

Minor mergers: fundamental but unexplored drivers of galaxy evolution

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Based on:
Kaviraj 2014, MN, 440, 2944
Kaviraj 2014, MN, 437, L41



The role of minor mergers

- Responsible for size growth of massive galaxies (e.g. Oser +12, Newman +12)
- Drive star formation in early-type galaxies (e.g. Kaviraj +11, Davis +13)
- May induce much of the morphological transformation at $z > 1$ by triggering disk instabilities (e.g. Welker +15)



Studying minor mergers

What is the role of minor mergers in driving star formation?

Theory: minor mergers drive radial inflows of gas, accelerating star formation ([Hernquist+ 98](#), [Hopkins +08](#))



Studying minor mergers

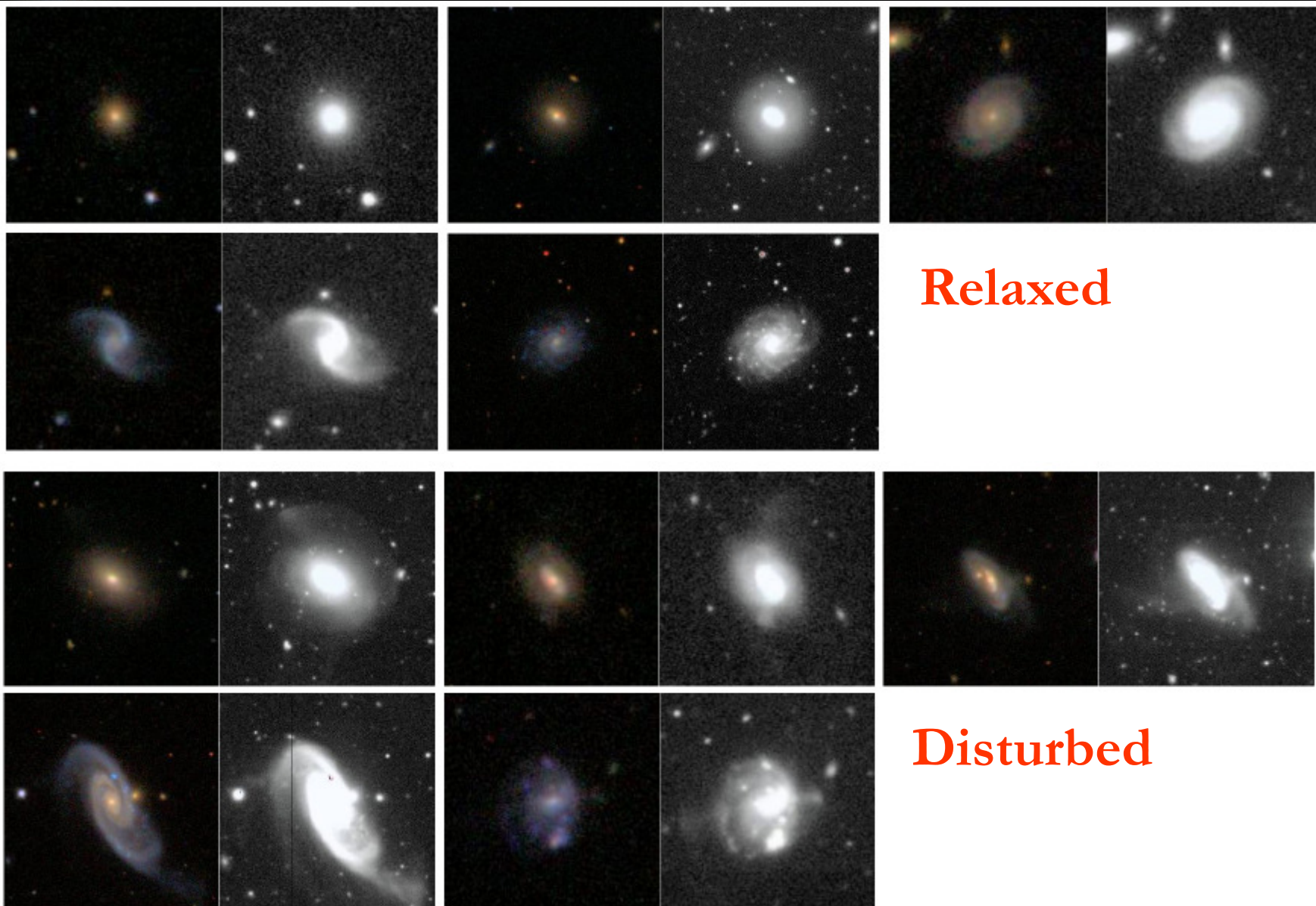
- Minor mergers poorly studied because (1) close pairs work difficult (2) tidal debris from minor mergers very faint
- Star formation enhanced in minor merger *remnants* (Woods+ 07, Ellison +13)
- Need deep, wide survey → large sample of minor-merger remnants
- Use SDSS Stripe 82: 300 deg², two mags deeper than standard SDSS



Selecting minor mergers from Stripe 82

- Major mergers destroy disks and create spheroids (e.g. [Barnes+ 02](#))
- **Disturbed spirals** are minor merger remnants (disk still intact)

Selecting minor mergers from Stripe 82



Relaxed

Disturbed



How much SF is driven by minor mergers?

Need to know:

- (1) enhancement in star formation η due to minor merger
- (2) fraction of time **D** galaxy spends in enhanced SF mode



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$$S = \underbrace{\phi_0 \cdot (1 - D) \cdot m \cdot \delta t}_{S_{\text{NORM}}} + \underbrace{\eta \cdot \phi_0 \cdot D \cdot m \cdot \delta t}_{S_{\text{MM}}}$$



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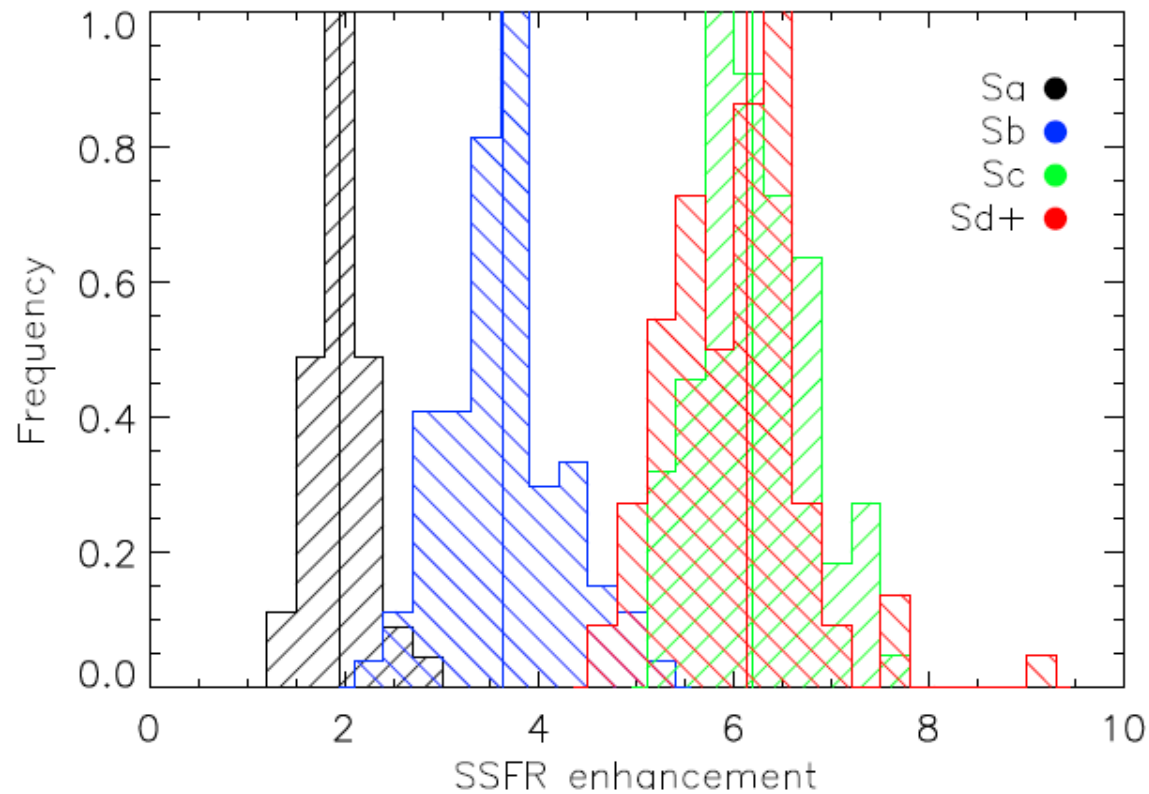
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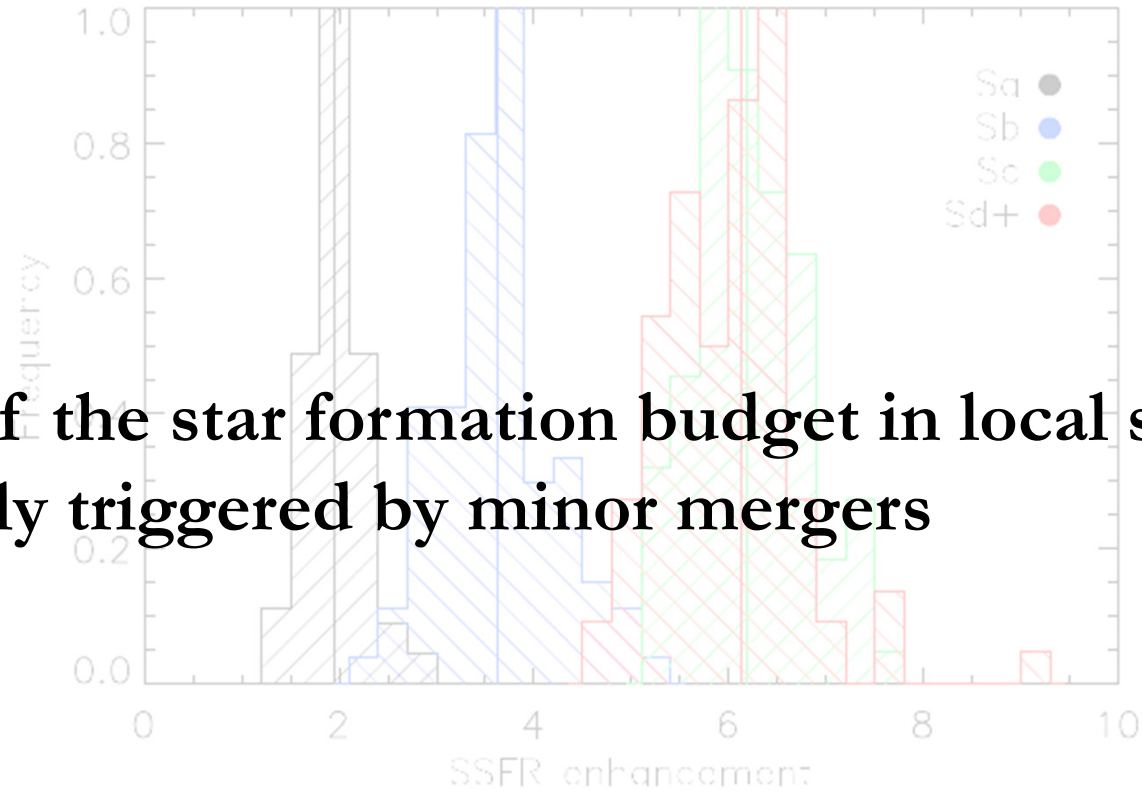
$$F_{\text{MM}} = \frac{S_{\text{MM}}}{S} = \frac{\eta \cdot D}{1 + D \cdot (\eta - 1)}$$

How much SF is driven by minor mergers?



Morphology	D	η	F_{mm}	Proportion of spiral SF budget
Sa	0.16	1.98	0.27	0.19
Sb	0.17	3.62	0.43	0.34
Sc	0.13	6.15	0.48	0.32
Sd/Irr	0.11	6.14	0.43	0.15

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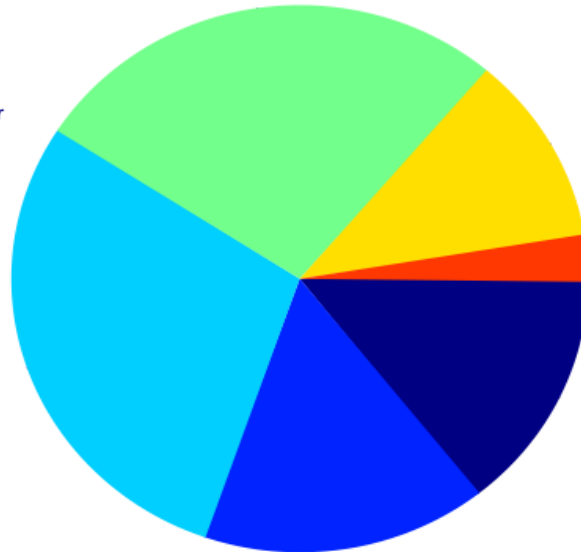
40% of the star formation budget in local spirals is likely triggered by minor mergers

Morphology	D	η	F_{mm} (via Eqn. 2)	Proportion of spiral SF budget (from K13)
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How much SF is driven by minor mergers?

SFR budget (Vmax corrected)

- E/S0
- Sa
- Sb
- Sc
- Sd
- Irr/Mgr



**E/S0 fraction ~
14%**

Morphology	Fraction of star formation budget
E/S0	0.143 ± 0.056
Sa	0.160 ± 0.063
Sb	0.288 ± 0.090
Sc	0.271 ± 0.100
Sd	0.112 ± 0.041
Irr/Mgr	0.026 ± 0.019

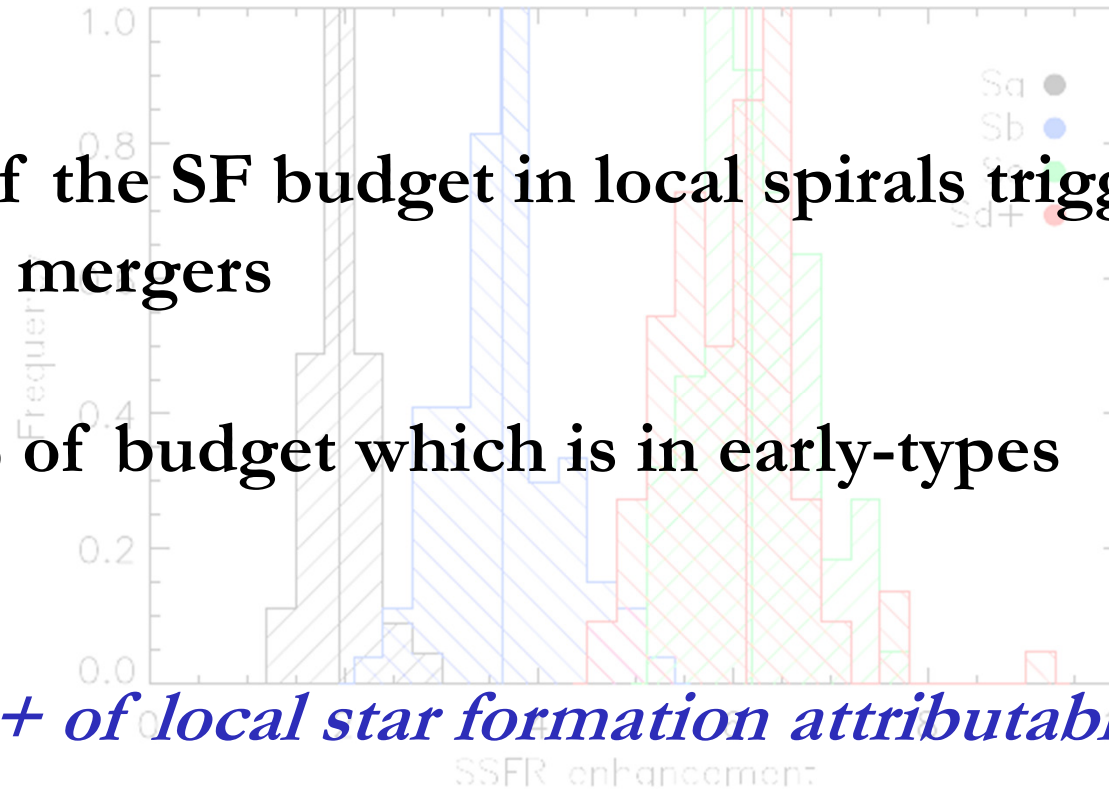
Kaviraj 2014, MN, 437, L41

How much SF is driven by minor mergers?

40% of the SF budget in local spirals triggered by minor mergers

+ 14% of budget which is in early-types

=50%+ of local star formation attributable to the minor-merger process



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Summary

Kaviraj 14, MN, 440, 2944 and Kaviraj 14, MN, 437, L41

- Minor mergers drive $\sim 40\%$ of SF in disk galaxies and around half of all local SF
- Fundamental process in galaxy evolution but poorly understood
- Systematic studies of minor mergers needed using Euclid, DES, LSST etc.