

The ubiquity of low-luminosity radio AGN among massive quiescent galaxies at $z = 0 - 1.5$

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Summary

The physical mechanism that keeps star formation (SF) inefficient in quiescent galaxies (QGs) is still a subject of controversy. In this work, we test for the presence of radio AGN by stacking QGs at long wavelengths (mid-IR, far-IR and radio). By comparing the IR luminosities derived from these 3 wavelength ranges, we reveal that the average radio emission of the most massive QGs are in excess compared to that expected of star formation alone. The widespread presence of low-luminosity AGN is likely responsible for the inefficient SF in QGs.

How?

Sample ~14,200 QGs selected using the NUV-r and r-J colors from the COSMOS/UltraVISTA catalog [3]

- at $z=0.1-3$
- the strong 24 μ m emitters (equivalent to $SFR=100$ Msun/yr) are treated separately and not discussed here

Stacking

	Instrument	Wavelength	Method	LIR derivation
Mid-infrared	Spitzer MIPS	24 μ m	median stacking	Template fitted to 24 μ m flux [5]
Far-infrared	Herschel	100, 160, 250, 350, 500 μ m	global stacking & deblending [7]	Greybody fit
Radio	VLA	20 cm (1.4 GHz)	median stacking	Radio-FIR correlation [1] scaled to radio flux

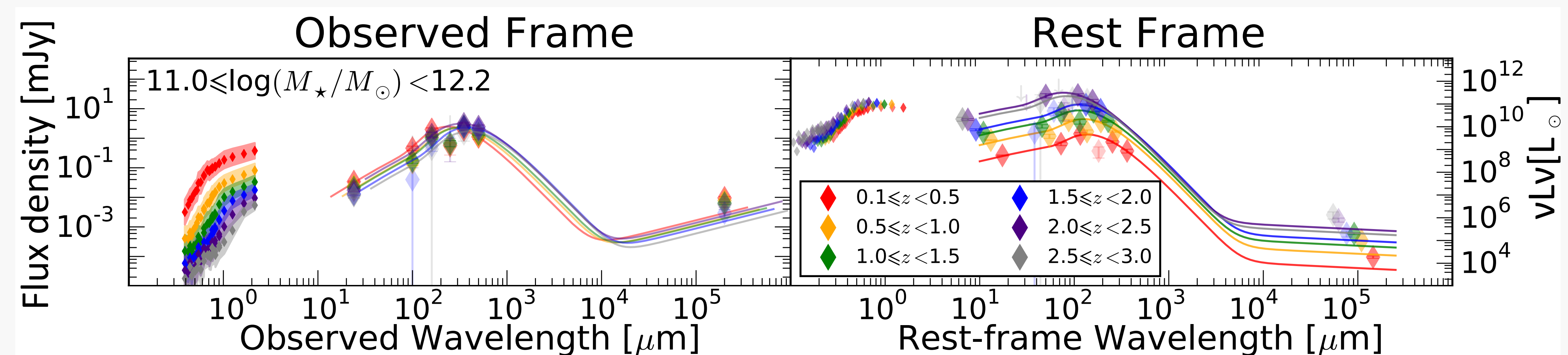
References:

1. Bell 2003
2. Best & Heckman 2012

3. Ilbert et al. 2013
4. Olsen et al. 2013
5. Rujopakarn et al. 2013

6. Schawinski et al. 2009
7. Viero et al. 2013

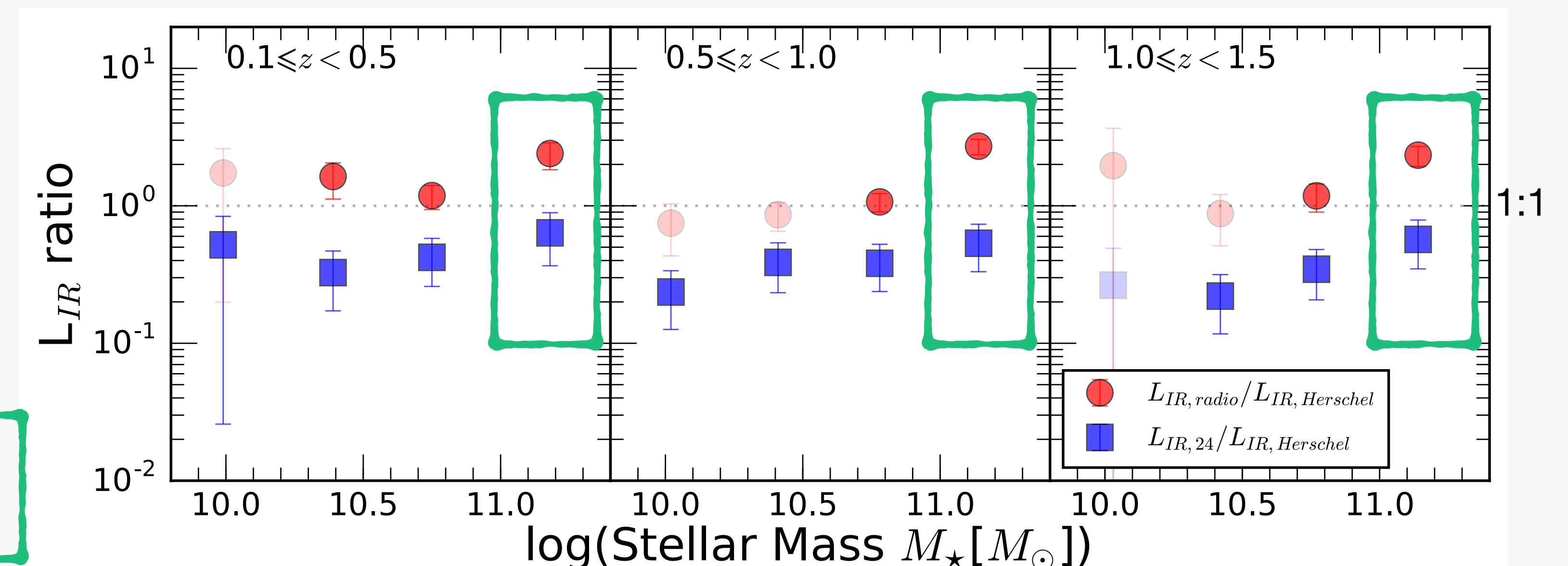
First UV-to-radio SED for quiescent galaxies



Redshift	z_{phot}	N_{gal}	$S_{24 \mu\text{m}}$ (μJy)	$S_{100 \mu\text{m}}$ (mJy)	$S_{160 \mu\text{m}}$ (mJy)	$S_{250 \mu\text{m}}$ (mJy)	$S_{350 \mu\text{m}}$ (mJy)	$S_{500 \mu\text{m}}$ (mJy)	S_{radio} (μJy)	$\log(L_{\text{IR,H}})$ $\log(L_{\odot})$	$\log(L_{1.4 \text{ GHz}})$ $\log(W \text{ Hz}^{-1})$	q_{IR}	SFR_{SED} ($M_{\odot} \text{ yr}^{-1}$)	SFR_{24} ($M_{\odot} \text{ yr}^{-1}$)	SFR_{FIR} ($M_{\odot} \text{ yr}^{-1}$)	SFR_{radio} ($M_{\odot} \text{ yr}^{-1}$)	$\log(SFR_{\text{FIR}})$ $\log(\text{yr}^{-1})$
$\log(M_{*}/M_{\odot}) = 11-12.2$ (median = 11.2)																	
0.1-0.5	0.4	232	34.0 ± 1.5	0.5 ± 0.1	2.0 ± 0.2	0.6 ± 0.3	1.9 ± 0.2	1.1 ± 0.2	9.6 ± 1.1	9.8 ± 0.1	21.7 ± 0.0	2.2	$0.05^{+0.07}_{-0.05}$	0.5 ± 0.2	$0.7^{+0.2}_{-0.1}$	1.7 ± 0.1	-11.3
0.5-1.0	0.8	1298	24.1 ± 0.9	0.1 ± 0.0	1.2 ± 0.1	0.6 ± 0.1	2.3 ± 0.1	1.2 ± 0.1	7.8 ± 0.5	10.5 ± 0.1	22.5 ± 0.0	2.1	$0.20^{+0.20}_{-0.20}$	1.8 ± 0.7	$3.4^{+0.4}_{-0.4}$	9.2 ± 0.5	-10.6
1.0-1.5	1.2	827	21.3 ± 1.0	0.2 ± 0.0	1.0 ± 0.1	0.7 ± 0.2	2.5 ± 0.1	1.4 ± 0.1	6.4 ± 0.6	10.9 ± 0.1	22.8 ± 0.0	2.1	$0.59^{+0.39}_{-0.39}$	4.6 ± 1.7	$8.1^{+1.2}_{-1.0}$	19.0 ± 1.7	-10.2
1.5-2.0	1.6	320	13.0 ± 1.2	0.0 ± 0.1	0.6 ± 0.2	-0.1 ± 0.3	2.4 ± 0.3	2.0 ± 0.2	3.0 ± 0.9	11.2 ± 0.2	22.8 ± 0.1	2.4	$0.42^{+0.50}_{-0.39}$	4.8 ± 1.8	$14.8^{+7.6}_{-5.0}$	20.0 ± 6.0	-10.0
2.0-2.5	2.2	185	17.6 ± 1.6	-0.1 ± 0.1	1.3 ± 0.3	0.6 ± 0.4	3.1 ± 0.4	2.5 ± 0.3	5.7 ± 1.1	11.7 ± 0.1	23.4 ± 0.1	2.3	$0.78^{+0.74}_{-0.71}$	9.4 ± 3.5	$50.1^{+16.0}_{-12.1}$	82.7 ± 16.6	-9.4
2.5-3.0	2.6	65	11.7 ± 2.2	-0.2 ± 0.1	0.4 ± 0.5	-1.2 ± 0.6	1.4 ± 0.6	1.7 ± 0.6	6.0 ± 2.1	11.5 ± 0.4	23.6 ± 0.1	1.9	$1.20^{+34.28}_{-1.16}$	12.8 ± 5.4	$35.5^{+60.0}_{-22.3}$	141.2 ± 48.4	-9.5

Excess radio emission indicates AGN presence

We obtain 3 independent measurements of the infrared luminosity (LIR) by stacking at MIR, FIR and radio. By comparing the ratios between the derived LIR, we constrain the source of the emission.



LIR derived from radio is higher than LIR derived from Herschel and 24 μ m

Radio emission is larger than expected from SF alone

Low 24 μ m emission compared to Herschel implies little hot dust

Obscured quasar-mode feedback likely not dominant in QGs

Implies that low-luminosity AGN is widespread among massive QGs [4], and contribute to their radio emission

Consistent with the idea that radio-mode feedback ('maintenance-mode') by AGN can keep massive galaxies inefficient in SF [2,6]