Development Status of the DOTIFS Project: a new multi-IFU optical spectrograph for the 3.6m Devasthal Optical Telescope

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DOTIFS Overview

• DOTIFS: Devasthal Optical Telescope Integral Field Spectrograph
• Multi-Integral Field Unit
• # of IFUs: 16
• IFU field of view: 8.7 x 7.4 arcsec (12x12=144)
• Spatial resolution: 0.8 arcsec (vertex to vertex, hexagonal)
• Spatial elements per IFU: 144 (12x12)
• Total # of spatial elements (# of fibers) : 2304
• Focal plane field of view: 8 arcmin (diameter)
• 8 Identical spectrographs
• Wavelength range: 370 – 740 nm
• Resolving power: $R \approx 1800 @ 555 \text{nm}$ ($\Delta \lambda = 3.08 \text{Å}$)
IFU:
(12x12) (hexagonal microlens array)

8 arcmin

x 16
Science Drivers

• Science Reference Document
  – Swara Ravindranath, Amitesh Omar, A. N. Ramaprakash, 2011
  – Circumnuclear rings in barred galaxies
  – H-alpha emissions from Lyman-alpha clouds
  – Rotation curves of nearby galaxies
  – AGN outflows, Dual AGNs or pairs
  – Galactic HII regions
  – Merging, and Interacting galaxies, ULIRGS
  – Galaxies in clusters and Groups: Star formation
  – Outer regions of star-forming galaxies
  – Emission-line galaxies at intermediate redshifts

2015-01-27 2015 Survey Science Group Workshop @High 1
3.6m Telescope

- Devasthal Optical Telescope
- Manufactured by AMOS @Belgium
- Effective focal ratio: F/9 (f=32400mm)
- Field of view: 30’ for axial port, 10’ for side ports
- Alt. 2450m
- Seeing: 1.1” (median), 0.7” (best)

Sagar et al. 2012
DOTIFS Optics Trail

Telescope Side port

F/9

Magnifier

F/21.486

8 arcmin Focal Plane

IFUs

F/4.5

x 16 IFUs. 144 fibers / 1 IFU

288 fibers (from 2 IFUs)

Collimator

VPH Grating

F/4

Spectrographs

8 x

Camera

CCD

F/1.5

2304 Optical fibers (~2m)
Integral Field Unit

Hexagonal shape microlens array

8.7” (2.61mm)

Example of one microlens (F/4.5, ~99% Fill factor)

Light from the magnifier (F/21.486)

Fiber (F/4.5, 100μm)
Deployment System
Spectrograph Optics

- Collimator: 3 singlets, 2 doublets
- Camera: 3 singlets, 3 doublets
- 8~16cm diameter, All Spherical
- VPH grating (615 lines/mm, 8.49 degrees, peak@480nm)
Throughput

- From telescope to CCD (Sky is not included)
- 27.5% on average
- 34.2% at peak, 16.4% and 17.5% at the blue and red end
DOTIFS Strength

• High throughput
  – Expect 27.5% on average, 16.4%@370nm, 31.3%@555nm and 17.5%@740nm

• IFU deployment system
  – Short IFU reconfiguration time (minimize overhead)
  – Fast x-y actuator system with proper deployment algorithm (avoid collision)
  – Target: < 30sec to reconfigure 16 IFUs.

• Multiplexity
  – 16 IFUs. FoV per IFU: 8.7” x 7.4”

• Spatial sampling
  – 0.8” vertex to vertex hexagonal shape.
DOTIFS Data Simulator

**DDS input parameters**

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<th>Parameter</th>
<th>Value</th>
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**DDS execution**

hchung@ubuntu:/data_simulation$ ./DDS_check3.dat
~~~~~~~~~~~~~~~DOTIFS DATA SIMULATOR~~~~~~~~~~~~~~
Reading simulation parameters...
ifu file names: hexa01.fits hexa02.fits
Allocating memory...
Reading probability distribution files...
Reading PSF grid file...
Reading flux data files...
Sky background file: esoskyMF000KA000M1000.flux
Sky transmission file: esoskyTA090.trans
Reading transmission data files...
Littrow ghost case1 sum: 0.008783
Littrow ghost case2 sum: 0.212856
~~~~~~~~~~~~~~~Simulation Parameters~~~~~~~~~~~~~~
Object name prefix: hexa
Number of fibers: 300
Wavelength range (nm): 370.0 to 740.0
Exposure time: 9.00e+02
Simulation wavelength dispersion (nm): 0.037000
Detector size (spectral * spatial): 3150 * 2100
PSF grid size (spectral * spatial): 32 * 22
Output file: Test.fits

Expected execution time: 12.20 second
Running...........
Noise flag: OFF
Done!
Execution time: 12.00 second

- It simulates a spectrograph CCD image.
- It is required to develop the data reduction software.
- It includes various instrument effects and observing conditions
  - Atmosphere, sky background, transmission, spectrograph optics effects, detector noise, moon phase, moon altitude, moon-target separation...
DOTIFS Data Simulator

- Virtual observation

Original IFU data from CALIFA Survey database

Image courtesy, NED
DOTIFS Data Simulator

- Simulation result

Log scale

Sky emission lines
Project DOTIFS

DOTIFS Project

3.6m Telescope
Technical advisement

Instrumentation Lab Facility
Design, build, and commission the instrument

Support by Prof. Changbom Park

DOTIFS Team

ARIES
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IUCAA
Dr. A. N. Ramaprakash
Mr. Sabyasachi Chattopadhyay
Mr. Chaitanya V. Rajarshi
Mr. Pravin Khodade

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Mr. Haeun Chung (SNU)
History

• Aug 2011: MoU signed (IUCAA & ARIES)
• Sep 2011: Science Reference Document developed
• Aug 2012: Conceptual design ready
• Oct 2012: Conceptual Design Review (at ARIES)
• Dec 2012: Start ordering of test components
• Apr 2013: Baseline Design Review (at IUCAA)
• Nov 2013: Spectrograph optics design ready
• Jun 2014: MoU signed (between IUCAA & KIAS)
• Jun 2014: Optics Design Review (at IUCAA)
• Aug 2014: Magnifier optics design ready
History

- Jun 2014: Optics Design Review (at IUCAA)
  - Decided to develop proto model before full configuration
  - 4 IFUs with 2 spectrographs

- Aug 2014~
  - Revisions on spectrograph optics
  - Re-quote lens pricing to lens manufacturers
    2 spectrographs + 1 magnifier optics
Current Status

• Design
  – Spectrograph and magnifier optics design
  – IFU and deployment system design
  – Opto-mechanical design

• Hardware
  – Optics vendor identification
  – Ordering optical components
  – Ordering major/sample parts
  – Testing sample parts

• Software
  – Data simulator
  – Data reduction software
  – Deployment software
• Apr 2015: Order optics lenses
• Jul 2015: Opto-mechanical design ready
• Aug 2015: Deployment system design ready
• Jan 2016: Start spectrograph assemble
• Jan 2016: Data reduction software ready
DOTIFS is a Multi-Integral Field Unit optical spectrograph for India’s 3.6m Devasthal Telescope

- International instrumentation project between KIAS, IUCAA and ARIES.
- Focal plane field of view: 8 arcmin
- # of IFUs: 16 (FoV per IFU=8.7 x 7.4 arcsec)
- Spatial resolution: 0.8 arcsec (hexagonal)
- Wavelength range: 370 – 740 nm (R~1800 @555nm)

Current status:

- Spectrograph optics / main parts design / data simulator are finalized.
- Several opto-mechanical parts and optics have been ordered.
- Reduction software is under development.

SPIE Proceeding paper: Chung et al, 2014

DOTIFS is planned to be commissioned around 2017.
Thank you !