Exploring the Need for Requirements for Polarimetric and Time Resolved Observing Capabilities with the TMT

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Abstract

The observatory requirements needed to support Polarimetric and Time Resolved observing programs are being explored. Many different observing programs covering a range of different science areas are being considered. Technical and cost implications will be balanced with scientific impact, new requirements will be generated with supporting science cases. Science areas include Exoplanet Characterisation, GRBs, Supernovae, Kilonovae, CVs, LMXBs, Neutron Stars, White Dwarfs, Star Formation, Starburst Galaxies, Galactic Structure, QSOs and AGN, Asteroids and Kuiper Belt Objects. This work is being carried out by a large number of people.

Polarimetry Observing Programs

Star and planetary formation	Searches for biomarkers on exoplanets
Kinematics around young stars	Flare stars
Direct detection and characterization of exoplanets	Magnetic field mapping of solar type stars peculiar stars, variable stars, evolved stars, etc.
Exoplanet magnetic fields	Brown Dwarf atmospheric processes
Studies of organic molecules, their formation and delivery mechanisms	Dust structure, outflow geometries and emission mechanism in QSOs
Soft γ-ray repeaters	Galactic magnetic field structure
Cataclysmic Variables	Structures and kinematics in starburst galaxies
Interstellar polarization and diffuse interstellar bands	Dust distribution and magnetic field structure in the solar neighborhood
Anisotropy of supernovae explosions	γ-ray bursts
Characterizing NEOs for sample return missions	Magnetic fields of compact objects

Time Resolved Observing Programs

Observing program	Resolution	Wavelength range	Observation details[2]	Integration time[3]
White dwarf surface Calcium pulsation mapping	6000	370nm to 640nm	Time resolved spectroscopy for a few hours of Mg II (4480Å) & Ca K (3933Å) to identify oscillations	12s
White dwarf and sdB star asteroseismology	4000	340nm to 610nm	Time resolved spectroscopy to get pulsation spectra of different modes	5s
	50,000	370nm to 520nm	Mode identification	5s
Pulsar non-radial oscillations and rotation	~100	340nm to 1200nm	Spin phase resolved spectroscopy with frame transfer EMCCDs	0.1ms
Prompt observations of GRBs & GRB afterglow	~100	400nm to 2200nm	TOO time resolved spectroscopy with Mv of 18 to 22	1s
Supernova core collapse shock breakout	2000	525nm to 950nm	TOO time resolved spectroscopy of targets from surveys	15s
		4500nm to 5100nm	TOO time resolved spectroscopy of targets from surveys	15s
Detached WD-WD merger candidates	~5000	370nm to 450nm	Time resolved spectroscopy to get orbital radial velocities[4]	30s
Doppler tomography of Cataclysmic Variables	>4500	320nm to 2400nm	Time resolved spectroscopy of orbital changes in line profiles	15s
Cataclysmic Variables: Spectral eclipse mapping	~1000	320nm to 950nm	Rapid spectroscopy to look at line profile changes during eclipse	100ms
Cataclysmic Variables: Studies of rapid variability	~3000	320nm to 950nm	Rapid spectroscopy to look at rapid continuum and line variability	50ms
LMXB echo mapping and Bowen blend secondary star measurements	1000	450 to 700nm	Correlation between X-ray and optical continuum and line emission (especially Bowen Blend 464nm and HeII 469nm)	100ms
Magnetic fields and habitable zones around dwarf flare stars	4000	350nm to 700nm	Time resolved spectroscopy of emission line & continuum changes	0.1s
Exoplanet studies: Transits, secondary eclipses & surface mapping	1000	Parts of 700nm to 5000nm	Time resolved spectroscopy of ingress and egress lasting about 30 min around Mv>10 host stars	<30s
Exoplanet studies: Rossiter-McLaughlin effect	60000	550nm	Time resolved spectroscopy of 2hr transit around Mv>15 host star	96s
Asteroid morphology, binarity and composition	~1000	800nm to 2500nm	IFU observations of 0.03" sized resolved target rotating in 2 mins or unresolved objects in a binary each with 2 min light curves and a separation of 0.02"	15s
Asteroid orbits	Broadband imaging	Optical/NIR	Wide field AO assisted astrometric observations with an astrometric error of 0.03"	72s
TNO/Kuiper Belt object occultations	~1000	340nm to 5000nm	Rapid spectroscopy of background star with occultation event lasting between 1s and 200s	10ms

Ramifications of exploring time resolved requirements

- Lots of high impact science require time resolution between 10^{-4}s to 100s
- Baseline capabilities of 1st light instruments being explored
- 1st light instrument teams are being 'sensitized' to time resolved science
- Scope for cost neutral changes to reduce dead time and readout rates
- Future instrument designs will respond to community demand
- Development of future instruments will be more rapid than for 1st light
- **Only emerging new requirement is for a high accuracy time server**

The process for exploring polarimetric requirements

- We have determined acceptable error bars and observing requirements for a variety of observing programs covering a range of science areas
- We will determine each program's tolerable instrumental polarization
- Zemax modeling is being used to estimate the baseline polarimetric performance for a range of exposure times
- We will explore simple steps that can improve polarimetric performance
- Polarimetry budget and draft subsystem requirements will be generated
- We will determine which science programs can be supported with the baseline and optimal designs
- Technical and cost implications of additional baseline and optimized requirements will be balanced against the scientific merits of programs that are enabled

Flow chart for exploring polarimetric requirements showing the sequence of tasks and connections between tasks. Blue boxes at the top denote the overall task and two tracks of effort. Green denotes completed work, yellow denotes partially completed. Purple boxes are polarimetric modeling tasks being conducted by TMT-India. The orange two way arrow indicates a significant amount of back and forth iterations.