Habitable exoplanet exploration using infrared radial velocity spectrometer and laser frequency comb on the Subaru telescope. M. Tamura[1] and IRD team, [1]UTokyo (Department of Astronomy, Hongo 7-3-1, Bunkyo-ku, Tokyo 113-0033, motohide.tamura@nao.ac.jp)

Introduction: Although more than 1800 exoplanets have been already discoverd and confirmed, our knowledge of the exoplanets around low-mass stars is still limited. This implies that we do not know the variety of the planetary systems in our Galaxy in which low-mass stars or red dwarfs are most abundant.

IRD is a near-infrared high dispersion spectrometer being developed for the Subaru 8.2-meter Telescope. It aims at achieving measurement precision of 1 m/s in radial velocity at near-infrared wavelengths and thus will be a powerful instrument for exoplanet searches around red M dwarfs.

Our main astronomical targets using IRD are late-M dwarfs, which are too faint to observe at optical wavelengths even with such a large telescope. The lower mass of these stars naturally causes a much larger velocity wobble than Sun-like stars due to any orbiting planets and their lower luminosities bring the potentially habitable zone (where water is liquid on the planet surface) closer to the star, making planets in shorter period orbits more interesting for the search of life outside our solar system.

With the RV precision of 1 m/s, we can expect to detect Earths (~1 Earth-mass) and Super-Earths (>1 - ~10 Earth masses) in the habitable zone around such low-mass stars. Recent Kepler mission discovered many low-mass exoplanets but their distances are mostly too large to follow-up with the current and near-future instruments.

Once any Earth-mass planets have been discovered around nearby M stars, they will also be the best targets for the future direct imaging and characterization with the 30-m class telescopes with dedicated instruments.

Instrument Specification: The spectrometer covers the wavelength range from 0.97 to 1.75 microns with a 70,000 spectral resolution and 3-pixel sampling. The instrument (see Figure 1) has a fore-optics part for star-light and laser frequency comb injection into fibers, and a backend spectrometer optics, and a detector unit. In contrast to the general purpose high dispersion spectrometer, IRD is optimized for stable and accurate monitoring of periodical wavelength shift of absorption lines of M stars and aiming for Earth-like planets orbiting around them.

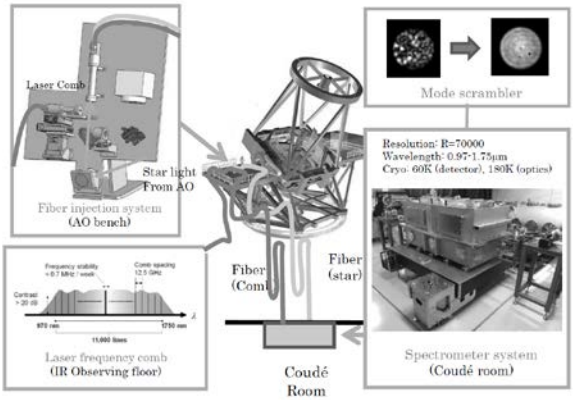

Figure 1: Overview of the IRD instrument, which composed of stable spectrometer, fiber injection module, laser frequency comb module, fiber-link, and adaptive optics.

Habitable Planet Survey: We paln to conduct a large scale survey on the Subaru 8.2m telescope for the habitable planets around late-M stars using IRD from around 2016. IRD survey focuses on late-M dwarfs, because early M dwarfs can be accessed with optical RV instruments. Furthermore, large aperture of the Subaru telescope can be a unique advantage for targeting faint late M dwarfs. We selected late M dwarfs with small rotational velocity and low stellar activity from available catalogs. Candidate target catalog includes about 250 stars which have J-band magnitudes of 7-11.5 mag, stellar mass of 0.08-0.3 Msun, spectral type of M4-M9. Further selection will be done by observations of stellar rotation period and activity with medium resolution spectroscopy and photometric variability measurements.

After the careful selection, best 100 stars will be the final survey targets. To evaluate feasibility of our survey plan, we carried out survey simulation assuming that a total ~ 170 nights are available for 5 years. From the simulation, we found that ~ 40 Earth-mass planets including some of them in their habitable zone, as well as many Super-Earths and Neptunes.

References:

[1] Kotani, T. et al., Proceedings of the SPIE, Volume 9147, id. 914714, 12 pp. (2014).