Large Binocular Telescope Observatory

Imaging Fourier Transform Spectrometer for LBTO

1st Users’ Meeting

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University of Hawaii & CFHT

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Contributors

- Frédéric Grandmont (ABB) - Contact
- Laurent Drissen (U. Laval) — PI SITELLE
- Rogier Windhorst (ASU)
- Mark Wagner (LBTO)
- John Hill (LBTO)
IFTS is for:

- Wide field (10’-28’) with a Spectrum at every pixel
- Contiguous area spectroscopy
- Extended objects
- Emission line sources
- Narrow — medium bandwidth filters
- Shot noise uniformly distributed
Modulated panchromatic images

IFFTS Concept

FFT

OPD

Spectral images
<table>
<thead>
<tr>
<th>M27</th>
<th>SPIOMM_V.cam1.RawData interferogram000.fits</th>
<th>M27</th>
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<tr>
<td>1.956</td>
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**SpIOMM raw data**
SpIOMM reduced data

5577Å
[NII] 5756Å
He I 5876Å
[OI] 6300Å
[OI] 6363Å
Diagnostic diagrams

M27 - SpIOMM
Vitesses radiales
[NII]
Drissen et al. 2010
SITELLE + CFHT

- 20x sensitive than SpIOMM
- Automated calibration
- Queue Ready
- Completed data reduction pipeline
SITELLE field of view compared to IFUs

SITELLE + CFHT + atm (12’ x 12’, f.f. = 1)

(1’ x 1’, f.f. = 1)

MUSE

VIRUS (16’ x 16’, f.f. = 0.1)

Drissen et al. 2010
Imaging FTS Paraxial Ray Trace
Unfolded Representation

Telescope

Instrument

Primary Mirror
Secondary Mirror
F/15 Focus

Interferometer Zone
CCD #1
CCD #2

Collimator
Beam Splitter
Interferometer Mirror (x2)
Beam Combiner
Objective
Mapping CCD FOV onto Interferometer Fringe Pattern

Centering FOV allows fitting more throughput.

LBT 12’ FOV @ M = 84x

Off-axis angle (15°)

Interferometer FOV = 16.8°

7.3° x 7.3° (11’x11’ FOV @ 40x Magnification)
Configurations Trade-offs

- Assumptions:
  - Maximise FOV (10 – 24 arc min)
  - Limit instrument size (interferometer beam: 100 – 150 mm)
  - Maintain high spectral resolution of $R > 10\,000$ in the visible
  - Maximum OPD sets spectral resolution: MOPD > 5 mm

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<th>SITEELLE</th>
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<td>FOV [arcmin]</td>
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LBT Focal Stations

- Direct F/1.4
- F/15 Direct: FoV <11'
- F/15 Bent: FoV <11'
- F/15 GLAO: 4'x4'
- Cass foci: FoV 40'

Wagner 2012
Design Challenge to be Validated

- Most technical challenge were demonstrated in SITELLE.
- Redesign still imply new verifications:
  1. Can imaging quality be matched to pixel size for selected configuration and bandpass (350-950 nm)
  2. Validate that instrument size, mass and torque are compatible with LBT limits.
  3. Design an instrument structure that can maintain instrument flexures to a few pixels during long integration (few hours)
  4. Validate LBT operational vibration to be compatible with SITELLE interferometer metrology and scan mechanism.
COST Evaluation

- Cost driver:
  - New detector development vs past design reuse? (SITELLE required custom vibration damped dewar design due to imposed cooling method)
  - Number, size & complexity of lens included in collimator and camera objective (2x)
  - 4-port interferometer approach using spatial separation doubles the number of optics (4 mirrors + 2 beamsplitter substrate)
  - Although more numerous interferometer optics are of similar complexity to those of SITELLE.
- Based on these considerations the cost of an LBT wide-field IFTS would be in the 5-6 M$ range.
LBTO+IFTS

- Emission and absorption line studies
- $\text{flux} > \sim 1\text{E-17 erg/s/cm}^2 \text{ in 4hr (5-sigma)}$
- LBTO+IFTS 4-5x more sensitive than CFHT+SITELLE
- Filter selection - community input

Science Projects

- Solar system - non-sidereal tracking - comets
- Galactic — HII regions, stars, SNR, planetary nebula
- Extragalactic — nearby galaxies, hi-z galaxies, Lyman-alpha emitters, etc.
LBTO+IFTS: Science

New Filter Bands

Lyα 2.1 < z < 6.7
[OII] 0 < z < 1.5
[OIII] 0 < z < 0.8
Hα 0 < z < 0.4
IFTS Software

- IFTS Simulator
- Setup IFTS observations
- Complete data reduction pipeline
  - Flux calibrated
  - Phase correction
- Reduced data cube \((\alpha, \delta, \lambda)\) are stackable
Summary

- SITELLE first light in fall 2014
- LBTO-Ifts 4-5x more sensitive than SITELLE
- Wider FOV than existing IFUs
- Science case that take advantage of wide-FoV and sources that are extended
Compare Dispersive Spectroscopy to IFTS

- M27 2hr IFTS observations
  - filter BW=100nm; 1.6m telescope
- Dispersive: 1” slit & BW=500nm
- 12’ => 720” or 720 slits
- 2hr or 7200s/720=10s per slit; SNR will be low