Physical Morphology
Bulge Structure and Star Formation Activity in Local LIRG

Ken Tateuchi (the Univ. of Tokyo), Kentaro Motohara, Masahiro Konishi, Hidenori Takahashi, Natsuko Kato, Yutaro Kitagawa, Soya Nishijima and TAO project team
Diversity in the form of galaxies

Hubble Ultra Deep Field

How have these shapes been formed and evolved?
Classical and Pseudo Bulge

Classical Morphology: based on the “Hubble Sequence”
→ Spirals: Barred Spiral ↔ Non-Barred

Focus on the bulge structure!!

Physical Morphology

Classical-bulges

① Dispersion supported
① Not as flat as disk
② Old stellar population

Elliptical like?

Psēudo-bulges

① Rotation supported
① As flat as disk
② Young stellar population

Disk like?

Kormendy (1993)

13, Jun., 2013  Subaru GLAO Science WS.
Theoretical Prospect of Morphogenesis

Merging/Interacting

Dry Merger? (Kormendy+2004)
From ULIRG? (Toomre+ 1977)

Primordial Disk? (Elmegreen et al. 2008)

Secular/internal Evolution


Classical Bulge Dispersion

Pseudo Bulge Rotation

Spiral

Kormendy+ 2004

High-redshift starburst? (Okamoto+ 2013)

However, there are few observational evidences...

Observational Verification is Necessary!
LIRGs – Ideal Laboratory of Morphogenesis -

Previous works → Normal Galaxies
The form has been formed already....

Luminous Infra-Red Galaxies

Starburst galaxies

\[ 10^{11} L_\odot \leq L_{\text{IR}(8-1000\mu m)} < 10^{12} L_\odot \]
\[ 10 < \text{SFR} \left( M_\odot \, \text{yr}^{-1} \right) < 100 \]

- On-going starburst galaxies
  → Ideal Laboratory of Morphogenesis
- Half of them are Spirals
  → Classical-, Pseudo- bugle factory?

However, LIRGs are so Dusty....

Wang et al. 2006
Paγ observation of Local LIRGs

Paγ is hydrogen recombination line at 1.8751 um

The advantages of Paγ

1. Unbiased tracer of the current SFR
2. One of the STRONGEST hydrogen recombination lines @ near-IR
3. Far less affected by dust extinction
4. High spatial resolution
   ※ Compared to far-IR and mid-IR

Observation with miniTAO/ANIR

38 LIRGs (Sanders et al. 2003 IRAS catalog)
miniTAO 1m Telescope/Atacama NIR camera
   → Paγ : Narrow-band Imaging
   → Ks : Broad-band Imaging

See through the internal bulge with Paγ!
Data Analysis

Class the two type of bulge by observation
→ Sersic Index of bulge

Bulge-disk decomposition with GALFIT

Ks  Model  Residual  Result

Sersic bulge + exponential disk

Normal galaxies

n > 2.3 : Classical bulge
n ≤ 2.3 : Pseudo bulge
(Fisher & Drory 2008)

13, Jun., 2013  Subaru GLAO Science WS.

Fisher & Drory 2008

This work (LIRG)
Bulge Structure and SF Region I

Nearby (z~0.03) LIRGs: Field Galaxies

Classical: compact-, Pseudo: Extend- starburst
Bulge Structure and SF Region II

From Theoretical prospects …

Our Results are Consistent with Theoretical Predictions !?
Physical Morphology
Towards Subaru/GLAO

We want to know the environmental effects on the bulges ...

Add the classification of “Classical” and “Pseudo” bulge in the right figure !!
K-band Science w/ Subaru/GLAO

To understand the Environmental effects on bulge structures...
→ we propose to observe nearby cluster of galaxies and field galaxies by K-broad band with GLAO

K-band observations of Nearby Cluster of Galaxies
About 2700 systems (Abell; z<0.2)
→ bulge-disk decomposition w/ 0″.2

K-band observations of Nearby Field Galaxies
COSMOS Field ?
New fields by HSC ?

Cluster
Compartmentalization ?
Ratio of Classical and Pseudo ?
Field

Wide-Field Near-IR Imager w/ GLAO is Essential !?
Resolution and Coverage of Clusters

To decompose the bulge-disk and evaluate the shapes ...

→ a few hundreds (2~300) pc scale resolution is necessary!

<table>
<thead>
<tr>
<th>Physical Scale with GLAO (0''.2)</th>
<th>Our nearby Science</th>
<th>( z = 0.05 )</th>
<th>( z = 0.1 )</th>
<th>( z = 0.2 )</th>
<th>( z = 0.3 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( D_A )</td>
<td></td>
<td>80 Mpc</td>
<td>200 Mpc</td>
<td>400 Mpc</td>
<td>700 Mpc</td>
</tr>
<tr>
<td>Physical Scale</td>
<td>300 pc</td>
<td>200 pc</td>
<td>300-400 pc</td>
<td>500-700 pc</td>
<td>700- pc</td>
</tr>
</tbody>
</table>

To cover the whole cluster of galaxies ...

→ Wide-FoV is necessary!

Subaru/GLAO can cover the whole cluster with 1 Snapshot!!

GLAO is suitable for the Science of Nearby Cluster of Galaxy!
Summary

To reveal these theoretical prospects...

We found that

Classical: compact starburst
Pseudo: extended starburst
in the near-by field galaxies

We want to know the effects of environment on these galaxies...

**K-band snapshot survey with Subaru/GLAO**

0.05 < z < 0.2 Clusters of Galaxies and Field Galaxies

**Cluster**
- K-band snap-shot survey: 10 min/cluster (2700 clusters are available)

**Field**
- K-band snap-shot survey: 10 min/FoV (?? area)

The specifications of Subaru/GLAO is sufficient and suitable for our science!

※The observation time is estimated as follows,
miniTAO=1m → Subaru=8m (64times), miniTAO sources=80Mpc → Subaru=600-700Mpc (about 64 times)
So, it is comparable observation time of miniTAO near-by sources with Subaru high red-shift sources
If we can observe some galaxies with Subaru/GLAO...

Kintaro

Acchan

We will be able to tell which the galaxy (person) “Pseudo” is!!

※ sorry for Japanese Joke
Q.1
Wide-Field Wide-Field Near-IR Imager

Q.2
The specifications of Subaru/GLAO is sufficient and suitable for our science!

Q.3
Supply many sources of Classical and Pseudo bulges!

Q.5
Observe nearby ($0.05 < z < 0.2$) clusters by K-band snapshot survey!!
If GLAO has narrow-band filters...

Thank you!