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Strategic Exploration of Exoplanets and Disks with Subaru: SEEDS

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Abstract. The purpose of the SEEDS project (PI: M. Tamura) is to conduct a direct imaging survey, searching for giant planets as well as protoplanetary/debris disks at a few to a few tens of AU regions around 500 nearby solar-type or more massive young stars with the combination of the Subaru 8.2m telescope, the new high-contrast instrument HiCIAO, and the adaptive optics system AO188. After instrument performance verification, the SEEDS survey successfully started in October 2009. We have already detected many companion candidates to be followed-up, and clear and much better detections of disks or details of known disks structures. In this contribution, we will outline our goal, current status, early results, and future instrumentation plans.

Keywords. stars: formation, surveys, circumstellar matter, planetary systems, techniques: high angular resolution

1. Introduction

Since the first detection of exoplanets orbiting normal stars in 1995, many exciting discoveries have been made, but our understanding of planetary systems and their formation is far from complete. As demonstrated with recent successes of direct imaging of planetary-mass objects around Vega-type A stars and a G star, direct imaging approach is indispensable for the detection of such "young" planets, especially planets beyond the snowline (4-40AU), which is complementary to radial velocity or transit searches.

SEEDS is the first Subaru Strategic Programs to conduct a direct imaging survey with the combination of the Subaru 8.2m telescope, the new high-contrast instrument HiCIAO, and the adaptive optics system AO188. The purpose of the SEEDS project is search for giant planets as well as protoplanetary/debris disks at a few to a few tens of AU regions around 500 nearby solar-type or more massive young stars. After instrument performance verification, the SEEDS survey successfully started in October 2009. We have already detected many companion candidates to be followed-up, and clear and much better detections of disks or details of known disks structures. The goals of our survey are to address the following key issues in exoplanet/disk science: (1) the detection and census of exoplanets in the outer circumstellar regions around solar-mass stars and massive stars, (2) the evolution of protoplanetary and debris disks including their morphological diversity, and (3) the link between exoplanets and circumstellar disks. The completeness and uniformity of this systematic survey will provide important statistical, or even useful null, results to be obtained as well as enabling the study of individual objects of particular interest. We will report current status, early results, and future instrumentation plans. A full list of the current SEEDS member (∼100 people) can be found on our web site.

2. Early Results

In the first one year, we have already some results and published papers. One of the paper is the direct imaging of a planet candidate around sun like star, GJ 758 (Thalmann *et al.* 2009). GJ 758 is a G9-type star (0.97 M_{sun}), 15.5 pc distant from the sun, and have no radial-velocity planets so far. The newly discovered planet candidate GJ 758 b is estimated to have a mass of 10-20 M_J at a projected distance of 29 AU, resemble to Neptune orbit.

The high contrast imaging of the circumstellar disk of LkCa 15 has revealed the surrounding nebulosity (Thalmann *et al.* 2010). We detect sharp elliptical contours delimiting the nebulosity on the inside as well as the outside, consistent with the shape, size, ellipticity, and orientation of starlight reflected from the far side disk wall, whereas the near side wall is shielded from view by the disk's optically thick bulk. We note that forward scattering of starlight on the disk surface could provide an alternate interpretation of the nebulosity. In either case, this discovery provides confirmation of the disk geometry that has been proposed to explain the SED of such systems, comprising an optically thick disk with an inner truncation radius of ∼46 AU enclosing a largely evacuated gap.

On the other hand, polarized intensity image of AB Aur (Hashimoto *et al.*, submitted) is prodicing the sparpest and closest image of the protoplanetary disk, providing the first clear fine structures of the inner disk (<50 AU) regions and providing evidence of an embedded planet.

HAT-P-7 b was reported to have a highly tilted orbit, massive bodies such as giant planets, and a binary star is expected to exist in the the outer region of the system. Our observations have discovered two companion candidates around HAT-P-7 (Narita *et al.* 2009). This paper modeled and constrained the Kozai migration scenario for HAT-P7 b under the existence of a binary star, and found that the Kozai migration scenario was realizable only in a very limited condition, and was not favored if the additional body HAT-P-7 c exist. It conclude that planet-planet scattering is particularly plausible for the migration mechanism of HAT-P-7 b.

3. Future Instruments plan: SCExAO

The SCExAO Project is a project for an upgrade of HiCIAO, that will be installed between Subaru's 188-actuator AO system and HiCIAO, led by Olivier Guyon and Frantz Martinache. The system essentially consists of a 1020-actuator MEMS Deformable Mirror to improve the AO correction, a high-performance PIAA (Phase Induced Amplitude Apodization) Coronagraph as well as aperture masking interferometry capability.

HiCIAO with SCExAO observation will start 2011.

References

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