**Bulge formation in massive disks at z~2**

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**Q1:** What do you think is the “KEY” science/observations for ULTIMATE in your research field? We hope to establish the very best science cases which are unique enough even in mid-late 2020s (i.e. post-JWST or WFIRST era!).

*a catchy phrase is “origin of the Hubble sequence”*

ULTIMATE-Subaru allows us to address this issue with 0.2″-resolution Hα narrow-band imaging for SFGs at z~2

More important thing is to utilize the performance of spatial resolution rather than sensitivity
a simple answer is
to explain why quiescent galaxies (QGs) are ellipticals although star-forming galaxies (SFGs) are exponential disks

What is ``to reveal the origin of the Hubble sequence’’

Massive z\sim 2 SFGs must change their morphologies!
When are massive QGs formed?

Massive QGs at z~1.5 would have quenched star formation at z=2-2.5 (less massive QGs would do at later epoch)

Massive z~2 SFGs must form bulge!
What should we study for SFGs at $z \sim 2$?

1. SF size = $M^*$ size: $r^*_s,1/2$ does not change
2. SF size $> M^*$ size: $r^*_s,1/2$ increases with $M^*$ $\Rightarrow$ size evolution
3. SF size $< M^*$ size: $r^*_s,1/2$ decreases with $M^*$ $\Rightarrow$ bulge formation

key element: spatial distribution of star formation within SFGs at $z \sim 2$

$\Rightarrow$ $0.2''$-resolution H$\alpha$ narrow-band imaging at K-band
Bulge and quenching of star formation

Bulge is probably related with quenching of star formation (Lang+14, Bell+12, etc.)
My suggestion about survey design

Q4: Which survey design sounds best for you (see survey_design.pdf)? Your comments/suggestions on the ULTIMATE survey design are very welcome.

**my suggestion is ``NB at K only'' survey**

<table>
<thead>
<tr>
<th>Deep (20 deg²)</th>
<th>Exp. time per FoV</th>
<th>(with overhead)</th>
<th>Limit mag.</th>
<th>N. of nights</th>
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<tbody>
<tr>
<td>NBK x 1</td>
<td>4-hours</td>
<td>(5-hours)</td>
<td>24.1</td>
<td>120</td>
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<td>K</td>
<td>2-hours</td>
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NB magnitudes for SFGs at z=2.2
(Tadaki+13, ~90 arcmin²)

main targets show NB<22.5 mag in total

S/N>20 is enough high to spatially resolve Hα emission?

~20 SFGs in 90 arcmin²
=> ~1e4 SFGs in 20 deg²
my suggestion is `NB at K only’ survey

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Four points of this survey

1. WFIRST does not have K-band and NB filter
2. This choice maximizes the GLAO performance in terms of angular resolution (this is critical for galaxy anatomy)
3. A survey area of 20 deg² matches up with HSC/SSP-Deep (~27deg²)
4. Wide K-band data is useful for general science cases

e.g., study of the rest-optical morphology for galaxies at z=3-4 and dusty star-forming galaxies
H and K-band maps for dusty SFGs at z~2

Tadaki et al. 2015
What should we study?

1. investigate where new stars are formed for individual galaxies at z~2
2. compared it with stellar mass distribution (WFIRST data is not necessarily required)
3. identify bulge-forming galaxies and disk-forming galaxies
4. study them as function of stellar mass/star forming activity/environment
5. reveal what drives bulge formation
A science case with MOIRCS+GLAO

Q3: Our current plan is to (1) build GLAO first, and then to (2) build new NIR instrument(s). This means that we will start our ULTIMATE science with **GLAO + MOIRCS** at the first stage. Do you have good science cases to be done with GLAO+MOIRCS during the period of ~2020-2023?

With small FoV, there is a risk for observing void regions

Pilot survey targeting high-density regions of HiZELS emitters at z=2.2

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**MOIRCS FoV (4’x7’)**

**total of 20 FoVs (0.15 deg²)**