INO3.4: Case for Exoplanet and Microlensing observations

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Why INO 3.4 is important for us and international community ?

1- No professional/operational Telescope at this longitude (suitable for astrophysical/cosmological follow-up observations)

2- Dry condition (55 % of night humidity is $< 60\%$)

3- Clear Sky (230 days shiny days)

4- High Altitude (3600 meter Gargash, ideal for Infra-red observations)

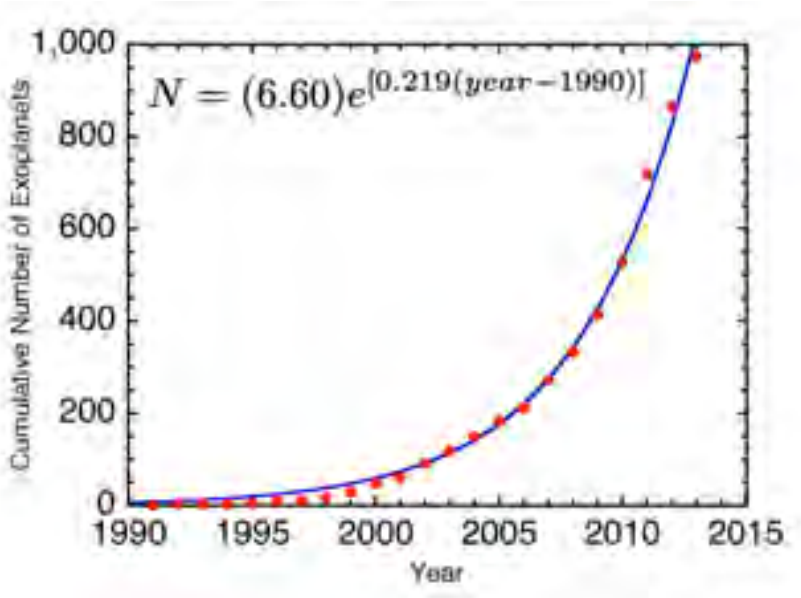
5- Seeing (~ 0.6, excellent seeing compare to the best observatories, ref: H.Khosroshahi arXiv:1101.3883)

6- Close to Europe for hosting/collaborating astronomers.

Figure: Gargash:3600 m

Extrasolar planet studies

In recent
years, the number of discovered
exoplanets increased exponentially.

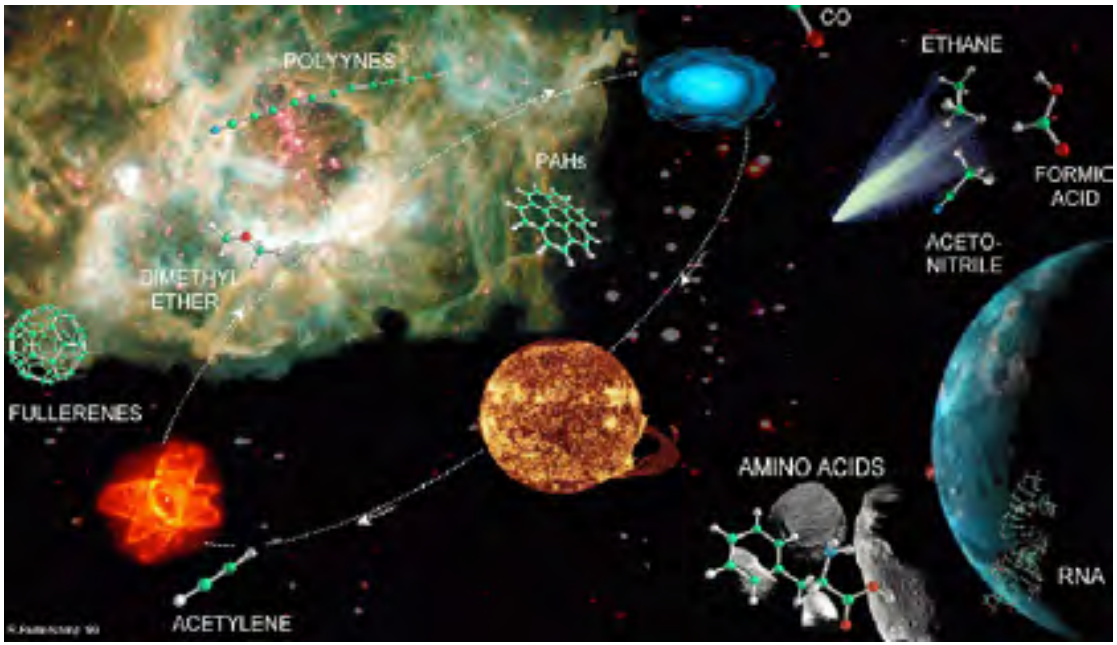


Why Exoplanets are interesting:

- Origin of planet Formation
- Origin of Life and discovery of life.

Astrobiology = Astrophysics + Biology + Cosmology and Philosophy

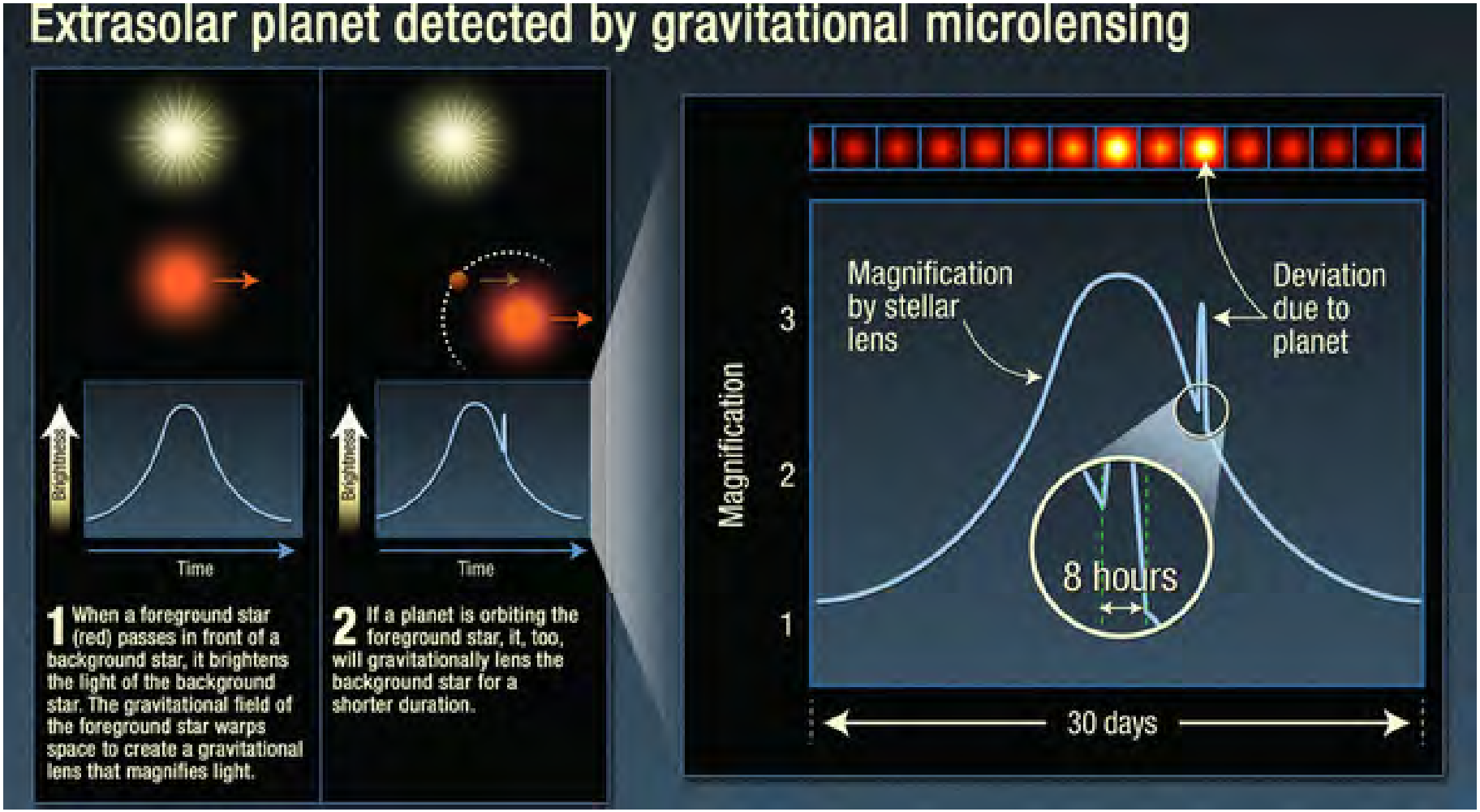
Exoplanet studies is an interdisciplinary area which contains: physics, astronomy, biology, organic chemistry, philosophy ...



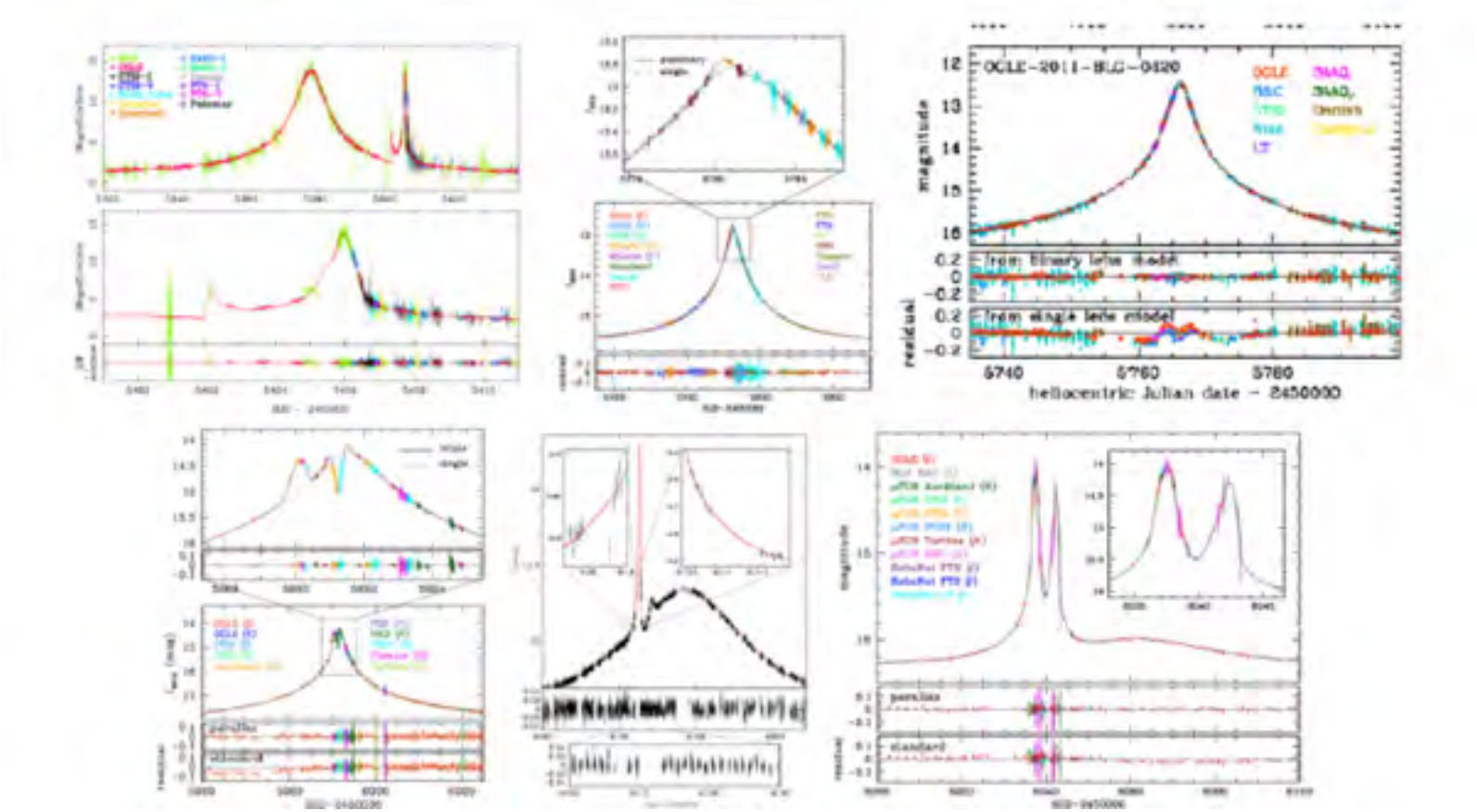
The aim is to answer the key question about the life. Where we came from ?
It worths investing in this field especially as one of INO science projects.

Contribution of INO3.4 ?

Physics of microlensing and exoplanet detection

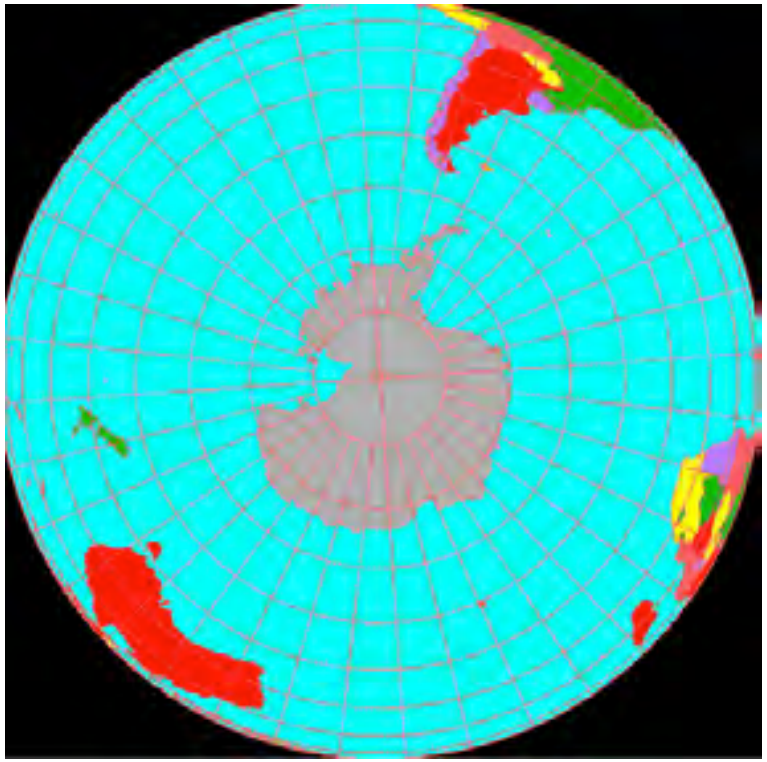


Sample of exoplanet Microlensing light curves



Contribution to this project

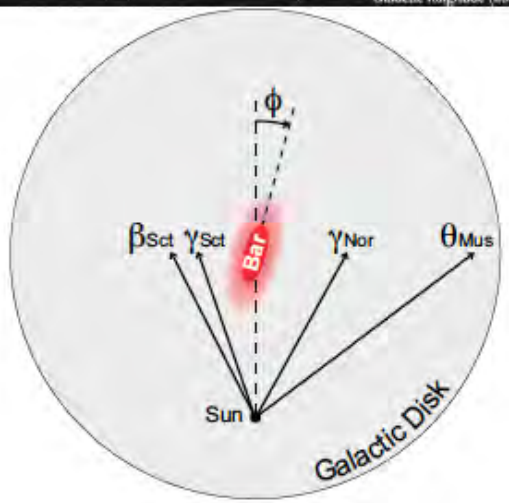
Observation is done
at south hemisphere in the direction
of Galactic Bulge. Three surveys
of OGLE- MOA and KMNet
monitor the Bulge for exoplanet
observation and the other telescope
perform follow-up observations.



Using the local coordinate of INO,
microlensing targets in the direction
of Bulge is observable in June and
July when parts of Galactic bulge
with $Dec > -24:00:00$ is above
horizon. From the INO location, we can observe 12% of ongoing
microlensing events.

Also, we can perform Spiral arm observations: investigating Milky Way structure

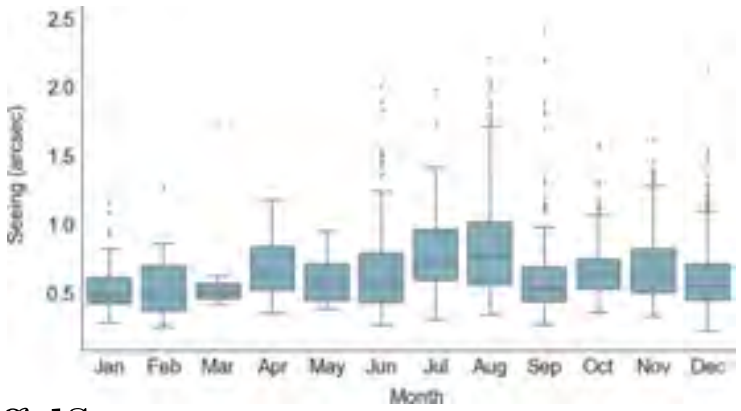
For more detail information about the application of microlensing for studying the Milky Way structure:



1- Moniez et al., arXiv:1701.07006
2- Rahvar, arXiv:1503.04271

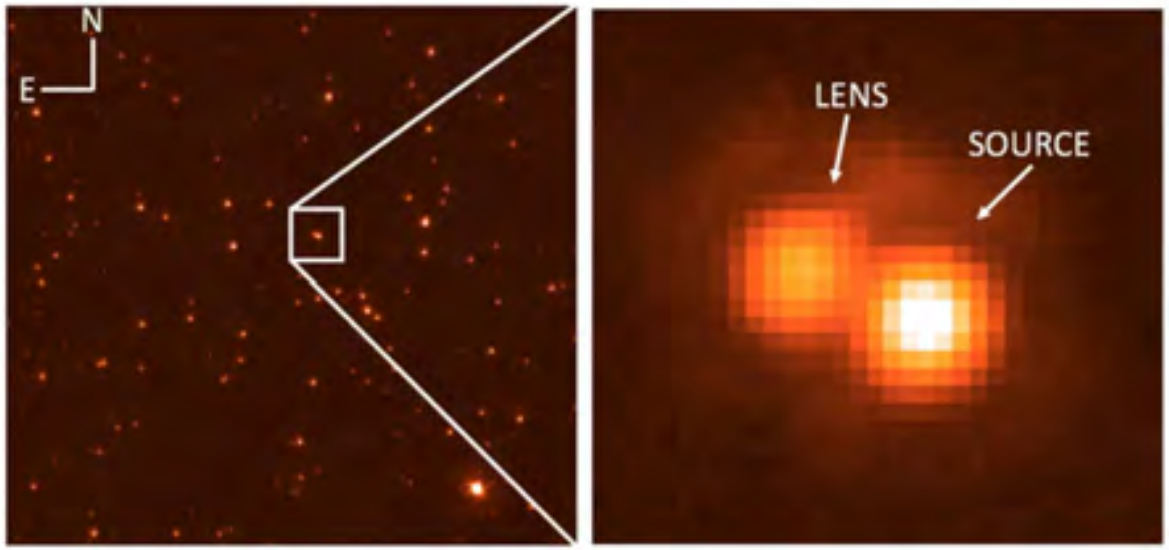
Also follow-up observations of microlensing for astrometry is an important activity

Astrometry of ongoing microlensing events



The median seeing of INO is around 0.65 arc sec and angular distance between the images in the microlensing is milli arc sec. However with follow up observations of events after a couple of years, we can resolve the lens and source stars. We have studied this in arXiv:2004.04615 for crossmatching the GAIA and OGLE data.

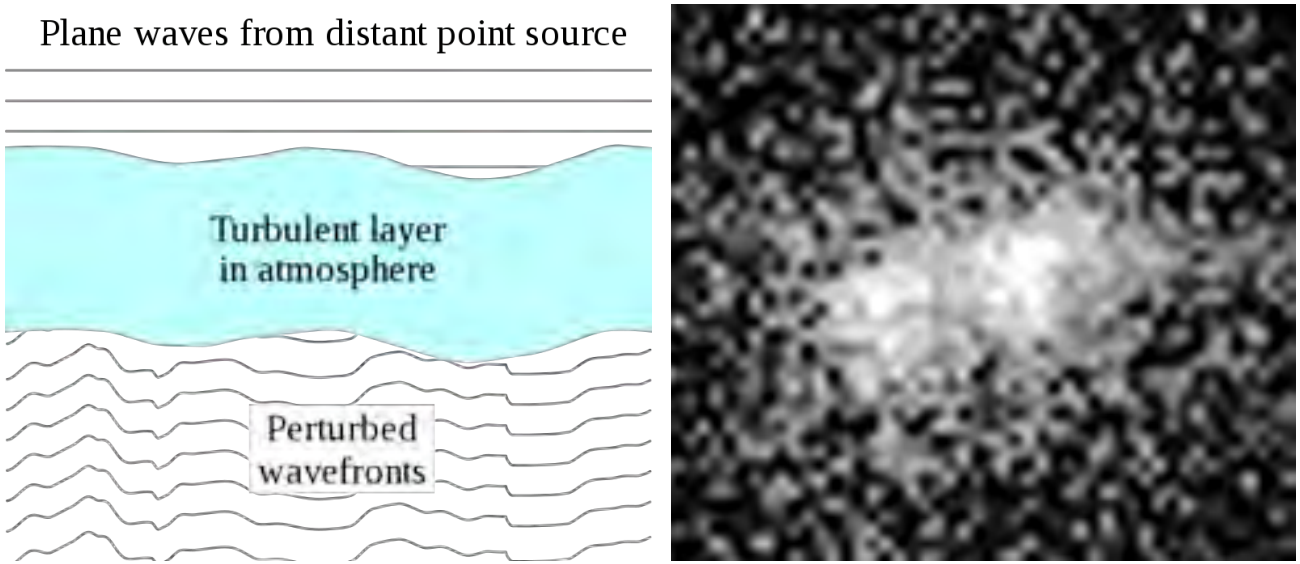
Astrometry



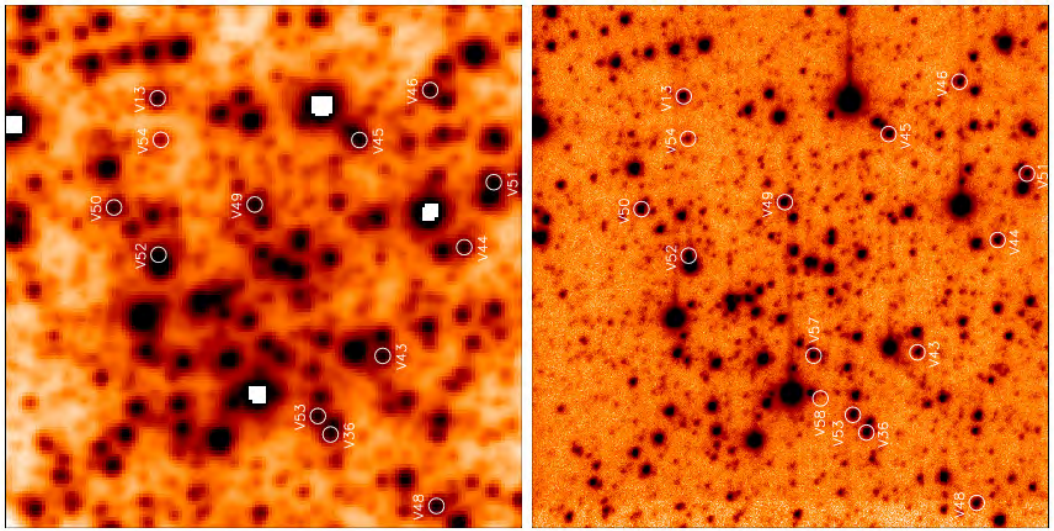
Keck image of MOA-2013-BLG-220 in the K band with the NIRC2 adaptive optics system, taken on 2019 May 27. On the left, the image is $10'' \times 10''$ and on the right the panel is a zoom of approximately $1'' \times 1''$. The right panel indicates the position of the lens and source 6 years after that microlensing happened. This is an ideal method to break the degeneracy between the lens parameters as well as idetifying the mass of planet.


Aug 8, 2011
Oct 31, 2011
Sep 9, 2012
Sep 25, 2012
May 13, 2013
Oct 22, 2013
Oct 26, 2014
Aug 29, 2017

Lucky imaging technique



The Atmospheric turbulence and its effect on the astronomical images makes distortion of a point like object.



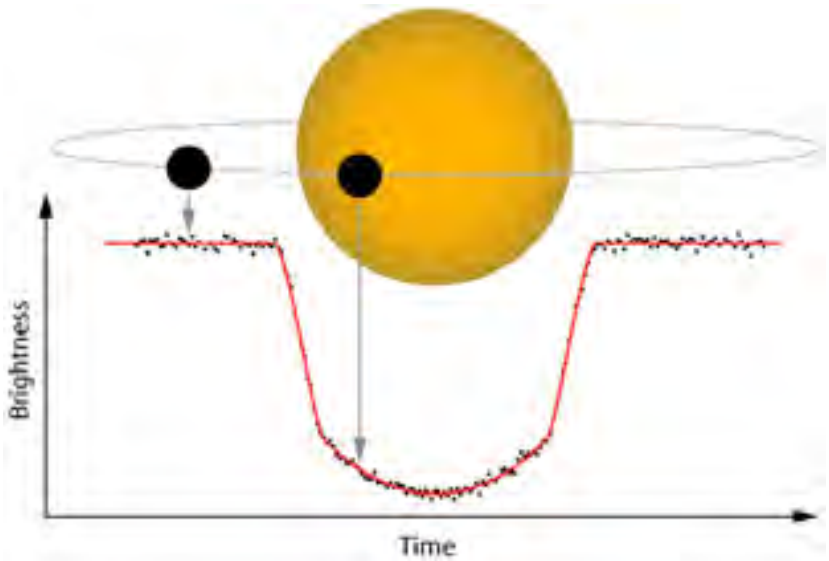
- Take images at high speed
- Remove distorted images by bad seeing and keep good images
- Shift and tilt in software to stack images
- With the best images, we can get to the diffraction limit of telescope
- Works best on up to 2m class and even 3m class
- Cheaper and easier than AO / space

Pixel Lensing

Monitoring M31 for long time and studying time-variation of all the pixels of CCD. By image subtraction, all the time variation can be studied. We note that each angular size of pixel contain hundreds of stars.

Follow-up transit observation

1- Measure the size of exoplanet
2- Distance of planet from the parent star

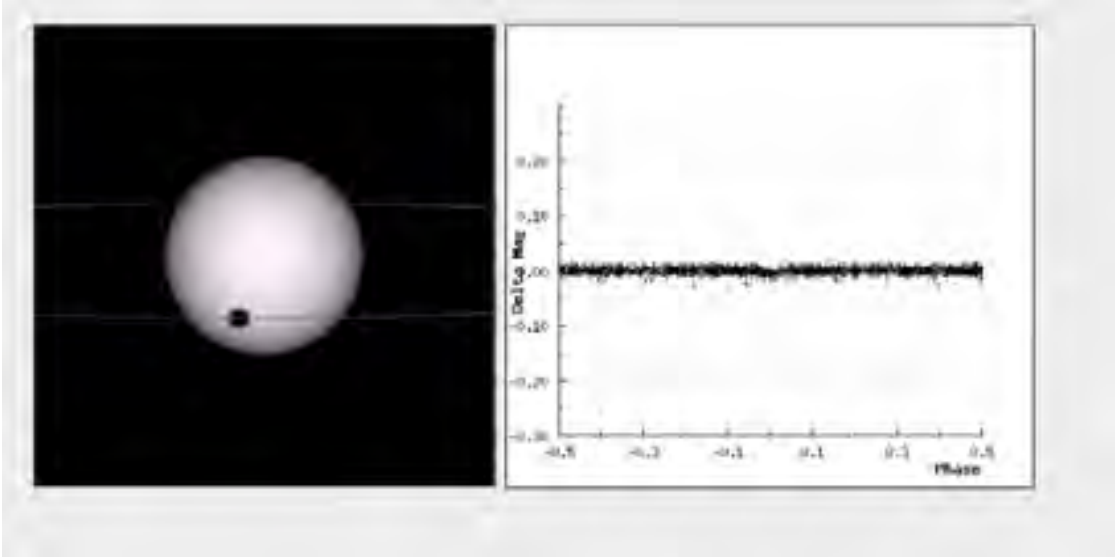


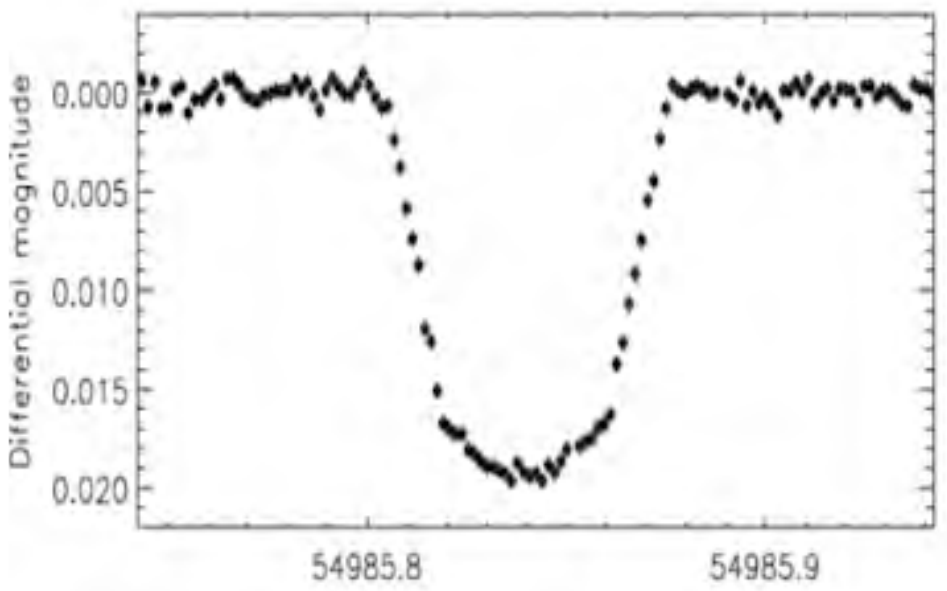
Sensitive to detection of hot Jupiters.

Survey mode and follow-up mode

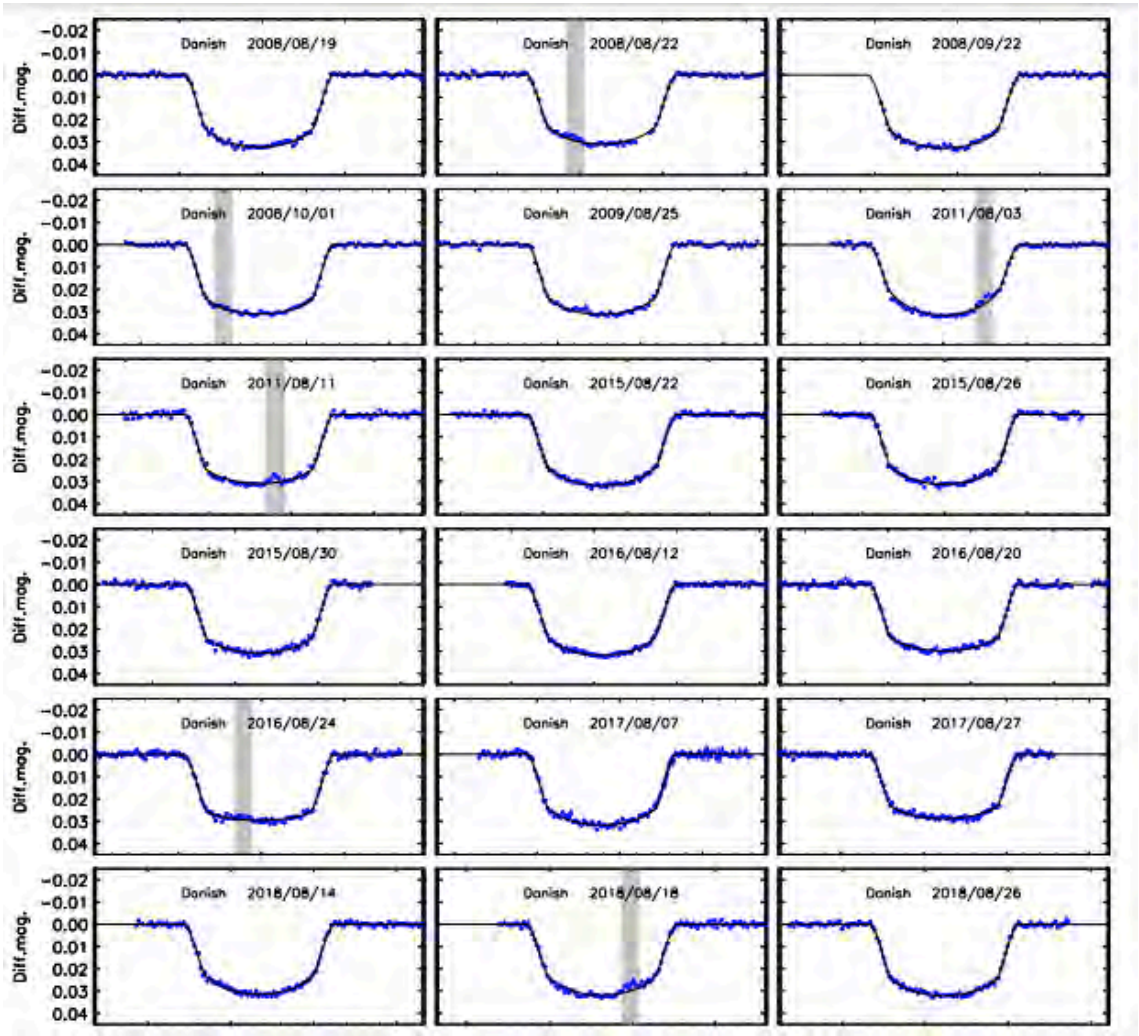
A set of wide field cameras to cover sky is an ideal tool as survey and INO3.4 meter as the follow up mode of transit observations.

Survey mode and follow-up mode:Light Curve

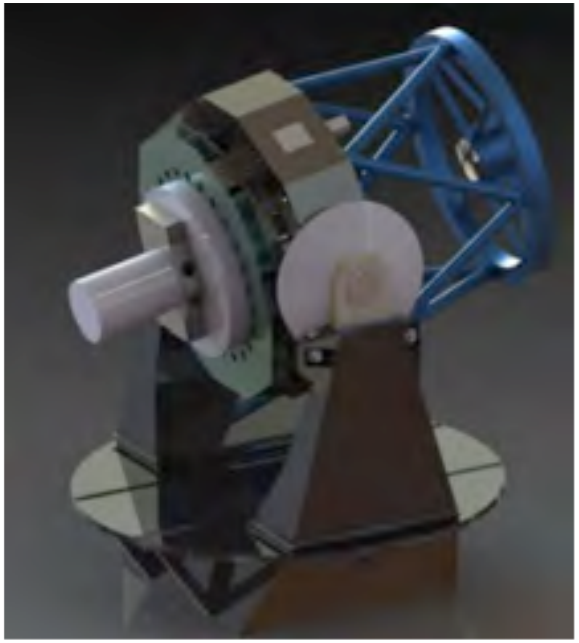


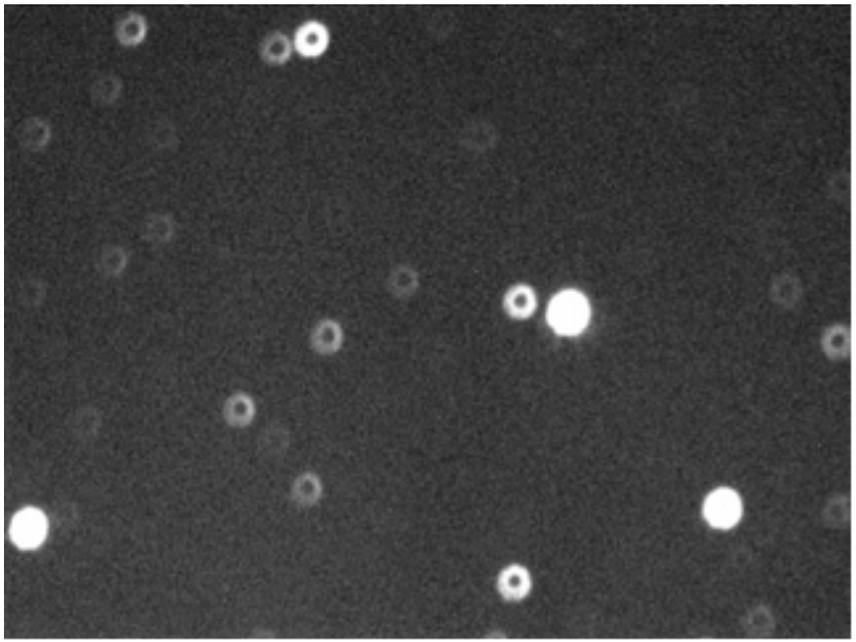


Observations of spots on transit events



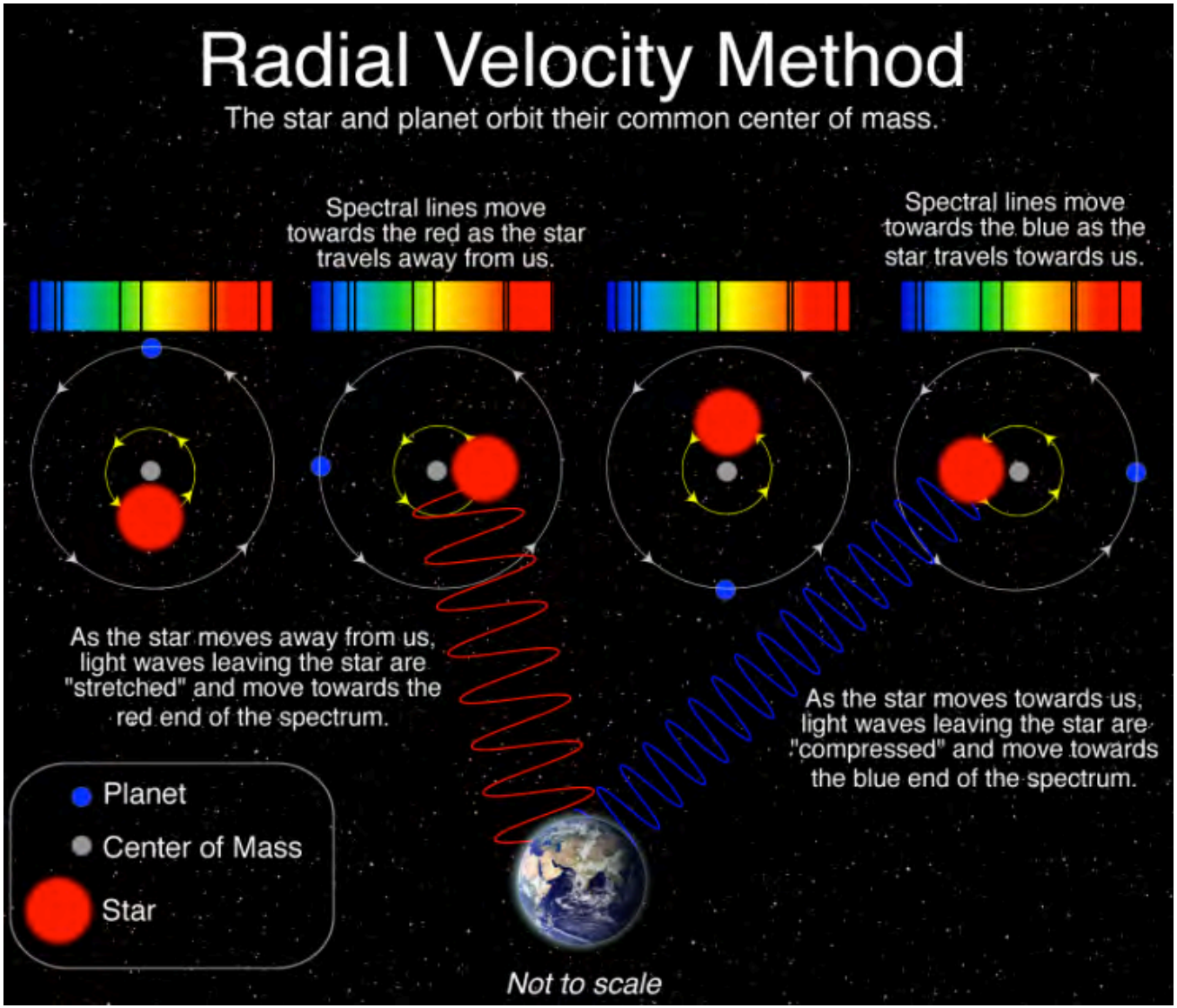
INO as follow-up mode





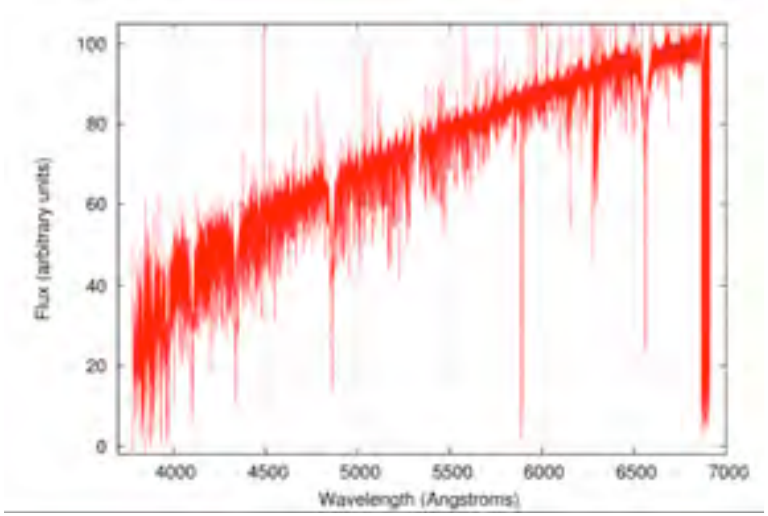
There are ground and space-based telescope in the survey modes that observe thousands of exoplanet candidates. Follow-up observation investigate the property of exoplanets with details. INO 3.4 is an idea telescope for this project and if we had it now, we could fill all the telescope time with the transits !

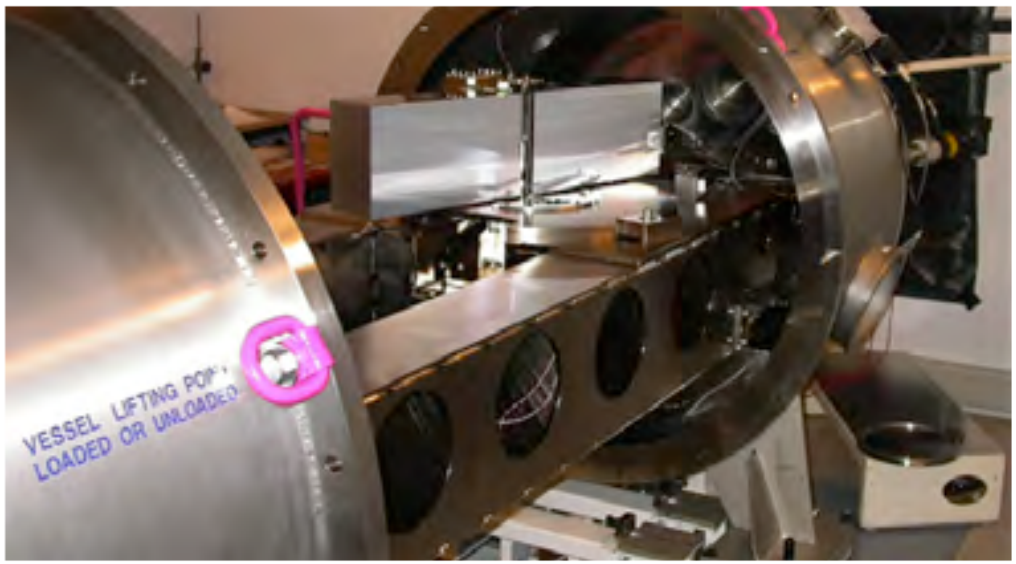
Radial velocity observations of exoplanet



Introducing the HARPS project

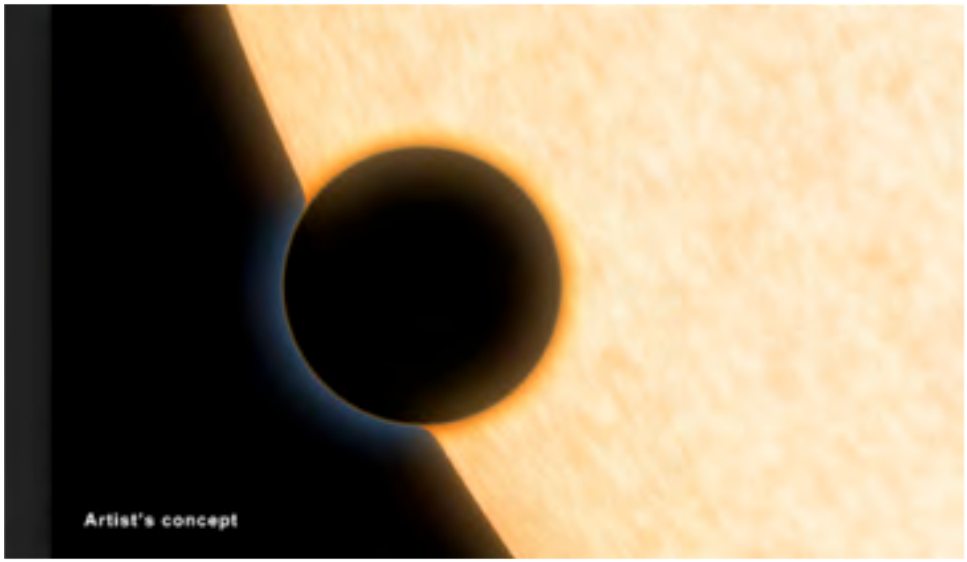
HARPS grating ($R = 120000$) @ 3.6 meter Telescope of La Silla. This telescope observed majority of stars

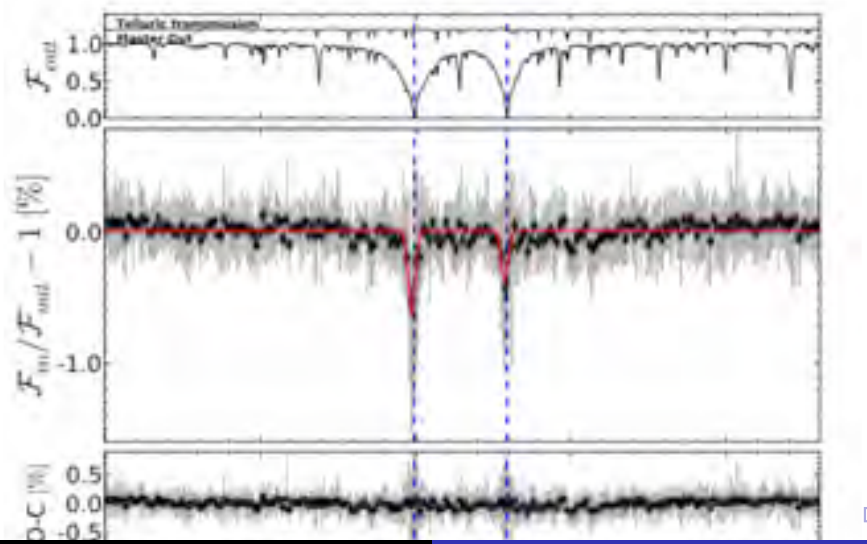




HARPS also studies the chemical ingredient of exoplanet atmosphere

Detection of Na (ref: 1503.0558), observed by HARPS





Conclusion

- Exoplanet observation is important subject for investigating the planet formation and formation of life
- INO3.4 can perform follow-up observations of Galactic Center, 12% of events are observable. Also for all the seasons spiral arms is observable.
- Pixel lensing of M31
- Lucky imaging camera for astrometry of exoplanet events
- defocusing method for transit observations
- High resolution spectroscopy for the radial velocity measurement

END