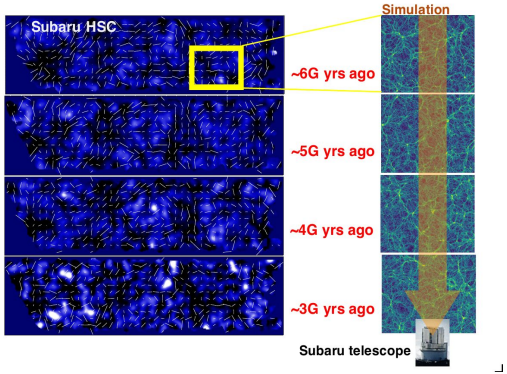
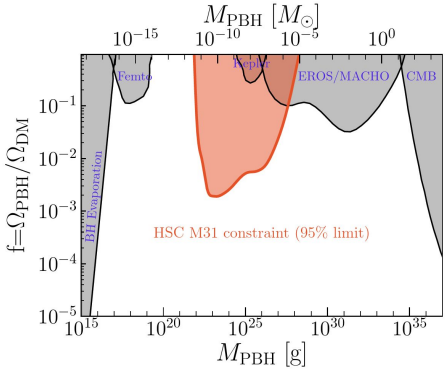
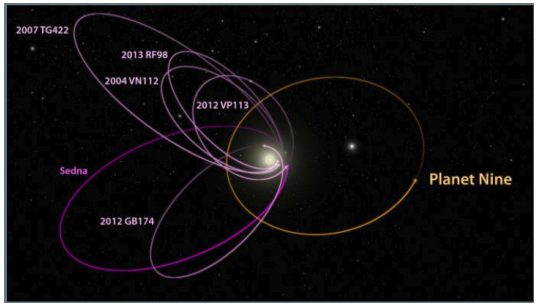
Indian participation in Subaru telescope

Surhud More (IUCAA)

Ongoing projects with the Japanese community







- The Hyper Suprime-Cam Survey weak lensing working group
- Mapping out dark matter in the Universe: sharp, deep and yet very wide maps*
- Cosmological constraints from cosmic shear power spectrum studies*
- Tight constraints on lunar mass primordial black holes*
- Ongoing survey to discover Planet Nine in the outer Solar system
- Mapping out the boundary of the dark matter halo of the Milky way using RR Lyraes

* Results covered in SUM2018

Astronomical research institutes in India

- Wide variety of astronomical research being pursued in India

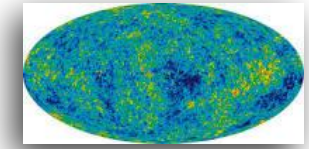
Funded by different channels

UGC: University Grants Commission, **MHRD:** Ministry of Human resource and development,

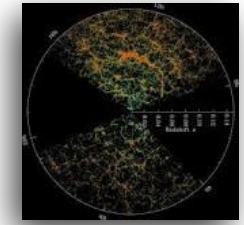
DST: Department of Space Technology, **DOS:** Department of Science, **DOE:** Department of Energy

Broad science areas

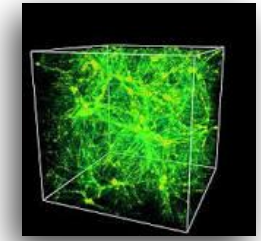
Solar physics



Cosmology



Large scale structure



Interstellar and intergalactic medium

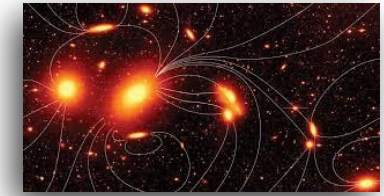
Gravitational waves

Stellar astrophysics

Transients

Galaxy formation and evolution

High energy astrophysics



Cosmic magnetic fields

A challenging climb!

8-10 m(1990s)

World

4- 6 m (1980s)

TMT

Science and Technology Readiness for TMT
Access and training with 8-10m telescopes

India

3.6 m (2015)
Devasthal optical telescope

TMT

Adapted from slides by G. C. Anupama (IIA)

The search for a 8m class facility

- The Project management board (PMB) for TMT-India requested the TMT-India SAC to review existing 8m class facilities and make a recommendation to get access to these telescopes (~mid-2016).
- TMT-India SAC reviewed a number of telescopes and their capabilities and match to Indian science.
- Given the location, range of instruments available, TMT-India SAC recommended PMB to talk to Subaru (Jan 2018).

Subaru is looking for long term partnership, and not just selling time.

NAOJ delegation visit @IUCAA (Dec 2018)

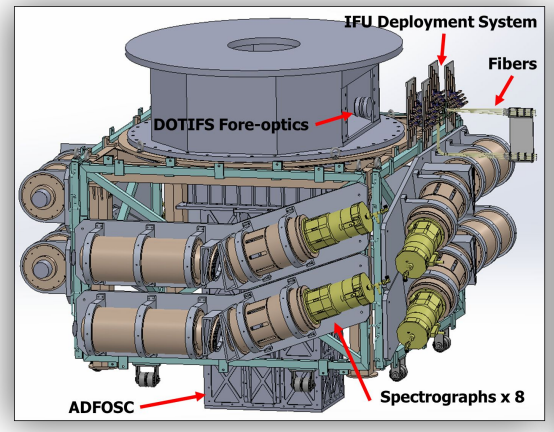
Draft meeting schedule for NAOJ delegatio

Schedule	Dec 3	
9:25	Welcome	S. Raychaudhury
9:30	NAOJ activities	S. Tsuneta
10:20	Subaru - past, present and future	M. Yoshida/ N. Ohashi
11:10	TBD	K. Sekiguchi
11:30	**Tea break**	
12:00	TIFR overview, facilities and interests	D. Ojha
12:30	NCRA overview, facilities and interests,	Y. Gupta
1:00	**Lunch**	
2:00	IUCAA overview, facilities and interests	S. Raychaudhury
2:30	ISRO Space Science Activities	P. Sreekumar
3:00	**Tea break**	
3:30	ARIES overview, facilities and interests	S. B. Pandey
4:00	PRL overview, facilities and interests	S. Ganesh
4:30	IIA overview, facilities and interest	T. Sivarani
5:15	Indian National Large Optical Telescope	P. Parihar
6:00	**Dinner organized by director**	
7:00		

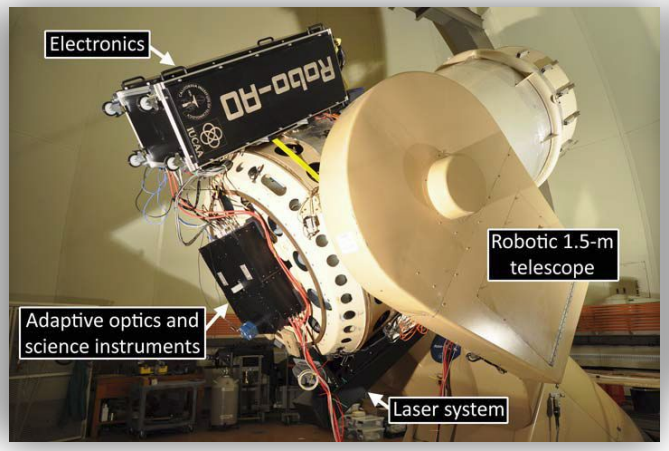
- **Strong interest in developing Indo-Japanese collaboration**

Instrumentation @IUCAA

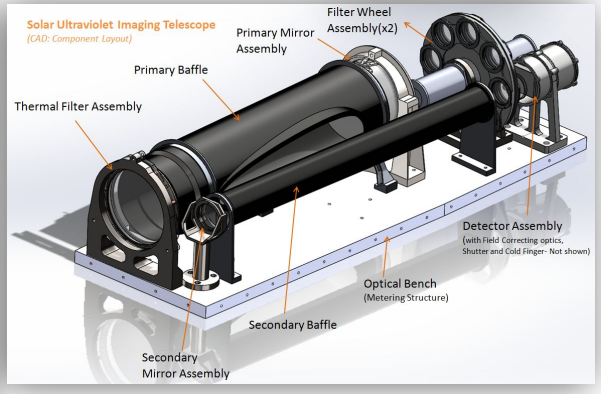
IUCAA



DOTIFS integral field spectrograph for Devasthal 3.6m



Robotic AO installed at Palomar (w/ Caltech)

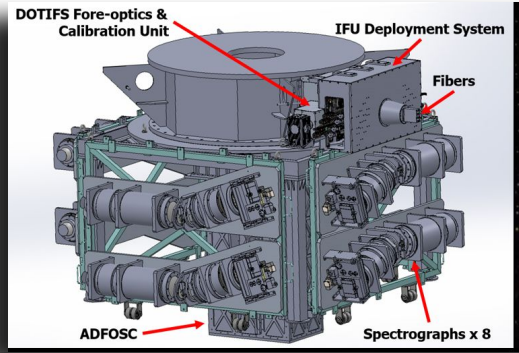


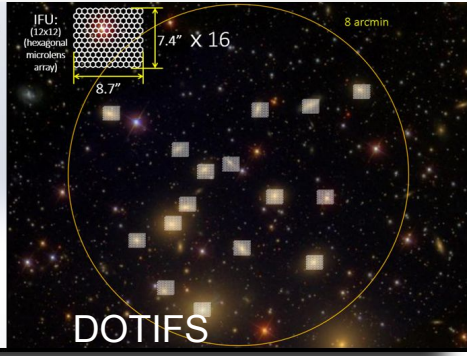
Aditya L1 Solar UV Imaging telescope

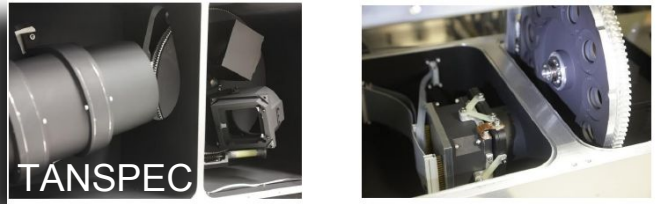
Capabilities include: Fiber fed spectrographs, Adaptive Optics, Controllers

Instrumentation on Devasthal optical telescope

4kx4k CCD imager







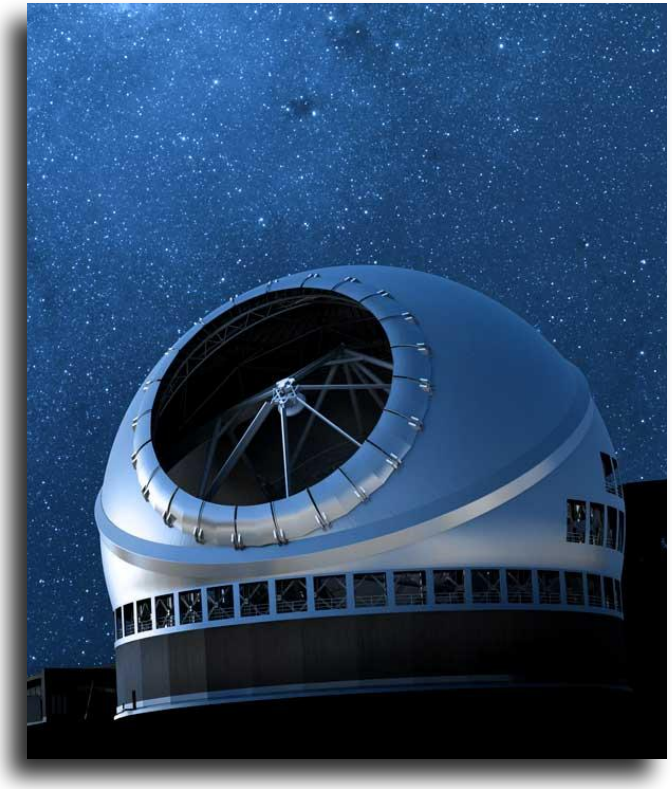
Near-IR spectrograph

- **Various institutes involved in the instrumentation**

TMT activities in India

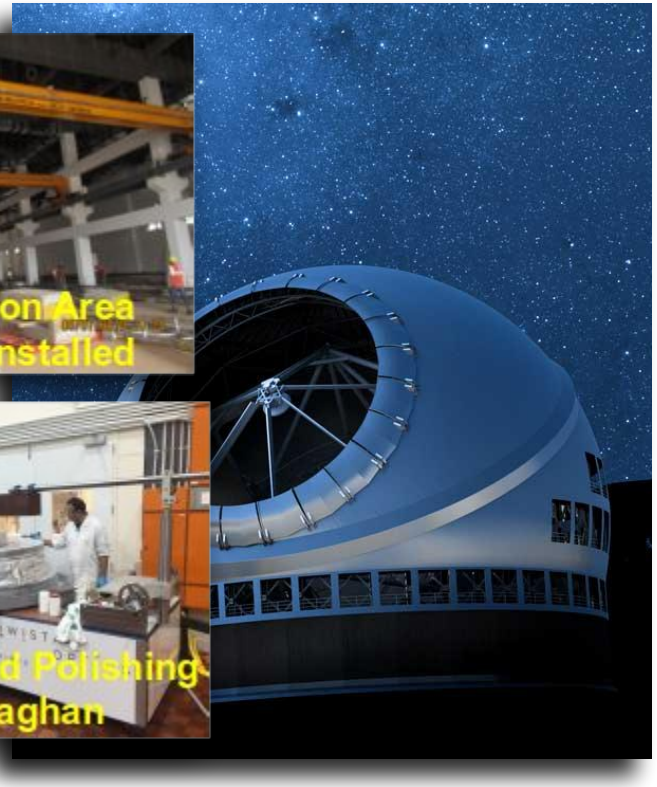
- Edge sensors
- Actuators
- Segment support assemblies
- Segment polishing
- Telescope control software

IIA, IUCAA, ARIES are PI institutes
TIFR, RRCAT are associates



TMT activities in India

- Edge sensors
- Actuators
- Segment sup
- Segment polishing
- Telescope c



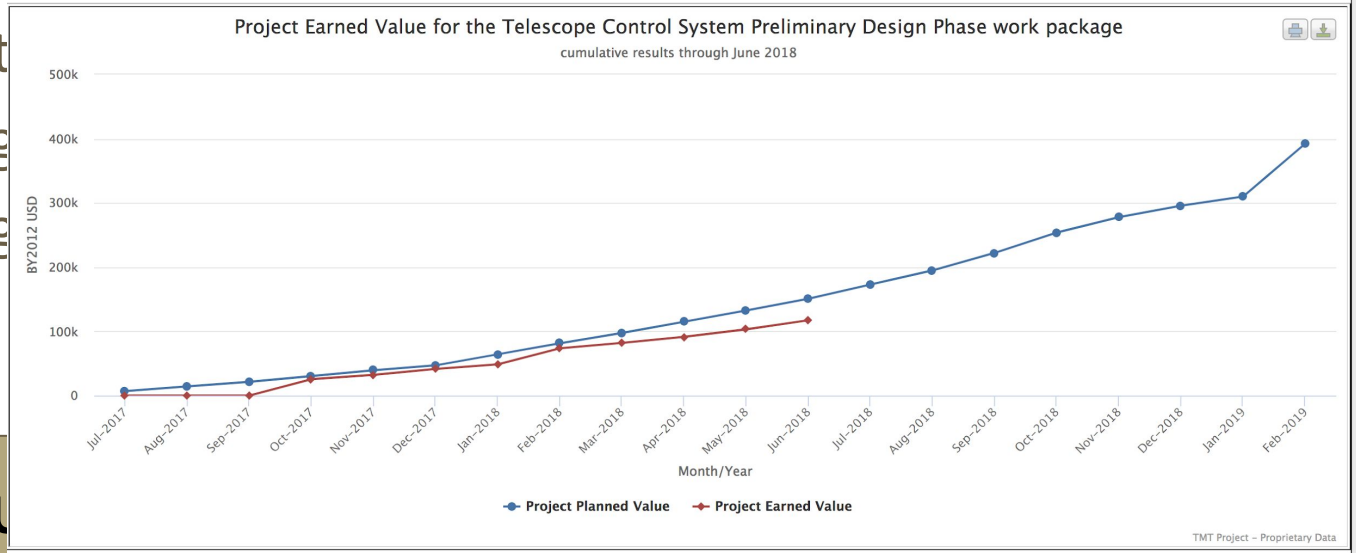
IIA, IUCAA, ARI
TIFR, RRCAT are associates

TMT activities in India

- Edg
- Act
- Seg
- Seg
- Tel

Jun 2018 Monthly Results			Cumulative Results through Jun 2018			At Completion		
Work Scheduled	Work Performed	Variance	Work Scheduled	Work Performed	Variance	Budget at Completion	Estimate at Completion	Variance
$18,307	$14,128	$-4,180	$150,842	$117,338	$-33,504	$392,434	$392,434	$0

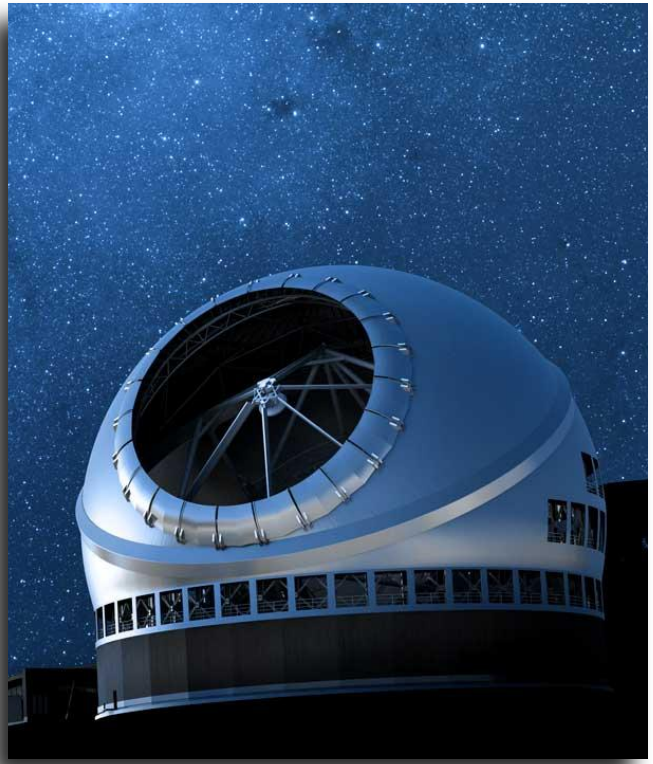
Schedule Performance Index (SPI): 0.78



IIA, IU
TIFR, RRCAT are associates

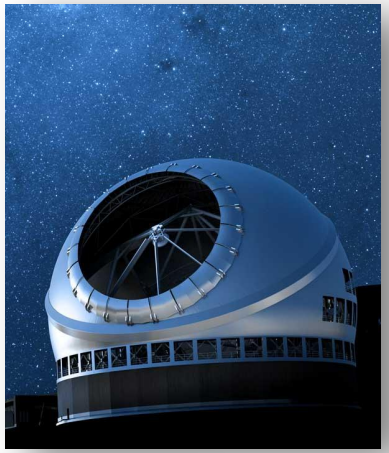
TMT science activities in India

- Study of polarimetric budget of telescope and first light instruments
- Generation of Infrared guide star catalog
- Wide field optical spectrometer
  - Optical design analysis, flexure modeling, fiber allocation simulation, sky subtraction, instrument software, detector electronics
- High resolution optical spectrograph
  - Lead role in whitepaper
- MICHI
  - Polarimetric mode, instrument control software



India’s involvement in mega-science projects

LIGO INDIA



SKA SQUARE KILOMETRE ARRAY

FAIR Facility for Antiproton and Ion Research in Europe GmbH

CERN

iter china eu india japan korea russia usa

- India is not shy of investing in mega-science projects, a number of ongoing space-based astronomy projects as well.

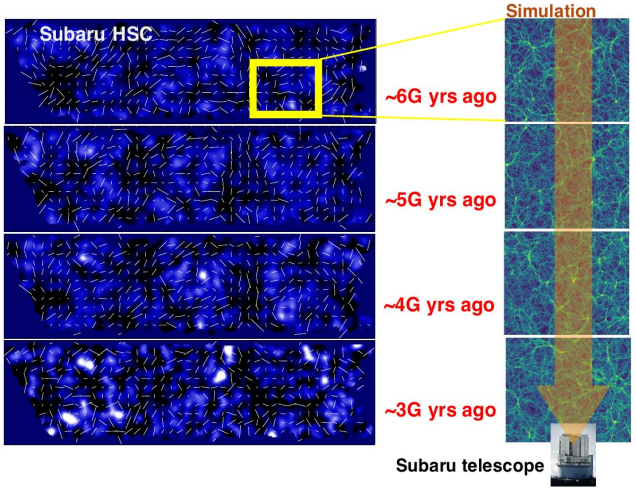
Summary

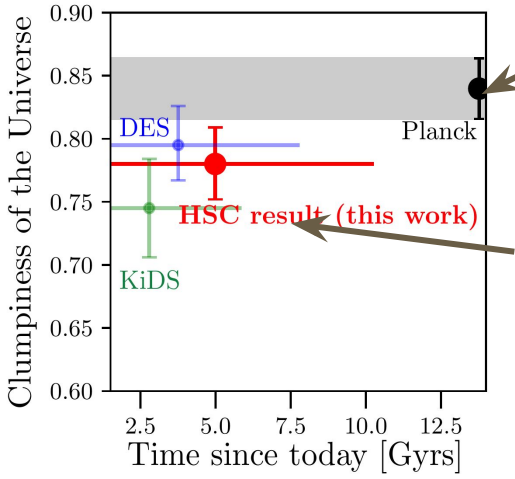
- Strong interest in developing Indo-Japanese collaboration
- Subaru international participation could just be a beginning, a good start to building relations and scientific collaborations for TMT era
- A committee being setup in India to have discussions with Subaru

Thanks!

Backup slides: Science projects (more personal view)

Cosmological constraints from cosmic shear





Planck prediction for cosmological constant model

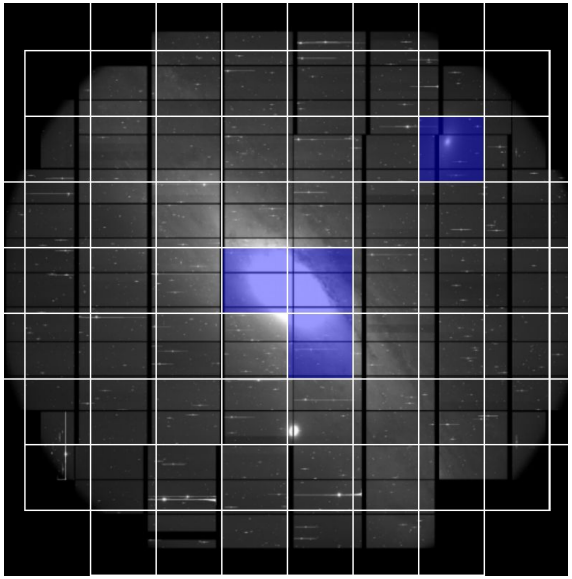
Cosmic shear surveys measure lower clumpiness, ability to probe breakdown of simple model

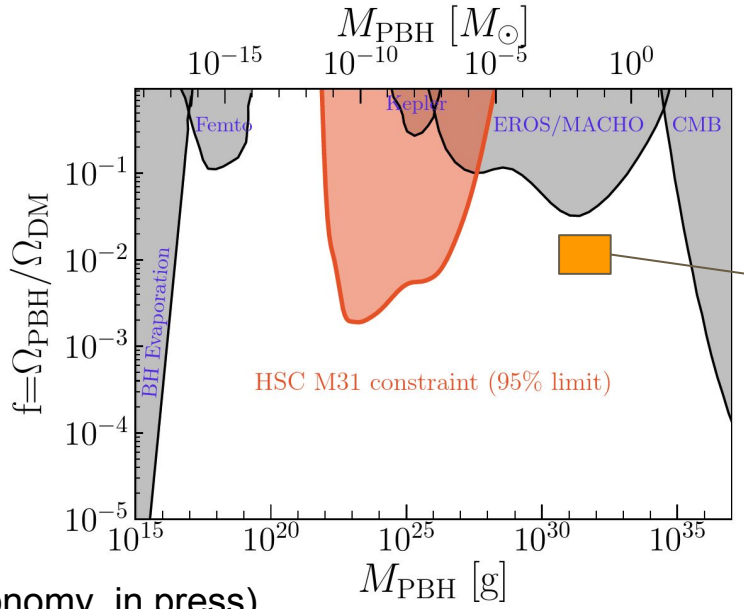
Hikage, Oguri, Hamana, More et al. 2018 (under review)

Chairs of the HSC weak lensing group: Hironao Miyatake and SM

- Dark matter map using weak gravitational lensing
- Statistical properties of dark matter map encoded in cosmic shear
- Growth of structure can probe sum of neutrino masses, dark energy models

Microlensing constraints on lunar mass primordial black holes



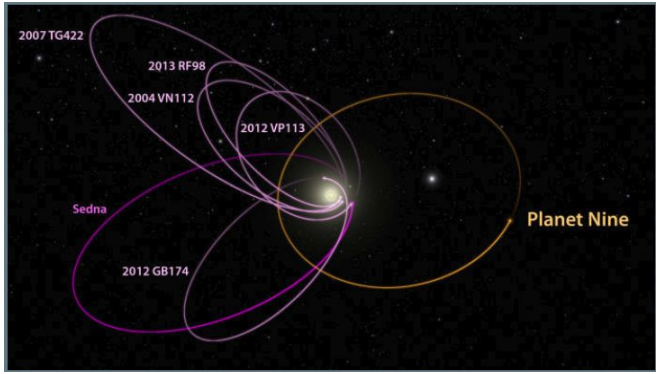


Test PBHs as GW sources (ongoing intensive program)

Niikura, Takada, ..., More et al. (Nature astronomy, in press)

- Primordial black holes were suggested as dark matter candidates (Hawking 1974)
- Monitoring Andromeda for a single night rules out lunar mass black holes
- Long term campaign ongoing for 10 Msun PBHs (PI: Takada, M.)

Search for Planet Nine in the outer solar system



- Planet Nine predicted based on orbits of far away trans-Neptunian objects
- Ongoing search with Subaru telescope (Japan-side proposal: Yoshida, F., More, S., et al. / Keck exchange proposal: Brown, Batygin, et al.)
- Awarded upwards of 18 nights over four semesters so far (upcoming observations next week).