FastSound: A BAO Survey with FMOS

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FastSound: A Brief Overview

- **FastSound:**
  - Fast: FMOS 暗黒振動探査 (Ankoku Shindou Tansa = Dark Oscillation Survey)
  - Sound: Subaru Observation Understanding Nature of Dark energy)

- A large galaxy redshift survey at z~1 using Hα by Subaru/FMOS

- **Purpose:**
  - precise measurement of the geometry of the universe at z~1
    - precise P(k) measurement including BAO → \( D_A(z) \), \( H(z) \)
      - \( D_A(z) \): angular diameter distance, \( dr/d \theta \)
      - \( H(z) \): the Hubble parameter, \( dr/dz \)
  - constraint on the nature of dark energy (w, dw/dt)
FastSound: A Brief Overview (2)

- Two important parameters for P(k) measurements: V and n

- survey volume, V
  - V >~ 1 Gpc$^3$ required for BAO detection
  - 300 deg$^2$ ~ 1 Gpc$^3$ for z=1.0-1.4
  - FMOS Survey Power ~ 100 \( (N_{\text{night}}/100)(N_{\text{fov-day}}/5) \) deg$^2$

- galaxy number density, n
  - nP >~1 required to suppress the Poisson error below the cosmic variance
  - nP >~1 satisfied by the FMOS fiber density (400/FOV, 30 arcmin diameter FOV)
Comparison with past redshift surveys

- **Survey Volume**
  - comparable to SDSS by 100 deg$^2$, to SDSS LRG by 300 deg$^2$
- **Galaxy Number**
  - 2dF ~220,000 (e.g. Percival+’07)
  - SDSS main ~500,000  (e.g. Percival+’07)
  - SDSS LRG ~50,000  (e.g. Eisenstein+’05, detection of BAO at S/N~3)
  - FMOS ~200,000 ($N_{\text{fov-day}}/5$) ($N_{\text{nights}}/100$) $f_{\text{eff}}$

  effective survey volume (small scale limited by Poisson noise)
Comparing with other future BAO projects

- **WiggleZ**
  - 4m Anglo-Australian telescope, AAOmega spectrograph
  - 220 nights during 2006-2009
  - 400,000 emission line galaxies, 1,000 deg$^2$
  - $z \sim 0.5-1.0$

- **SDSS-III BOSS**
  - 2009-2014
  - 1.5M luminous red galaxies, 10,000 deg$^2$, $z \sim 0.3-0.7$
  - Ly$\alpha$ forests of 160,000 quasars at $z \sim 2.2-3$

- **HETDEX (Hobby-Eberly telescope Dark Energy Exp.)**
  - 2010-2013
  - Ly$\alpha$ emitters at $z = 1.9-3.5$
  - 750,000 galaxies, 420 deg$^2$

- **WFMOS”-like”**
  - $> 201X$?
FastSound Design Status

- The Key Issues:
  - Which imaging survey should be used to select targets for FMOS?
  - How to select the target galaxies from photometric information?
Possible Choices of Imaging Data Sets

- Existing/Completed Surveys
  - CFHTLS Wide 170 deg² (170 deg², u*g’r’i’z’)
  - RCS2 800 deg² (g’, r’, z’ (+ i’?) and GALEX?)

- Future Surveys?
  - PanSTARRS
  - VST/VISTA
  - still others?
RCS2 (Red Sequence Cluster Survey 2)

- 830 deg² in total, 13 patches
- mag limit:
  - g'~25.3 (4 mins exposure)
  - r'~24.8 (8 mins exposure)
  - z'~22.5 (6 mins exposure)
  - i' available (H. Yee, private comm.)
  - GALEX
CFHTLS-Wide

- 4 fields, 170 deg² in total

<table>
<thead>
<tr>
<th>Survey</th>
<th>Area (deg x deg)</th>
<th>Filters</th>
<th>Depth for a point source SNR=5, 1.15”ap, 0.8”</th>
<th>Total integration per field</th>
<th>Observing strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wide Synoptic</td>
<td>170</td>
<td>u*</td>
<td>26.4</td>
<td>6000 s (27.2%)</td>
<td>7x850 s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>g’</td>
<td>26.6</td>
<td>2500 s (11.3%)</td>
<td>5x500 s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>r’</td>
<td>25.9</td>
<td>2000 s (9.1%)</td>
<td>Twice 2x500 s 3 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>i’</td>
<td>25.5</td>
<td>4300 s (19.5%)</td>
<td>7x620 s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>z’</td>
<td>24.8</td>
<td>7200 s (32.7%)</td>
<td>9x800 s</td>
</tr>
</tbody>
</table>
Target Selection Simulations

- Simulations using SDF & SXDS photometric data sets underway
  - Sumiyoshi, Totani, Glazebrook et al.
- 9 band photometry (BVRizJK, 3.6, 4.5μm) in ~1deg² fields
- Estimating Hα flux from photometric redshift fitting
- Calibration of “photometric” line luminosity by using SDSS data set
Photometric Hα and [O II] Luminosity Function of SDF and SXDF Galaxies: Implications for Future Baryon Oscillation Surveys

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Abstract

Efficient selection of emission line galaxies at $z \gtrsim 1$ by photometric information in wide field surveys

- Sumiyoshi+’09, arXiv:0902.2064
Simulating Target Selection

- RCS2: two color selection by $g'r'z'$
- CFHTLS Wide: $u^*g'r'i'z'$ five band photo-$z$
Target Selection Simulation: Results

- typical success rate of ~30-40% can be achieved both for RCS2 and CFHTLS-W
  - Line flux detectable by FMOS
  - correct redshift range

- $b \sim 1.5$, a crude bias estimate from galaxy stellar mass
Fisher Matrix Study about BAO Detection

- **CFHTLS Wide:**
  - 170 deg², 130 nts, 45min exposure + overhead 15min
    - D_A: 3.9%, H: 4.4%, alpha: 4.5%, BAO detection = 2.1sigma
    - Limited by the survey area (170 deg²), ~100 nts will be sufficient but BAO detection S/N <~2

- **RCS2:**
  - 340 deg², 130 nts, 15min exp. + overhead 15min
    - D_A: 3.4%, H: 3.8%, alpha: 3.9%, BAO detection = 2.5sigma
  - 830 deg², 330 nts, 15min exp. + overhead 15min
    - D_A: 2.2%, H: 2.4%, alpha: 2.5%, BAO detection = 3.9sigma

- (80% fine weather assumed in the number of nights)
An example of $w-w'$ constraint

**WCDM model**

$$w(z) = w_0 + w_a \frac{z}{1+z}$$

Parameters: $(w_0, w_a)$

Other cosmological parameters are fixed.
My Personal Opinion

- RCS2 should be the primary option
  - we can start FastSound survey soon once FMOS becomes in commission
  - a large total area sufficient for BAO detection
  - selection efficiency needs to be checked by real data

- CFHTLS-W as the second/back-up choice
  - limited by volume/area, BAO detection with >2 sigma difficult

- Still other options? new idea?
Next Steps

- Test of target selection by “real” data
  - Engineering/GT observations
    - preliminary observations of CFHTLS-Wide field have been done in May 2009 run, though data quality is not good

- Decision of the imaging data set
- Determination of exact target selection efficiency, selection function (redshift distribution)

- More realistic estimate/simulation of P(k)/w determination power and systematic uncertainties
  - realistic FMOS window functions
  - photometric errors, fiber positioning errors, ...
  - N-body simulations (Naoki Yoshida, Ryuichi Takahashi, ...)
  - BAO systematics (Taka Matsubara, ...)

- submit the formal proposal to Subaru
Expected Timeline

- Eng. runs and GTO for test of target selection
  - next eng. run scheduled in Oct-Dec 2009 (6 nights)
  - GTO likely starts from S10A (Feb. 2010-)
  - normal/intensive open use deadline for S10A: early Sep.

- Real survey from S10B or later?
  - relation to the SSP proposal?
Items to be discussed

- Imaging survey data choice

- Relation to the other science programs
  - combined SSP (galaxy evolution + BAO)?
  - separate and independent SSPs for gal-ev and BAO?
  - SSP for BAO and Intensive Program for gal-ev?
今後の検討課題

- RCS2, CFHTLS-Wide を想定したターゲット選択、輝線検出効率のテスト
  - RCS2 のデータは H. Yee から提供してもらえるそう
  - 次回エンジニアリングまでに準備

- より現実的な解析のシミュレーション
  - 系統誤差の吟味
  - GTO でのテスト観測の結果をもとに、迅速な戦略枠提案書の執筆

- RCS2, CFHTLS-Wide 以外のサーベイ領域使用の可能性
系続誤差の検討： 現実的なシミュレーション

- Beyond the Fisher Matrix Analysis

- 考慮すべき効果
  - 現実的な selection function, survey volume geometry
  - photometry の精度
  - reconstruction of P(k) and likelihood analysis
RCS2/CFHTLS 以外の撮像サーベイ使用の可能性

- RCS2 は広さは魅力だが、深さが不十分かもしれない
- CFHTLS-Wide は、深さは十分だが、広さはちょっと足りない
  - 100 nights で BAO 検出 S/N ~ 2
  - これ以上夜数を投入しても、広さ(170 deg²) limited でうまくはない
- より広い撮像サーベイの利用？
  - UKIDSS
    - ~4000 deg², K_{Vega} = 18.4, 浅すぎ？
  - KIDS/VIKING by VST/VISTA
    - ~1000 deg² の深いサーベイ計画
SXDS

optical

X-ray