Japanese Terrestrial Planet Finder

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ABSTRACT

A Japanese roadmap on direct extrasolar planet studies is presented, from the current ground-based telescope to future IR/Opt space-based telescopes. Several searches for young planets and disks have been conducted with the Subaru 8.2m telescope and its adaptive optics (AO) infrared coronagraph, CIAO. The instrument will be soon upgraded to a new AO and a coronagraph with simultaneous spectral and polarimetric differential imaging modes (HiCIAO), which improve the contrast performance by more than order of magnitudes. A sensitive unbiased survey for extrasolar zodiacal emission around nearby stars is being conducted with the recently launched AKARI space IR telescope (0.7m diameter, 2–200 micron). A successor space IR telescope, SPICA (3.5m diameter, 5–200 micron), is also planned; its high sensitivity will enable the detection and characterization of outer-most planets around nearby stars. For the studies of extrasolar terrestrial planets in Japan (JTPF), a high contrast space telescope (HCST; 3.5m, 0.3–2 micron) is under discussion. We are also seeking for collaborations with or joining to foreign missions.

A roadmap shown in Figure 1 is an approach to the explorations of exoplanets in Japan. Our ground-based direct explorations are concentrated on the fully-operated and successful Subaru 8.2m telescope at Mauna Kea, Hawaii. Making use of the good observing site and the excellent image quality, the infrared coronagraph CIAO (Coronagraphic Imager with Adaptive Optics) has been used for various kinds of surveys. CIAO is the first among IR coronagraphs equipped with a full cold coronagraph mode (with various cold occulting masks and Lyot stop optics) on the world 8-m class telescopes. Compared to previous coronagraphs, it has unique features of near-infrared operation and small occulting masks (down to 0.2 arcsec in diameter; Tamura et al. 1998, 2000). CIAO has been successful to directly reveal the morphological diversity of protoplanetary disks, such as rings, spirals, and banana-split, with a high spatial resolution of 0.1″ (Fukagawa et al. 2004, 2005). In addition, first 2 micron imaging polarimetry of beta Pic has demonstrated that the disk is composed of several planetesimal belts with a gap at r ~ 100 AU (Tamura et al. 2005). It has also detected young brown dwarf around a classical T Tauri stars DH Tau (Itoh et al. 2005).

HiCIAO is a new high-contrast instrument for the Subaru telescope, which is currently developed by NAOJ and University of Hawaii (Tamura et al. 2006; Hodapp et al. 2006). HiCIAO is used in conjunction with the new 188 actuators adaptive optics system at the Infrared Nasmyth platform. It is designed as a flexible camera comprising several modules that can be configured into different modes of operation. The main modules are the AO module with its near-future extreme AO capability, the warm coronagraph module, the high contrast optics module, and the cold infrared camera module. HiCIAO will be the first instrument on the 8-m class telescopes which can combine coronagraphic techniques with simultaneous polarization and spectral differential imaging modes which minimizes the common path errors.

Regarding space-based explorations, the MIR and FIR space telescope, AKARI (aka ASTRO-F), is developed by JAXA/ISAS and is successfully launched in 2006 February. This telescope has a similar size to the Spitzer telescope, but is optimized to all-sky survey observations. Although its low spatial resolution is not suitable for direct explorations, it will conduct an unbiased survey for faint disk emission. This enables us to make census of exo-zodi and disk evolution with a large sample of stars. As a successor of AKARI, the SPICA mission plans to launch as a cooled (4.5K) large (3.5m) single-mirror telescope into a halo orbit around the Sun-Earth L2 orbit around 2014. Its unprecedented sensitivity at MIR and FIR and its simple telescope pupil make SPICA to be one of the best platforms to implement coronagraph instrument for exoplanet studies.

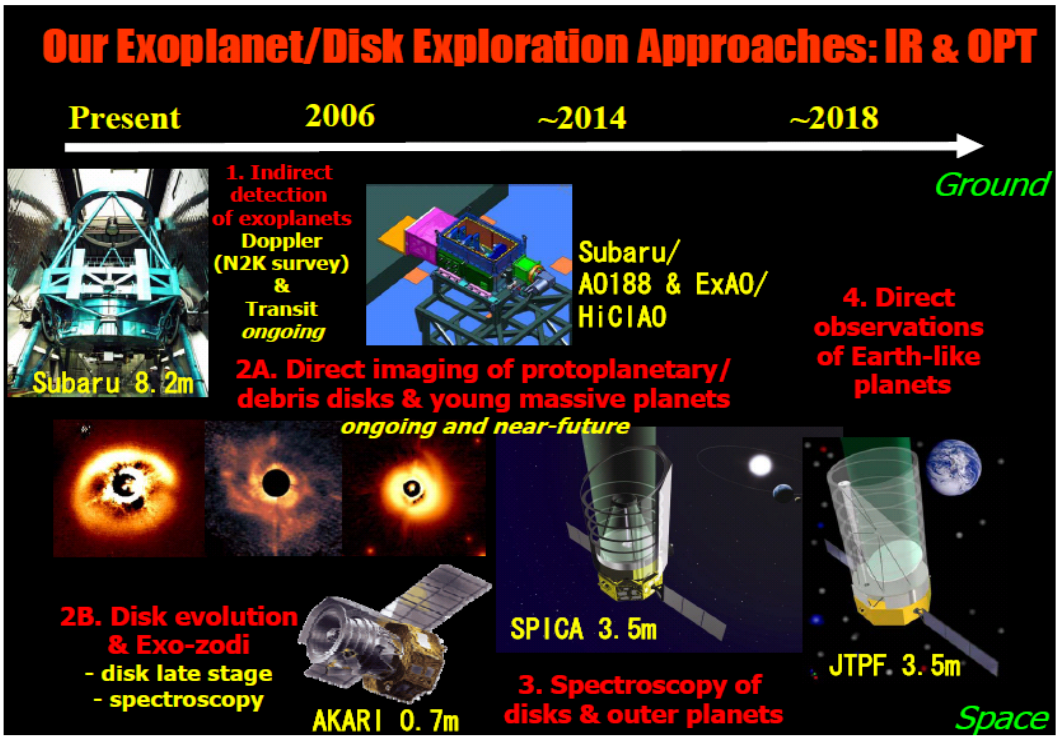

Figure 1. *A roadmap of exoplanet explorations in Japan.*

JTPF (Japanese Terrestrial Planet Finder) is a future space mission whose main science driver is the extrasolar terrestrial planet studies. The project is officially approved both by NAOJ and ISAS. In NAOJ, its activity is regarded as one of the main themes of the Phase A project which has started in April 2005. In JAXA/ISAS, the JTPF Working Group has been approved by the ISAS Science Steering Committee in 2002. Discussion has been made among both astronomy and planetary communities in Japan, and regarded as one of the important programs for optical and infrared astronomy. It could be either an independent mission or a joining collaboration to TPF/Darwin missions. At present, an 3.5m high contrast optical space telescope (HCST), which realizes clean and stable images, is under main discussions for the JTPF architecture among JTPF WG (see Figure 2). JTPF/HCST might make full use of the SPICA bus system with an optimization to shorter wavelengths.

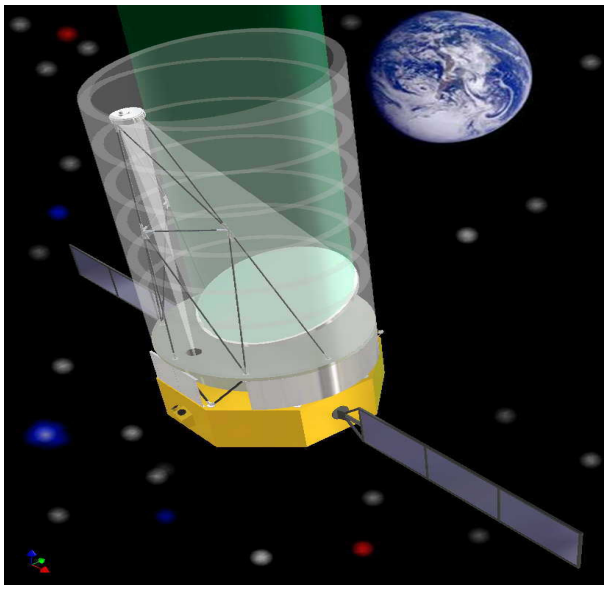

Figure 2. *JTPF/HCST -3.5m high contrast optical telescope.*