Exploring the nearby galaxies - present and future

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• Galactic Structure

- Sun's location
- Disk: 28,000 light-years
- Bulge
- Halo: 1,000 light-years
- Globular clusters

• (105 – 106 stars)
Neighbours to our Galaxy:
Local Group of galaxies
Edwin Hubble's Classification Scheme

Ellipticals

E0 E3 E5 E7 S0

Spirals

Sa Sb Sc
SBa
SBb
SBc
Orientation is an important consideration

Hubble Sequence

E0

S0

Sa

Sb

Sc

E6

Irr

(Barred examples)
• Galaxies:
  • Content
    ▪ Stars
    ▫ Gas, Dust
  • Structure & Kinematics
  • Dynamics & Ecology
  • Formation & Evolution
    ▪ Star formation
    ▪ Chemical evolution
    ▪ Dynamic evolution
    ▪ Interaction with neighbours
  • Galactic Centre
• Galactic Disk: Ecology

• Leads to Chemical Enrichment
Figure shows schematically, right part of the figure, the cycle that matter follows since the origin of the universe, enriching at each cycle the interstellar medium of heavier elements. Ms indicate the original mass of the star and Mc the residual mass after the mass loss.
Isotopes are us...  

Where, how and why?

Present-day Solar System Composition
Evolutionary Tracks off the Main Sequence

Effective Temperature, K
30,000 10,000 7,000 6,000 4,000

Absolute Magnitude, M_V

Luminosity compared to Sun
10^5
10^4
10^3
10^2
10^1

Spectral Class
O5 B0 A0 F0 G0 K0 M0

-0.5 0.0 +0.3 +0.6 +0.8 +0.9 +2.0

Colour Index (B - V)

Supergiants (I)

Giants (II, III)

Helium flash

RGB - Red Giant Branch
HB - Horizontal Branch
AGB - Asymptotic Giant Branch

5 M_☉ star
10 M_☉ star
Magellanic Clouds – test case for an interacting pair

- Magellanic Clouds (Large Magellanic Cloud & Small Magellanic Cloud) are two irregular and nearly face on galaxies which are located at a distance of 50 kpc & 60 kpc respectively from our Galaxy.
- They are known to have interactions with each other as well as with our Galaxy.
- These interactions have altered the structure of the LMC & SMC.
- Magellanic bridge, Magellanic stream and leading arms are signatures of these interactions.

Putman et al 2003
Sky coverage of data sets (OGLEII, OGLE III, MCPS)
3D picture of the LMC disk – internal or external perturbations?

- The figure clearly shows that the inner regions have smaller inclination and the outer regions have large inclination.
- The increase in the inclination seems to be start at a closer radius in the north-east, when compared to the south-west, which makes it off-centered.
- The change of structure in the outer LMC could be due to tidal effects.

SMC structure – spheroidal/ellipsoidal


X:Y:Z
1:1.3:1.6

i = 2.6
PA = 70.2
Deprojection to the LMC plane, *free from viewing perspectives*

An extension of younger star forming regions towards the N-NE

Indu & Subramaniam (2012)
Fig. 10. The intensity weighted mean velocity map using GASS data. Colour coding is according to the variation in $v_{mod}$ in $km\ s^{-1}$. The alphabets marked are locations of (a1) ram pressure stripping/outflow from west and SW of the LMC disk, (b) the extension of Arm B feature to the MB/SMC. Both (c) the plume of blue points near the NW edge and (d) the blue points in the south and SE of the LMC disk, are suggestive of gas infall, (a2) and (a3) are locations of ram pressure stripping from south and SW of the MB respectively.

Indu & Subramaniam (2014)
Outliers in HI gas

Indu & Subramaniam (2014)
Australian Astronomical Telescope
AAOmega
Figure 1. A $9^\circ \times 9^\circ$ image of the sky centered on the SMC (100$\mu$m IRIS data, Miville-Deschênes & Lagache 2005). The circles, which each correspond to an AAT + 2dF/AAOmega pointing, highlight the areas included in our photometric and spectroscopic survey. Note that at least two distinct fibre configurations were observed for each of the four central fields. Two Galactic globular clusters within our survey area are also highlighted (open squares).
Figure 19. A conceptual plot of the SMC highlighting the position-angles of the HI (Stanimirović et al. 2004) and the RGB star kinematic axes (this work). The locations of the NE (possibly the Magellanic Bridge) and the suspected NW (possibly the “Counter-Bridge”) tidal structures are highlighted, as are the optical and the HI centers of the Cloud, the SMC’s direction of tangential motion and direction of the LMC.

Dobbie et al. (2014a & 2014b)
ASTROSAT

• Three identical Large Area Xenon-filled Proportional Counters (LAXPC) – timing and low resolution spectral studies in 2 - 80 keV band

• Cadmium-Zinc-Telluride Imager (CZTI) – imaging and moderate resolution spectroscopy in 10 - 100 keV band

• Soft X-ray Imaging Telescope (SXT) – imaging and medium resolution spectroscopy in 0.3 - 8.0 keV band

• Scanning Sky Monitor (SSM) – monitoring X-ray sky

• Ultra Violet Imaging Telescope (UVIT)
UVIT – basic information

- UVIT is primarily an imaging instrument.
- Images are made simultaneously in three channels: FUV (130-180 nm), NUV (200-300 nm), and VIS (320-550 nm), in a field ~ 28’ circle and with a spatial resolution (FWHM) < 1.8”.
- In each channel, a set of filters are available, in the filter-wheels, for selecting a band.
- In the two ultraviolet channels, gratings are provided for low resolution (~ 100) slitless spectroscopy.
Integrated UVIT Payload in 1000Class

Plan view
FUV- UVIT Payload in Class 100 Tent

FUV Telescope

NUV/VIS Telescope

Realized

30 05 2012 13 41
India’s participation in the Thirty Meter Telescope Project:

(TMT-India Group)
The Thirty Meter Telescope:

3.1m convex hyperboloidal secondary mirror

Ritchey-Chrétien optical design

30m hyperboloidal f/1 primary mirror with 492 segments

20 arcmin field of view

f/15 final focal ratio

Flat 2.5m x 3.5m tertiary mirror
TMT Site: Mauna Kea

- Clear/usable nights: 76%
- Precipitable water: <2mm
- Altitude: 4000m
- Av. Temp.: 2.7°C

Seeing statistics (50m above ground):
- 25%: 0.40 arcsec
- 50%: 0.54 arcsec
- 75%: 0.75 arcsec
Project Schedule and Status

- Cabinet approval for India to join the project – September 2014
- Final approval by the Board of Land and Natural Resources for construction.
- Construction begins in early October 2015
- India will sign the partnership agreement soon.
TMT-India’s role in the project

- M1 polishing
- M1CS: Actuators
- Edge Sensors
- Segment Support Assembly (SSAs)
- Telescope and Observatory Control Software
- Instrument Development – MOBIE, IRMS
Primary Mirror Segment Polishing

- 574 segments of 82 different types: 492 + 82 Spares
  - 1.44 m across corners, 45mm thick; Aspheric, Off-axis
  - Curvature changes from centre to edge
- Surface roughness <2nm rms with no sub-surface damage

India’s part: ~125 segments

0.7μm PV, 0.18μm rms Asphericity 225μm
(Tinsely, USA)
Primary mirror Control system (M1CS)

Segment (115-150)

Edge Sensors (~3000)

Segment Support Assembly (492)

Actuators (1476)
Platform layout with First Generation Instruments
A Few Major Science Drivers
(DPR_DST2010 science Case)

30-m Advantage

Angular Size: factor of 3 better than current 8-m telescopes and 12 times of HST

Sensitivity: factor of 14 (seeing)-200 (AO) (αD2, αD4) better than current 8-m and 20,000 (AO) better than HST.
Near field cosmology at diffraction limit

TMT will help to understand the chemical history of the local group of galaxies through optical and IR spectroscopy.
Science Team Progress

- Completed trade studies on optical configurations, detector gaps…
- Astrometry team – 40 page report led by Matthias Schoeck identifying detailed breakdown of requirements.
- M31 simulator, continued simulation of key cases
- Beginning discussions of data reduction pipeline (Wright)
Thirty Meter Telescope

Astronomy’s Next-Generation Observatory