Subaru Next-Generation AO: Possibilities of Observing Distant Galaxies (Progress Report)

Y. Minowa, I. Iwata (Subaru Telescope)
Objectives

• Observations of distant (z ~ 1 or higher) galaxies would be one of the possible strong candidates of driving science cases for next-generation AO / new IR instrument(s) for Subaru.

• What kind of AO we need? What we can do with them?
  • AO-assisted spectroscopy of distant galaxies has been carried out by Keck (OSIRIS) and VLT (SINFONI) -- Integral Field Spectroscopy
  • Distant galaxies are faint -- With 8-10 m class telescopes, only the brightest galaxies may be observable?

• Need to quantitative studies to determine the specifications of the ngAO and to build strategies of the observations with it
Resolved Kinematics of a Galaxy at $z \sim 2$

VLT / SINFONI
NGS-AO IFS
Giant Star-forming
galaxy at $z=2.38$
Resolution $\sim 0.15''$
($=1.2$ kpc)

Genzel+ 2006, Nature 442, 786
Kinematics of Galaxies at $1.3 < z < 2.6$

VLT SINS >60 Galaxies
Mostly Seeing Limited
Some NGS or LGS-AO (yellow rectangles)

Resolved Spectroscopy of Dust-Obscured Galaxies at $z \sim 1.5$

- Keck / OSIRIS LGS-AO assisted observations of 4 ULIRGs
- Resolution: $\sim 0.1''$ (<1kpc)
- Separation of Broad-line components (Black Hole) and Narrow-line components (Star Formation)

1'' FOV H$\alpha$ maps

Melbourne+ 2011, AJ 141, 141
Resolved Spectroscopy of Dust-Obscured Galaxies at z~1.5

- Keck / OSIRIS LGS-AO assisted observations of 4 ULIRGs
- Resolution: ~0.1” (<1kpc)
- Separation of Broad-line components (Black Hole) and Narrow-line components (Star Formation)

Melbourne+ 2011, AJ 141, 141
Possibilities of Observing Distant Galaxies

• Construct AO-simulated images of distant galaxies
• Examine their expected S/N
  • Slit spectroscopy and IFS
• Estimate number densities of observable targets
  • How many galaxies can be observed within, say, Φ10 arcmin FOV or FOR?
• Specifications of ngAO and new instrument(s)
Simulated Images of $z \sim 2$ galaxies based on HST/ACS I-band images of galaxies at $z \sim 0.2$
Simulated Images of $z \sim 2$ galaxies based on HST/ACS I-band images of galaxies at $z \sim 0.2$
Simulation Based on Real Galaxies at $z > 1$

- HST/ NICMOS or WFC3/IR images of distant galaxies
- Sample field:
  Extended GOODS-S (E-CDFS)
  MUSYC:
  http://www.astro.yale.edu/MUSYC/
Redshift Ranges

- Two Good Redshift Ranges:
  - $2.1 < z < 2.6$
    - J-band: OII
    - H-band: H\textbeta, OIII
    - K-band: H\alpha
    - (Ly\alpha: 3770AA-4380AA)
  - $1.3 < z < 1.7$
    - J-band: H\textbeta, OIII
    - H-band: H\alpha
    - (OII: 8570AA-1006AA)
MUSYC 2.1<z<2.6

Red: Spec-z
Open Black: Photo-z
MUSYC $1.3 < z < 1.7$

Red: Spec-z
Open Black: Photo-z
<table>
<thead>
<tr>
<th>HST/ACS</th>
<th>NICMOS or WFC3/IR</th>
<th>Spitzer/IRAC1</th>
<th>$z_{sp}$</th>
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Examples: $2.1 < z < 2.6$ K(AB) < 22

$z_{sp} = 2.13$, $6''$ or $9''$, $9''$
Examples: $1.3 < z < 1.7 \ K(AB) < 22$

<table>
<thead>
<tr>
<th>HST/ACS</th>
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<th>Spitzer/IRAC1</th>
<th>$z_{sp}$</th>
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5”  6” or 9”  9”
Surface Densities: $2.1 < z < 2.6$

MODS data by courtesy of Kajisawa san
Surface Densities: $1.3 < z < 1.7$

MODS data by courtesy of Kajisawa san
Surface Densities of $K(AB)<22$ Galaxies in MODS

<table>
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<th>N/arcmin$^2$</th>
<th>N/10'Φ</th>
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<tr>
<td>$1.3&lt;z&lt;1.7$</td>
<td>0.764</td>
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<td>$2.1&lt;z&lt;2.6$</td>
<td>0.320</td>
<td>25</td>
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MODS data by courtesy of Kajisawa san
Surface Densities of $K(AB)<21$ Galaxies in MODS

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<th>N/arcmin$^2$</th>
<th>N/10′Φ</th>
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<td>$2.1&lt;z&lt;2.6$</td>
<td>0.068</td>
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MODS data by courtesy of Kajisawa san
Summary

• Feasibility studies on observations of distant galaxies with next-generation AO are on-going.
• Simulation of images of distant galaxies
• Sample selection based on GOODS-S MUSYC catalogue
• Items to do in ~1 month:
  • Sensitivity with slit spectroscopy and IFS with different AO performances