NIR BAO Search by Subaru/FMOS

Tomo Totani
- **Fiber-Multi-Object Spectrograph in NIR, 400 fibers**
- A Second Generation Common Use Instrument for the 8.2m Subaru Telescope
- Collaboration with: Japan (Kyoto), UK (Oxford, Durham, RAL), Australia (AAO)
- First light of objects: 2006 spring
- Open Use S07A? (2007 Feb-Jul)
- Details will be given by Ohta-san’s talk
Specification of FMOS

- 400 fibres (1.25” Φ) in circular FOV (30’ Φ)
- Wavelength coverage: 0.9um - 1.8um
  - Fully covered in a low resolution mode
- Spectral resolution
  - Low resolution mode: R=500
  - High resolution mode: R=2200
- OH Airglow Suppression with OH masks
  - ~1/20 suppression of continuum level
  - 75% clearance of the wavelength coverage
- Limiting magnitude (1 hr, S/N=5)
  - J ~ 22.3
  - H ~ 20.9
BAO Search by FMOS. 1

- Target Redshift: $z \sim 1.4-1.7$ by detecting Hα from star forming galaxies
- Required Survey Area to achieve $V \sim 1\text{Gpc}^3$
  - $z \sim 1.4-1.7 \Leftrightarrow \sim 0.5$ comoving Gpc
  - 10 deg $\Leftrightarrow 0.8$ comoving Gpc
  - $300 \text{deg}^2 \Leftrightarrow \sim 1\text{Gpc}^3$ ($h=0.7$, $\Omega_M=0.3$, $\Omega_\Lambda=0.7$)
    - 1500 pointings required for FMOS-FOV (0.2 deg$^2$)
    - $1500 \times 400$ (fibers) = **600,000 galaxies** by 1 pointing per 1 location
- Required number of galaxies
  - 20,000 galaxies per deg$^2$ and unit $z$ for the cosmic variance to dominate short noise (Glazebrook & Blake 2005)
  - **1,200 galaxies** for 0.2 deg$^2$ (FMOS-FOV) and $\Delta z=0.3$
    - should be compared the 400 fibers
BAO Search by FMOS. 2

- Necessary number of nights: ~O(100)
  - 200 (nights) × 10 (pointings/night) = 2,000 pointings

- Sensitivity to the Hα Flux:
  - FMOS S/N=5 (1hr) \( \Rightarrow \) \( F(\text{Hα}) \sim 1-2 \times 10^{-17} \text{ erg/s/cm}^2 \)
  - galaxy with SFR = 1 \( \text{M}_{\text{sun}}/\text{yr} \) @ \( z=1.5 \)
    - \( L(\text{Hα}) = 1.3 \times 10^{41} \text{ erg/s} \)
    - \( F(\text{Hα}) = 0.86 \times 10^{-17} \text{ erg/s/cm}^2 \)
(Too) Many Target Galaxies!

Hα Luminosity Function
Hopkins et al. 2000

FMOS sensitivity
400 gals / (0.2 deg²)
for z = 1.4-1.7
Input Imaging Surveys

- UKIDSS Large Area Survey
  - 4000 deg$^2$
  - K < 18.4
- VISTA & VST
  - Deep
    - 100 deg$^2$
    - K < 21.0
  - Wide
    - 3000 deg$^2$
    - K < 19.5
- plan a special survey of a few hundreds deg$^2$ for FMOS BAO search?

From S. Warren
How to select z~1.5 targets?

The K20 Survey, Cimatti et al. '02.

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Required Depth of Input Imaging Survey

- Surface density of K<20 spiral galaxies at z=1.4-1.7 is comparable to fiber number density of FMOS
  - photo-z selection?

- K>20 galaxies may also have strong Hα
  - selection primarily by optical?

Prediction by the model of Totani et al. ‘01

![Graph showing predicted galaxy counts as a function of K magnitude.](image)

- 400 gals / (0.2 deg²)
- 1.4 ≤ z ≤ 1.7
Uniqueness & Strength

- Unique redshift range by H\(\alpha\) in NIR
  - redshift desert of 1.5 < \(z\) < 2.5 in optical spectroscopy
    - 0.5 < \(z\) < 1.3 by [O II]
    - 2.5 < \(z\) < 3.5 by Ly\(\alpha\)

- The instrument available soon!
  - Astronomical first light: 2006 spring
  - Open Use S07A? (2007 Feb- Jul)
  - will serve as a pilot project for future WFMOS

- will remain as a unique data set even in the WFMOS era by being NIR
Status of the proposal

- working group:
  - Japan
    - Toshinori Maihara
    - Kouji Ohta
    - Tomonori Totani
    - Takahiko Matsubara
    - Masahrio Takada
  - UK/USA
    - Gavin Dalton
    - Karl Grazebrook
    ...

- needs to persuade the Japanese community to get >100 nights
- 20 nights / yr is the maximum for open use
- needs to establish the selection procedure from input imaging surveys
Roadmap

- a pilot study by using FMOS GTO (20? 40? nights)
  - especially to establish the target selection procedure
  - SXDF is a good field for this study
  - optimize the survey parameters for w/w’ determination

- If the prospect is good, start political actions
  - appeal to the Subaru committee for a special project
  - making the survey useful also for other astrophysical purposes
    - a fraction of fibers assigned to some astrophysically interesting objects?
  - don’t forget sending a good cognac to the Subaru director
Conclusion

- NIR BAO search by Subaru/FMOS may give a useful and unique constraint on the dark energy, and will be an important step to the future WFMOS project.

- Feasibility study will start soon by FMOS guaranteed time.
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memo

- sensitivity to H\(\alpha\)
  - Karl’s ppt: \(L(\text{H} \alpha) = 1-2 \times 10^{-17} \text{ erg cm}^{-2} \text{ s}^{-1}\)
  - H band limit: \(20.9 \rightarrow 2.1 \times 10^{-15} \text{ erg cm}^{-2} \text{ s}^{-1}\)
  - line width \(\sim\) resolution \(R=500 \rightarrow 30\text{A}\)
  - band width \(\sim 4000\text{A}\)
  - \(2.1 \times 10^{-15} \times 30/4000 = 1.6 \times 10^{-17} \text{ erg cm}^{-2} \text{ s}^{-1}\)

- SFR\((\text{Msun/yr}) = 7.9 \times 10^{-42} L(\text{H} \alpha)(\text{erg/s})\)