Stellar Mass Tully-Fisher Relation Evolution in Disk Galaxy Merger Simulations

Joel Primack
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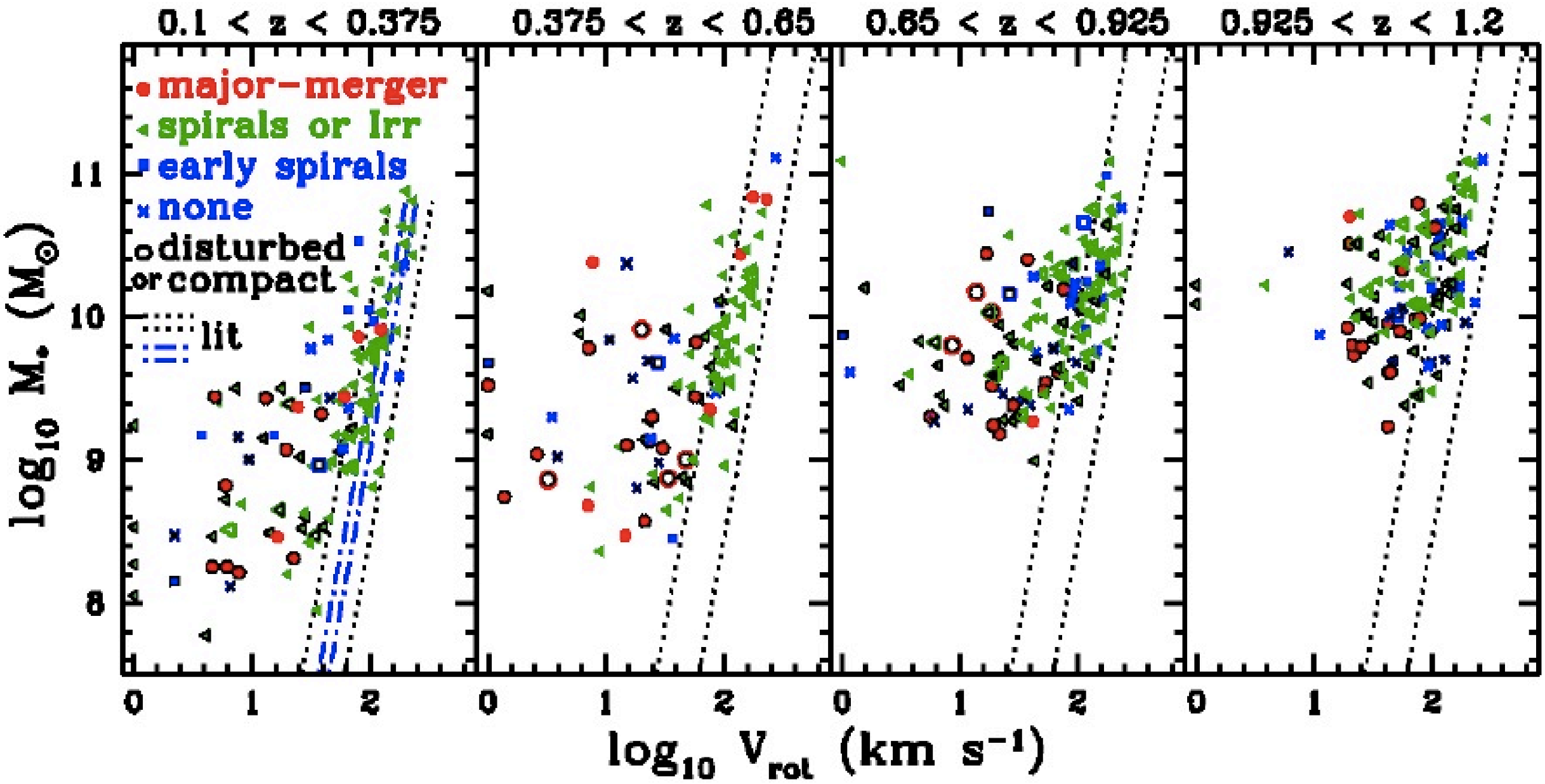
Here we analyse a suite of merger simulations of disk galaxies initially set up to obey the TF law. The relation between $S_{0.5}$ and stellar mass holds not only for progenitor disks but also for spheroidal remnants and intermediate disturbed/merging stages. The $S_{0.5}$-stellar mass relation is thus a link between the TF and FJ laws. We also find that the $S_{0.5}$ parameter tracks the mass, including both baryonic and dark matter components, of all types of galaxies.

Jerusalem Galaxy Workshop - Institute for Advanced Studies of Hebrew University - June 13, 2008

THE STELLAR MASS TULLY-FISHER RELATION TO Z = 1.2 FROM AEGIS

Susan Kassin et al., ApJ Letters, 2007



M* TF relations { z ~ 0, Bell & de Jong 2001; z ~ 1, Conselice et al. 2005

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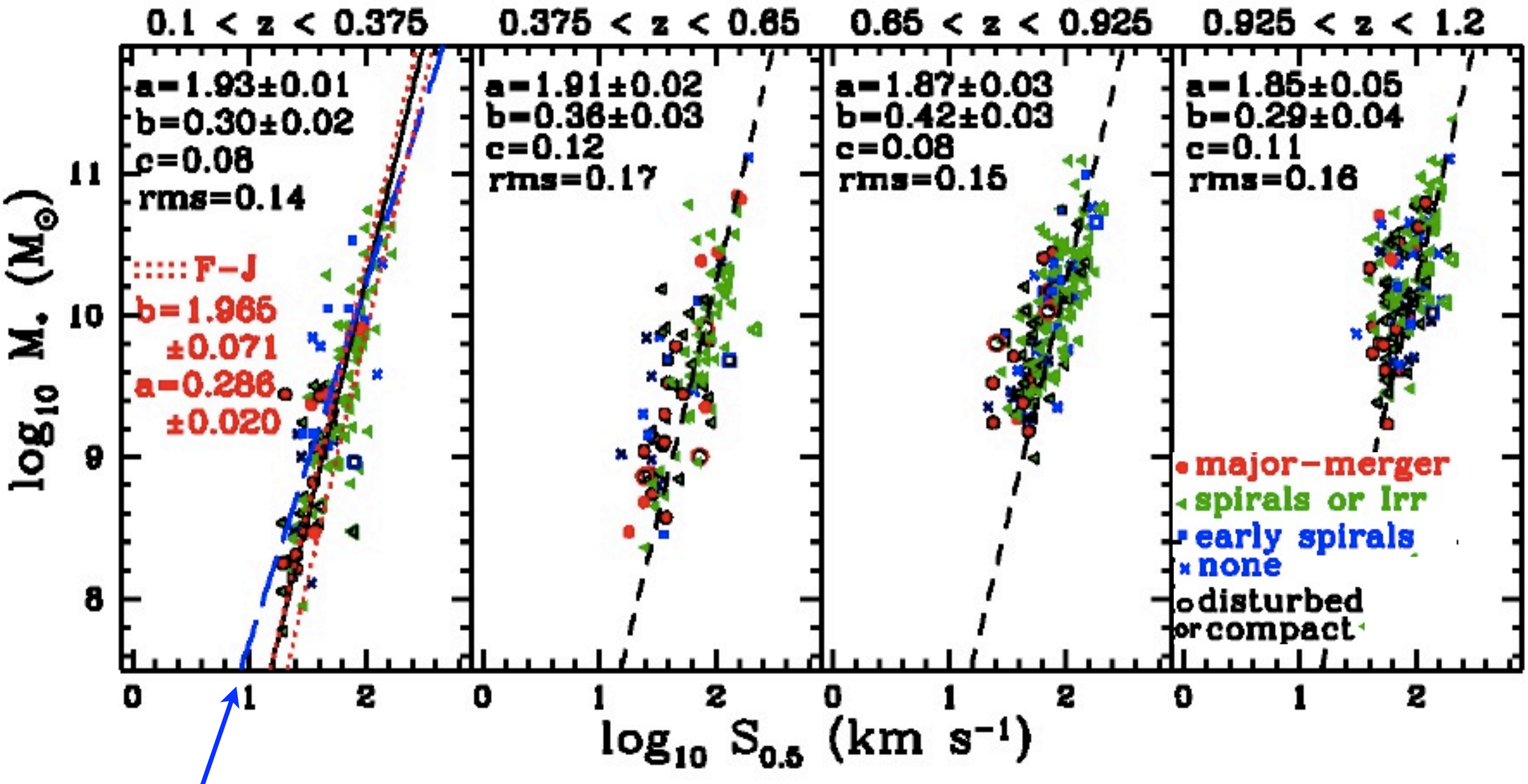

local $S_{0.5}$-M* relation

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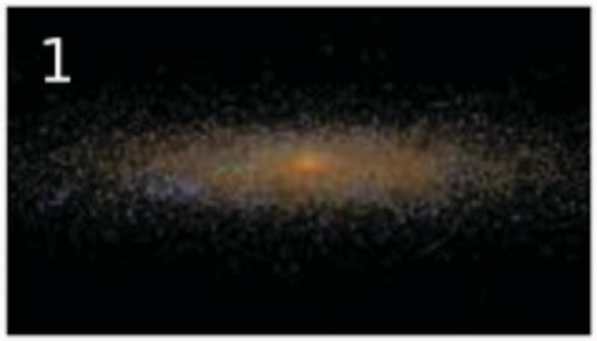
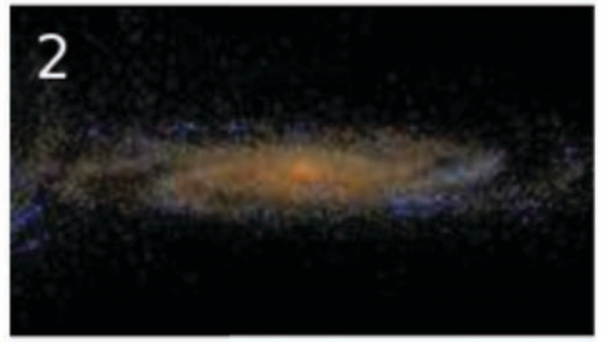
Matthew D. Covington, Susan A. Kassin,
Aaron A. Dutton, Benjamin J. Weiner,
Thomas J. Cox, Patrik Jonsson,
Joel R. Primack, Sandra M. Faber, &
David C. Koo

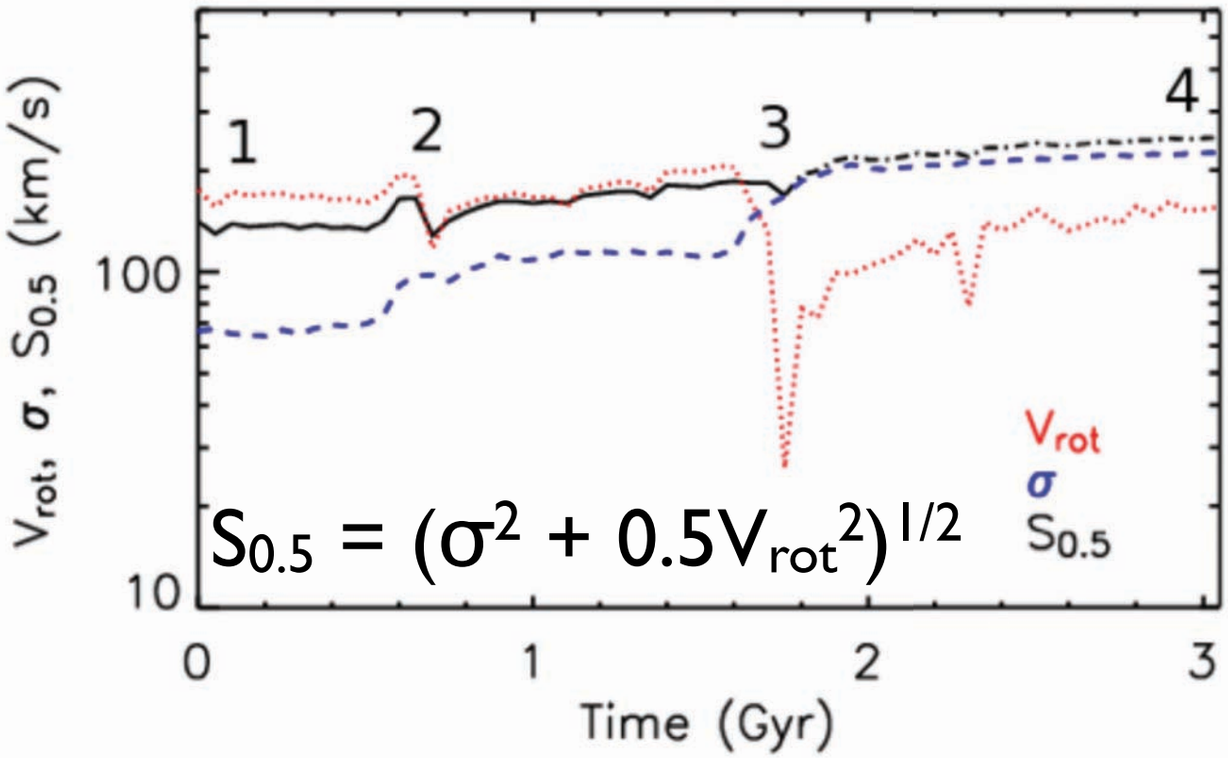


Before any encounters

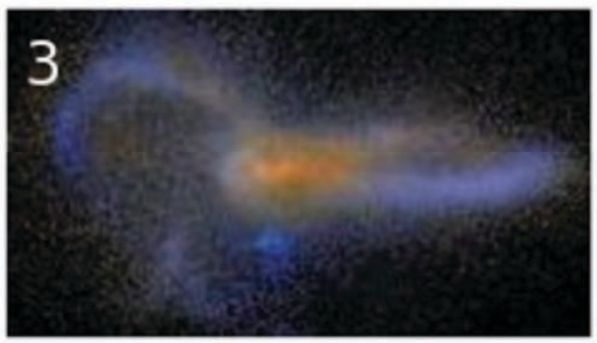


Shortly after the initial encounter

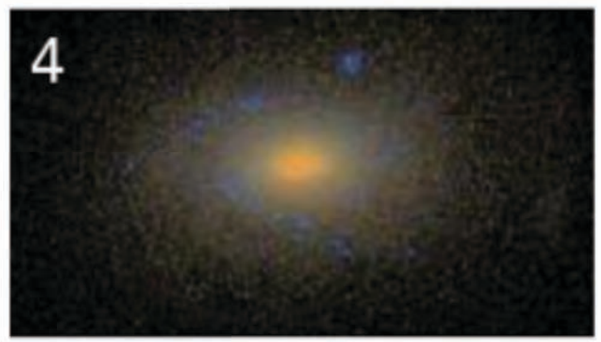
Time evolution of rotation velocity (red dotted line), velocity dispersion (blue dashed line), and $S_{0.5}$ (solid and dash-dot black lines) during a single merger simulation of two Sbc galaxies with stellar masses of ~5x10^{10} solar masses initially on a parabolic orbit. Care is taken to "observe" the simulations just as in the actual observations. The solid portion of the $S_{0.5}$ line denotes the snapshots where only a single progenitor is ``observed," in the slit and the dash-dot portion denotes snapshots where both progenitors are "observed" in the slit.

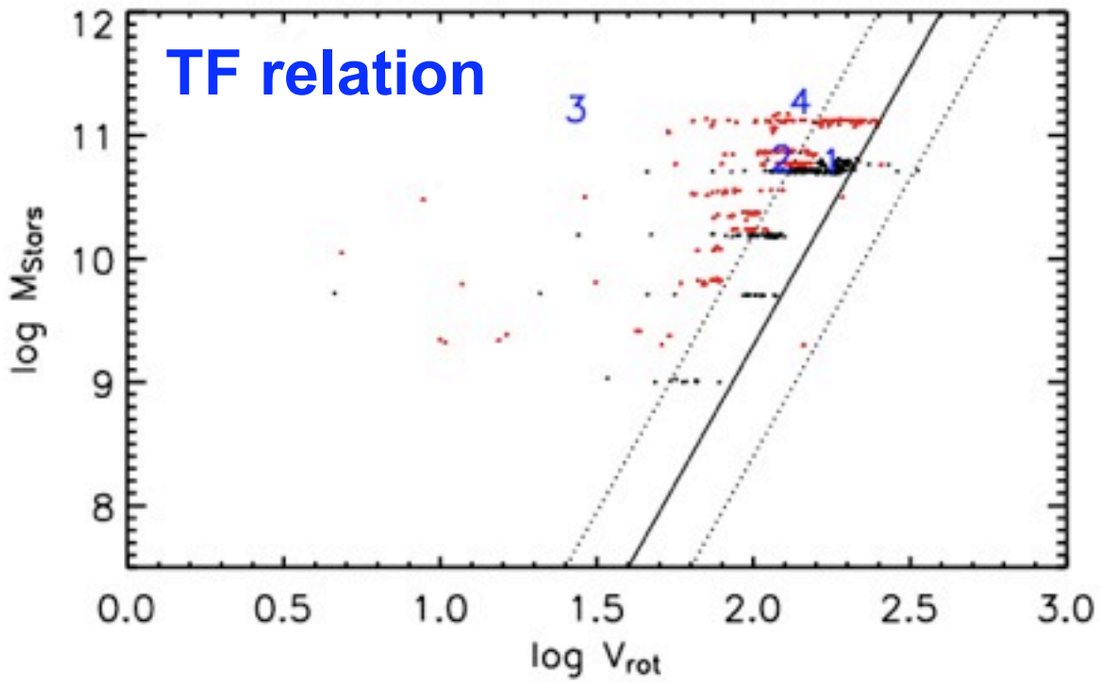


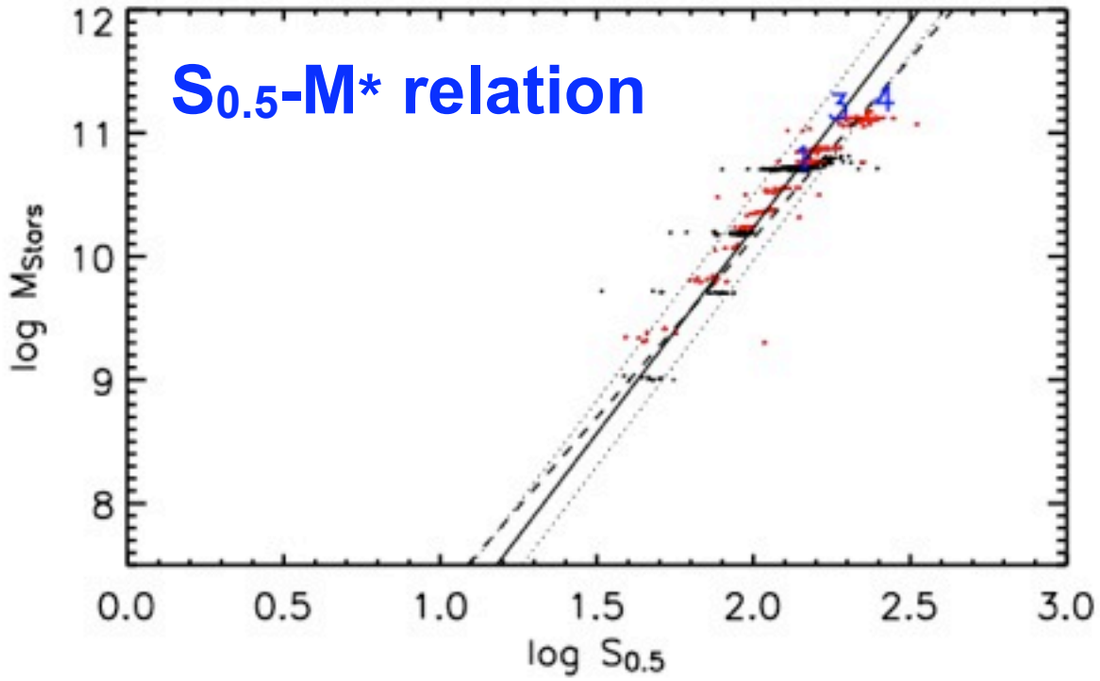
At the final coalescence



Remnant after coalescence

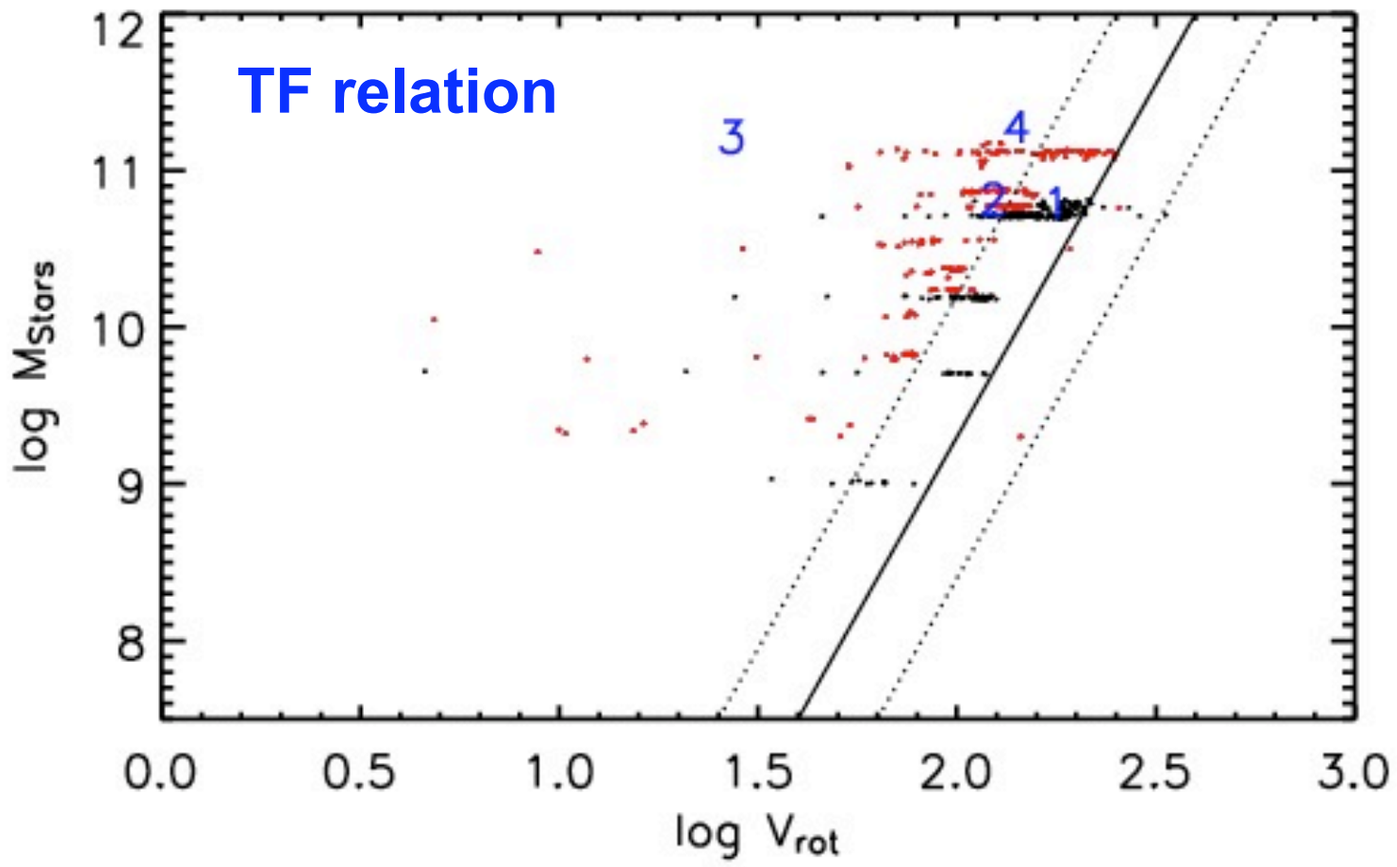


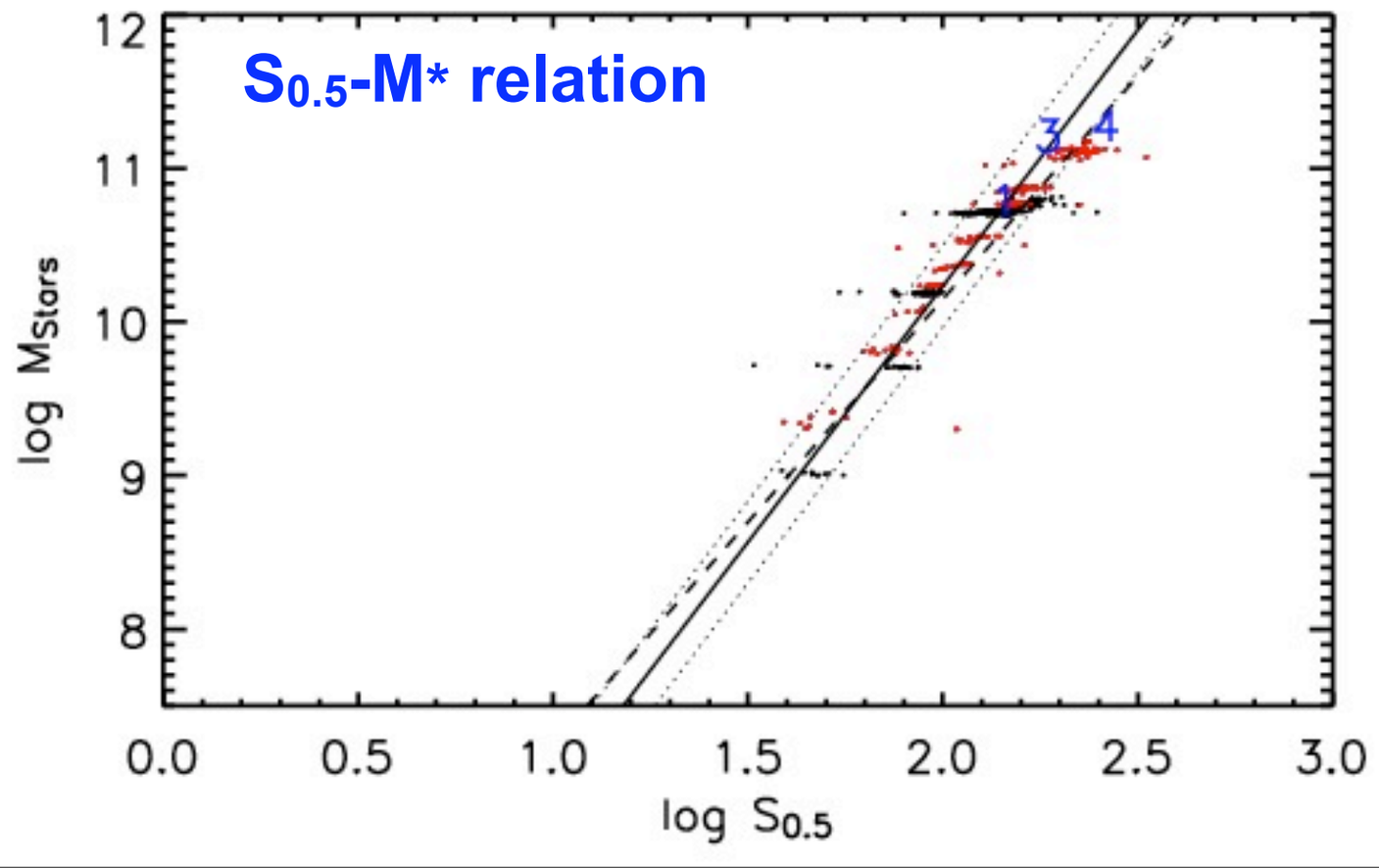




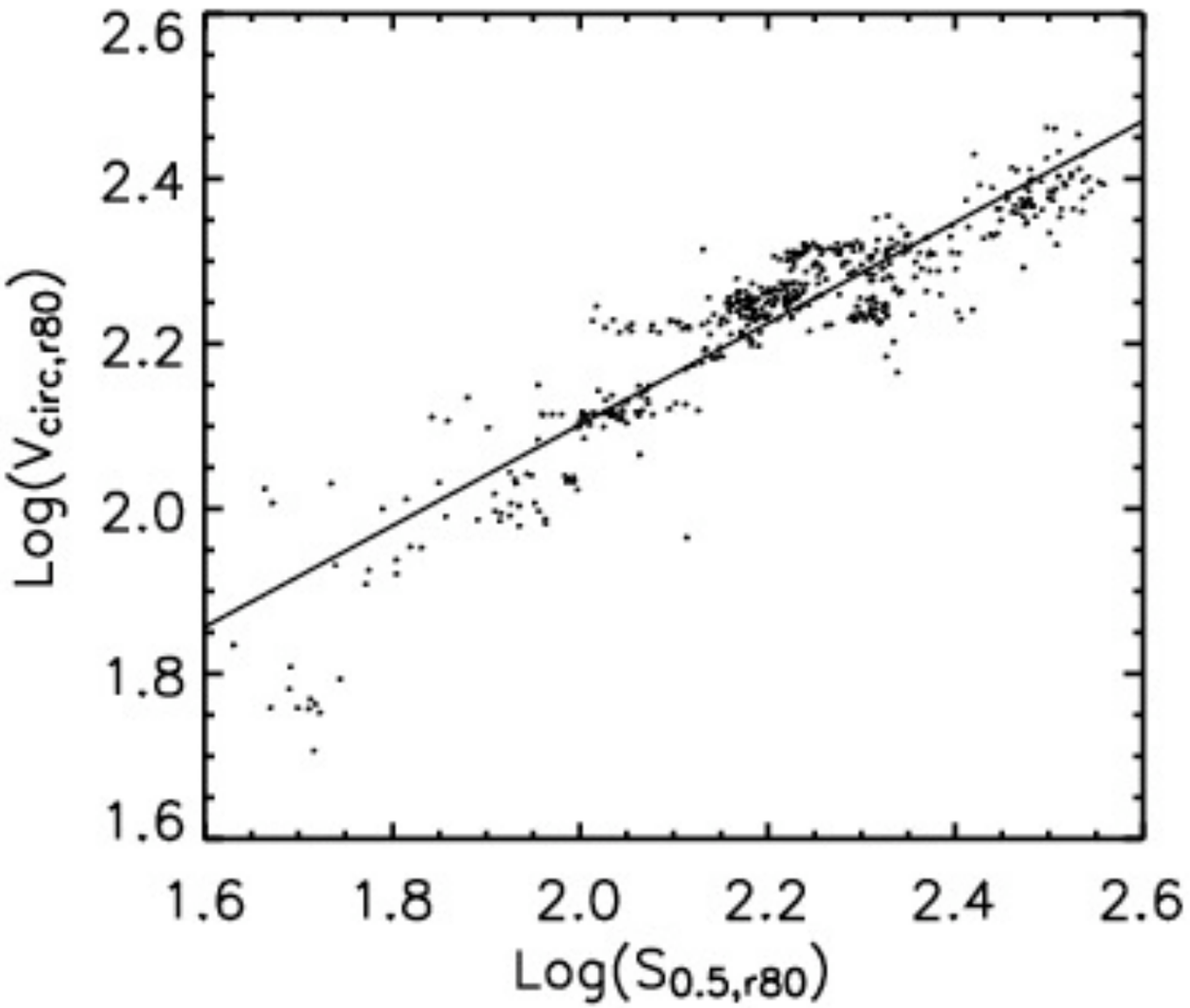
Numbers on the plots show the location of the numbered merger stages. In the bottom panel, 2 overlaps 1.

The TF relation (top) and $S_{0.5}$-stellar mass relation (bottom) for mock observations of simulated merging galaxies. Each dot represents a mock observation of a single snapshot viewed from a single angle. In order to compare with the observational results from Kassin et al. 2007, 500 such images were chosen from the simulation set at random. Red points are mock observations where both galaxies are present in the slit (i.e. close encounters and the merger remnant), and black points are mock observations of single simulated galaxies. The solid line is the high-redshift TF ridgeline, with the dotted lines representing the scatter. As in Kassin et al. a significant number of the simulated galaxies scatter to low V_{rot}. In the Kassin et al. observations, these galaxies have disordered or compact morphologies, and in the simulations the majority of these are cases that either are undergoing or have recently undergone an encounter. In the bottom panel, the solid line is a fit to the observations of Kassin et al., and the dotted lines depict scatter in the relation. The dashed line is the best fit to the simulations. Including velocity dispersion greatly reduces the scatter and brings the progenitors, disturbed galaxies, merging galaxies, and merger remnants onto a single kinematic relation. The relation and scatter found for the simulated galaxies is comparable to the observed relation.


TF relation
3
4
2
1
12
11
10
9
8
log M_{Stars}
0.0
0.5
1.0
1.5
2.0
2.5
3.0
log V_{rot}


$S_{0.5}$-M* relation
3
4
1
12
11
10
9
8
log M_{Stars}
0.0
0.5
1.0
1.5
2.0
2.5
3.0
log $S_{0.5}$

$S_{0.5}$-M_{tot} relation



The $S_{0.5}$-total mass relation, where total mass is the baryonic and dark matter mass inside a spherical aperture of radius R_{80}, the radius that encloses 80% of the stellar mass. Each point represents a single snapshot of a merger simulation ``observed" from a single angle, and the sample shown is the same 500 randomly selected images as in the previous Figure. The rotational component of $S_{0.5}$ was measured at R_{80}. The total mass is used to compute an effective circular velocity ($V_{circ,r80}$). The solid line is a fit to the data with a slope of 0.6 and a y-intercept of 0.3. This relation demonstrates a direct correlation between $S_{0.5}$ and total enclosed mass.

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