High resolution and simultaneous spectroscopy in optical and near-infrared wavelength

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High resolution spectroscopy for exoplanet characterization

Characterizing...

Planetary orbit and diversity

Precise radial velocity survey

As for transit planets...

✓ RM-effect (spin-orbit alignment λ)

Line-profile tomography (spectroscopic "planet's shadow")

Planet atmosphere

- (Transmission spectroscopy)
- In Planet "Radial velocities" using...
 - Molecular lines
 - Reflected light
- (Biosignature)

Precise RV measurement

- Blind planet search
 w/ RV technique requires...
 - long time baseline
 - many nights must be awarded continuously
 - SNR~100-200 per exposure



private mid class telescope should be appropriate within a survey for nearby stars

Follow-up observations for transit-planet candidates can be approximate use of 10~ m class telescope

RM (Rossiter-McLaughlin)-effect





Line-profile tomography



Planetary RVs (CO absorption lines)

tau Boo b (non-transiting planet)

· Jayne's talk yesterday





Planetary RVs (CO absorption lines)



Planetary RVs (reflected light)



- Stacked CCF of 51 Peg spectra (HARPS) showed significant dip originated from planet's reflected light
 - geometric albedo ~ 0.5 (assuming planetary radius to be 1.9R_J)

Phase-critical observations are required

Characterizing...

- Planetary orbit
 - Precise radial velocity survey

As for transit planets...

✓ RM-effect (spin-orbit alignment λ)

- Line-profile tomography ("planet's shadow" in spectroscopy)
- Planet atmosphere
 - (Transmission spectroscopy)
 - ✓ Planetary RVs
 - CO lines
 - Reflected light
 - (Biosignature)

Simultaneous spectroscopy in optical and near-infrared wavelength

- Although superlarge aperture telescope (TMT) will provide best chance to characterize low-mass planets...
 - Phase-critical observation have less opportunity to get data during each observational semester (quarter)
 - Difficult to gain the observation time (easy?)
- Need to extract information as much as possible per exposure
- Simultaneous observation in optical- and NIR-WL regions

advantages (except the time efficiency)

Cross-check the detection of planetary RVs









Korhonen+15

- (figure) blackspot model on the solar photosphere, and the estimated RV variation
- Activity induced RV noise (activity barrier) must be removed for the conformation of orbits of Earth-like planets

• cf. k_{Earth}~15 cm/s

Dumusque+12



Stellar activity varies along with time

Toward a firm discovery of "Second Earth"



- Simultaneous spectroscopy enables us to model stellar RV "jitter" induced by blackspots, precisely
 - RV measurements in optical WL
 - RVs from stellar blackspots and oscillation
 - in infrared WL
 - Only from stellar oscillation (should be explored)

Summary

- Phase-critical observation have less opportunity to get data during each observational semester (quarter)
- Need to extract information as much as possible per exposure
- Obtain both optical and NIR spectra simultaneously!

This also provides us...

 A cross-check for the planet RV detection
 A precise estimation on the stellar activityinduced RV noise