A Magellan M2FS Spectroscopic Survey of Galaxies at 5.6 < z < 6.8

Linhua Jiang (江林华)
Kavli Institute for Astronomy and Astrophysics
Peking University

Outline

- Introduction
  - A little background
- Our Magellan/M2FS survey
  - Program details
  - Science goals
  - Current status
- Preliminary results
  - Very luminous LAEs
  - Lyα Luminosity functions
  - Giant protoclusters
- Summary
Introduction

Background of our galaxy survey (back to 2014)

- “Well” derived Lyα LF s at $z \sim 5.7$ and $6.5$; plus a couple of $z \sim 7$ LAEs
- But – large discrepancy of the LF normalizations
- Note that we focus on spectroscopically confirmed samples

A Magellan M2FS survey of galaxies at 5.6 < z < 6.8

Introduction to Magellan M2FS
- Fiber-fed, multi-object spectrograph on the Magellan Clay telescope
- 256 optical fibers
- A circular FoV of 30 arcminutes in diameter
- Low-R mode with red-sensitive gratings
- High throughput

(Mateo et al. 2012)
Program details

- Team (led by Jiang): KIAA-PKU + Arizona + Carnegie + PUC + ANU
- Telescope/instrument: Magellan/M2FS; five hours per pointing
- Fields: well-studied fields
  - Including COSMOS, SXDS, GOODS, SSA22, etc.
  - A total of > 3 deg²
- Imaging data and targets
  - Deep Subaru Suprime-Cam images in a series of broad and narrow bands
  - LAEs at z = 5.7 and 6.5
  - LBGs at 5.6 < z < 6.8
  - Many other targets in the same fields
- Goal: a large and homogeneous sample of bright LAEs and LBGs at 5.6 < z < 6.8
**Scientific goals**

- **A unique galaxy sample**
  - Large area coverage
  - Same imaging data for target selection
  - Same target selection carried out by the same team
  - Same instrument for spectroscopic observations
  - Large number of fibers → highly complete

- **Lyα LFs at z ~ 5.7 and 6.5**
  - From a large LAE sample
  - Accurate measurement of Lyα LF (at least the bright end), and its evolution at the two redshifts

- **Notes**
  - There are existing large samples of photometrically selected LAEs
  - But ours is spectroscopically confirmed sample

(Refs: Santos+2016; Ota+2017)
Scientific goals: understanding reionization

- Increasing fraction of neutral IGM from $z=5.7$ towards higher redshift
- Patchy reionization
  - Ly$\alpha$ luminosity function
  - Ly$\alpha$ halos (?)
  - Enhanced galaxy clustering

Enhanced clustering of LAEs

- Have we found it?
- How do we find it?
- Are $z \sim 6.5$ LAEs our best chance?

(Refs: McQuinn+2007; Ouchi+2010; Kashikawa+2011; Silva+2013; Treu+2013; Cai+2014; Dijkstra+2014; Jensen+2014; Kakiichi+2015)

(Model (i) vs Model (ii))
Fraction of LBGs with strong Lyα emission
- Increases from low redshift to z~6
- Decreases towards higher redshift
- Broadly consistent with LF evolution

(Bian et al. 2014)

Diffuse Lyα halos
- Based on ground-based NB (Lyα) images
- At high redshift: predicted by simulations
- Also see none detection in Jiang et al. 2013b?

z = 5.7 LAEs
(Zheng et al. 2011)

(Ref: Stark+2010, 2011; Schenker+2012, 2014; Treu+2012; Jiang+2013; Bian+2014)
- **Diffuse Lyα halos at z=5.7**
  - In Jiang et al. 2013, ApJ, 773, 153, we stacked a few tens of LAEs at z=5.7 (and 6.5)
  - We claimed that we did not detected halos, and we provided various reasons; but wait ...

(Steidel+ 2011)
Large protoclusters at \( z > 5.5 \)
- Secure redshifts are critical

Physical properties of spectroscopically confirmed galaxies
- These fields are (partly) covered by deep near-IR (e.g., UDS, ultraVISTA, HST CANDELS) and mid-IR imaging data (IRAC 1,2)
- Various properties of high-redshift galaxies, such as size, morphology, UV slope, star-formation rate, age, dust, stellar mass, etc. (Note that spec redshifts remove one critical free parameter, see Jiang+2016a)
Program status and some preliminary results

- Completed ~2.5 degree$^2$
- Depth: 4 – 7 hours per pointing (>25.5 mag in NB816)
- Expect to complete it this year

(Part of a fully reduced M2FS 2D image)
Very luminous LAEs at $z=5.7$ and $6.5$

- Large area coverage $\rightarrow$ rare, luminous objects
- NB921 $\sim$ 24 mag; NB816 $< 24$ mag

(Sobral et al. 2015)
How interesting are CR7-like objects

Final sample of SDSS z~6 quasars

(Matsuoka et al. 2016)

(Willott et al. 2009, 2010)

(Jiang et al. 2016b)
Lyα LF at z=5.7

- ~166 LAEs down to NB816 ~ 25.6 mag over 1.9 deg$^2$
  → ~90 LAEs per deg$^2$
- Hu et al. sample: ~60 LAEs per deg$^2$
- Kashikawa et al. sample: ~135 LAEs deg$^2$
- Rough estimate: will be between the two samples (Zheng, Jiang, et al. in preparation)
Summary

- We are carrying out an extensive survey of bright LAEs and LBGs at $5.5 < z < 6.8$ over more than 3 deg$^2$
- The sample will be used to study
  - Evolution of the Ly$\alpha$ LF from $z=5.7$ to higher redshifts
  - Fraction of line-emitting galaxies among LBGs changes with redshift
  - Diffuse Ly$\alpha$ halos around LAEs
  - Enhanced LAE clustering
  - Giant protoclusters in the distant universe
  - Physical properties of spectroscopically confirmed galaxies
  - ......
- We already have some interesting results