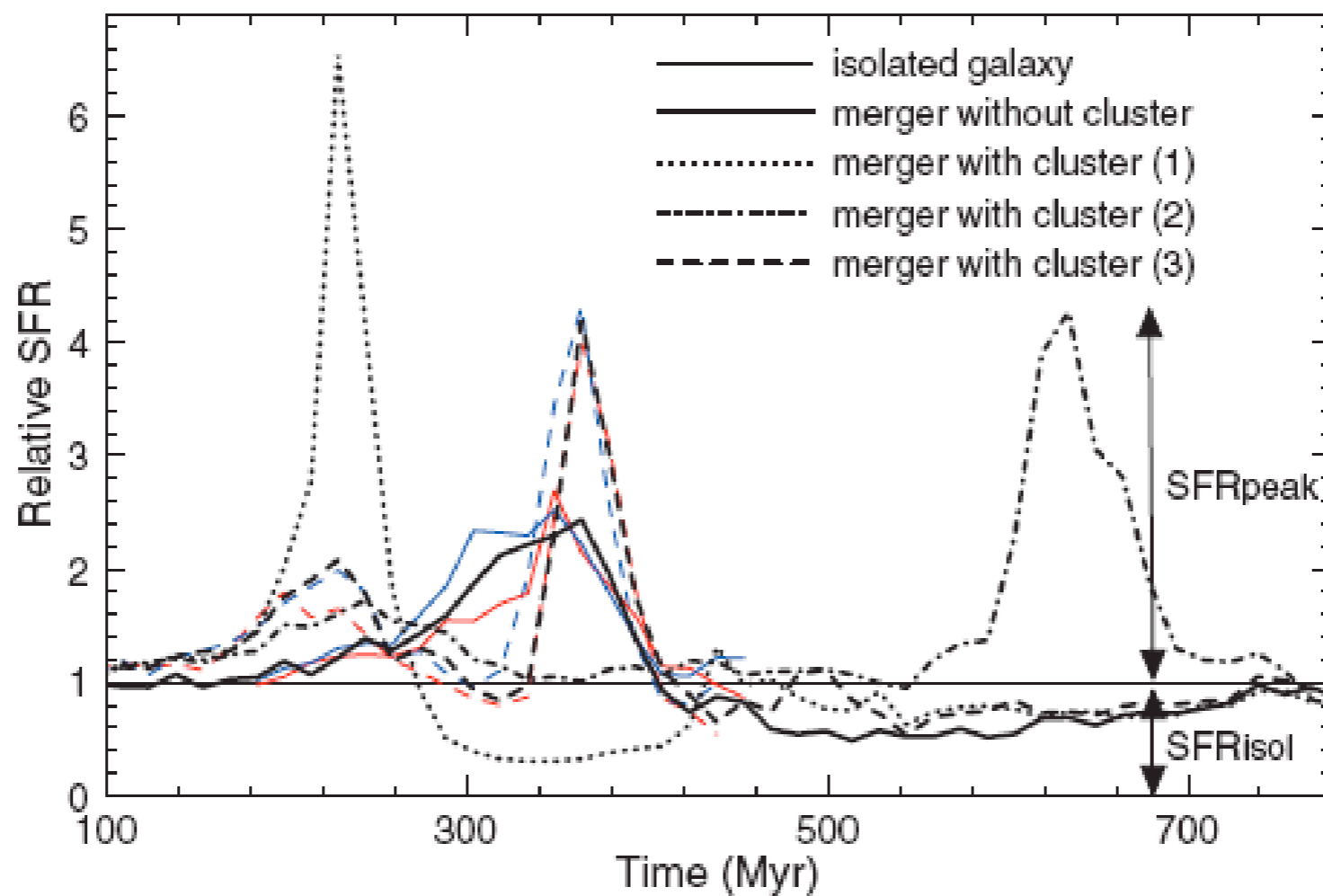
- ◆ At low redshift, most of the ULIRGs in interacting systems (Sanders & Mirabel 1996)
- ◆ But the reciprocal is not true (Bergvall et al. 2004)

Interactions and star formation: comparison with observations (2)

Interactions and star formation: comparison with observations (2)

- ◆ **Knapen & James, 2009:** local galaxies with close companions have SFR increased by a factor of 2 at most with respect to galaxies without companions.
- ◆ **Li et al. 2008:** The SFR enhancement is a function of the projected separation r_p of the companions. Enhancements of a factor 1.5-4 for companions with $r_p < 20$ kpc.
- ◆ **Jogee et al. 2008:** over $z \sim 0.24-0.80$, the average UV-based and UV+IR-based SFR of mergers *are only modestly enhanced*, at best by a factor of a few, compared to the non-interacting galaxies.

Interactions and star formation: major mergers in groups and clusters



MARTIG, BOURNAUD 2008

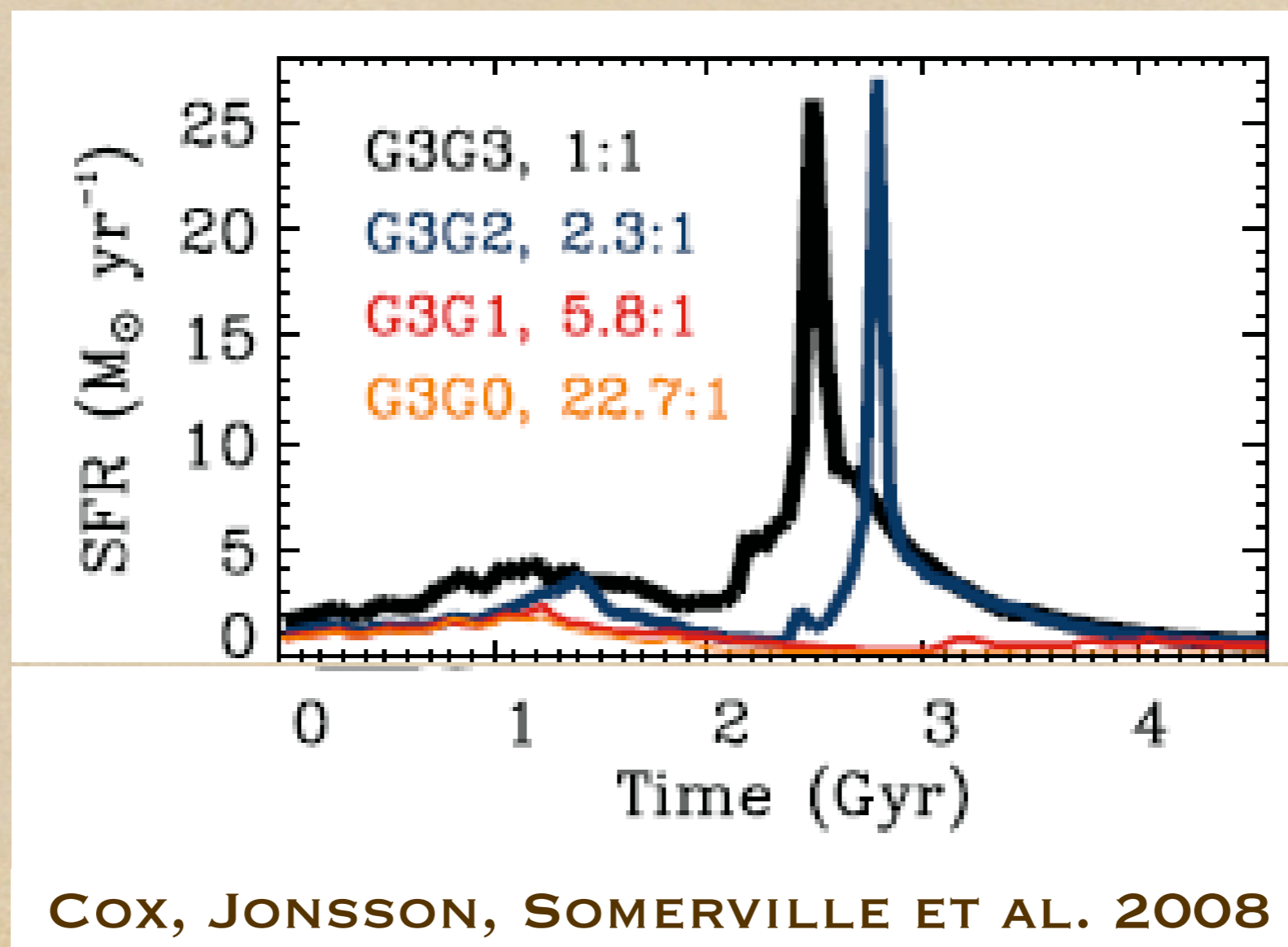
Interactions and star formation: major mergers in groups and clusters



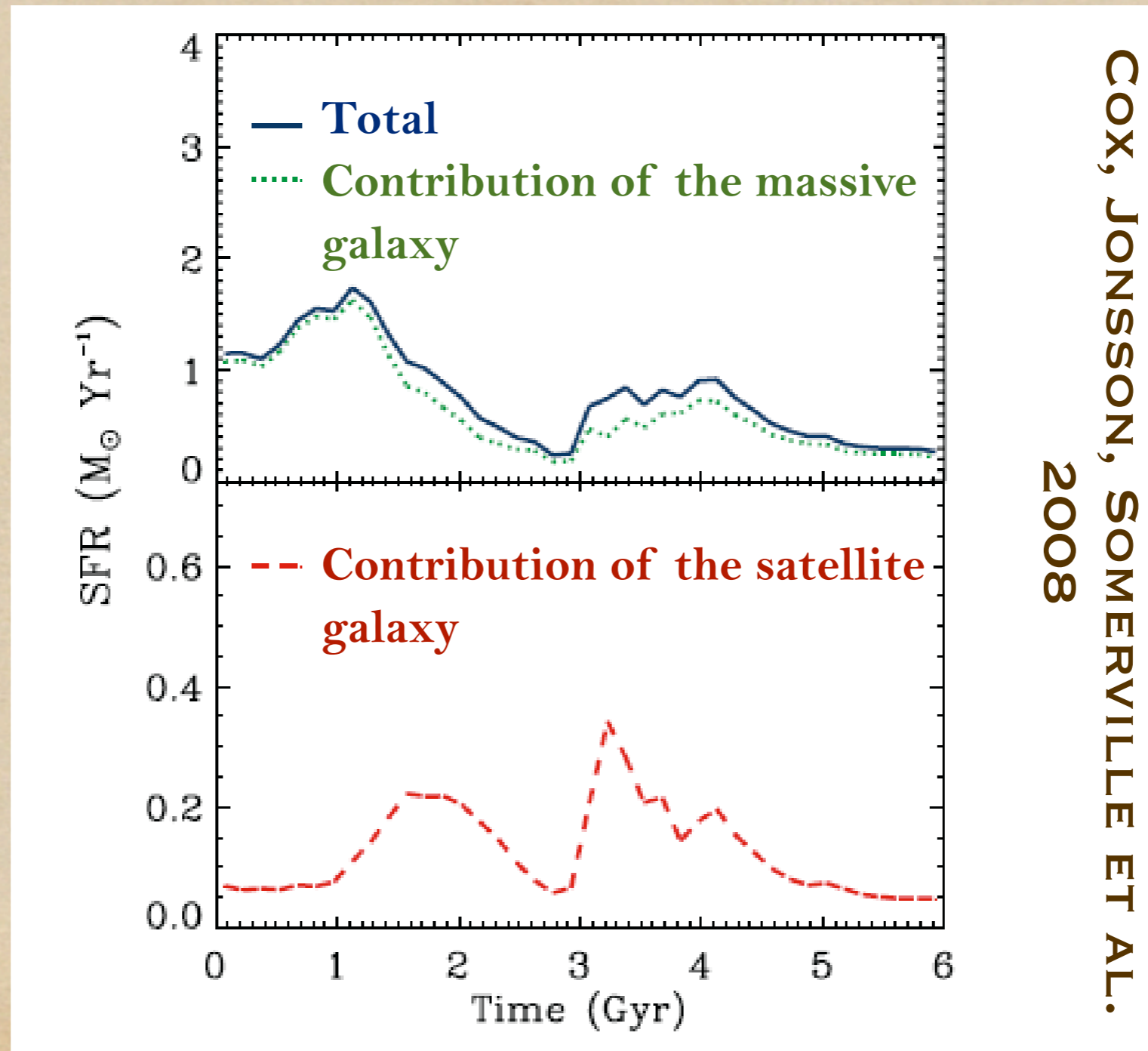
- ◆ Major galaxy mergers can have SFR amplified by a factor of 2 (with respect to mergers in the field) on average if they take place in the tidal field of a group or a cluster

MARTIG, BOURNAUD 2008

Interactions and star formation: dependency on the galaxy mass ratio



Interactions and star formation: dependency on the galaxy mass ratio



Interactions and star formation: Conclusions (1)

Interactions and star formation: Conclusions (1)

Using a large number (~ 1000) of simulations of galaxy interactions:

- ◆ Major interactions and mergers can produce a **variety of SF histories**, from low SF enhancements to starburst episodes
- ◆ In most of the cases, **the SF enhancement is less than a factor of 5**, i.e. starbursts in interacting and merging galaxies are rare!
- ◆ **Good agreement with observations**

Interactions and star formation: Conclusions (2)

Interactions and star formation: Conclusions (2)

- ◆ Mergers in the peripheries of groups and clusters can have a SF enhanced of a factor of 2 with respect to mergers in the field
- ◆ **The SF efficiency decreases with the mass ratio**
- ◆ **For high mass ratios, the SF enhancement takes place mostly in the satellite galaxy**