The Astrophysics of Planetary Systems: Formation, Structure, and Dynamical Evolution
Proceedings IAU Symposium No. 276, 2010
A. Sozzetti, M. G. Lattanzi & A. P. Boss, eds.

doi:10.1017/S1743921311020618

High-contrast polarimetric imaging of the protoplanetary disk around AB Aurigae

M. Fukagawa[1], J. P. Wisniewski[2], J. Hashimoto[3], Y. Okamoto[4], C. A. Grady[5,6], T. Muto[7], S.-I. Inutsuka[8], K. W. Hodapp[9], T. Kudo[3], M. Momose[4], H. Shibai[1], M. Tamura[3] and the SEEDS Team

[1]Department of Earth and Space Science, Graduate School of Science, Osaka University, 1-1 Machikaneyama, Toyonaka, Osaka 560-0043, Japan
email: misato@iral.ess.sci.osaka-u.ac.jp

[2]Department of Astronomy, University of Washington, Box 351580 Seattle, WA 98195, USA

[3]National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan

[4]Institute of Astrophysics and Planetary Sciences, College of Science, Ibaraki University, 2-1-1 Bunkyo, Mito, Ibaraki 310-8512, Japan

[5]Eureka Scientific, 2452 Delmer, Suite 100, Oakland, CA 96002, USA

[6]NASA Goddard Space Flight Center, Code 667, Greenbelt, MD 20771, USA

[7]Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 2-12-1 Oh-okayama, Meguro-ku, Tokyo 152-8551, Japan

[8]Department of Physics, Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8602, Japan

[9]Institute for Astronomy, University of Hawaii, 640 N. Aohoku Place, Hilo, HI 96720, USA

Abstract. We present the spatially-resolved polarization measurements for the disk around the Herbig Ae star, AB Aurigae. The images were obtained in J, H, and Ks bands with the coronagraphic camera HiCIAO on the Subaru Telescope. The inner region beyond 30 AU from the star was imaged, which reveals an azimuthal dip, a radial gap at around 80 AU, and complex spiral-like emission in polarized light.

Keywords. planetary systems: protoplanetary disks, planetary systems: formation, techniques: high angular resolution, techniques: polarimetric

1. Protoplanetary Disk around AB Aur

Direct imaging of disks provides valuable information on the distribution of disk material that may be linked to the presence of unseen planets. Imaging has been challenging due to small sizes of disks and high contrast ratios relative to the central stars. However, resolving the structure on ∼10 AU or less spatial scales is now possible in near-infrared by employing adaptive optics even from the ground. Moreover, one can effectively overcome the contrast problem by utilizing imaging polarimetry which is a powerful technique to extract scattered light from the disk by suppressing the bright, unpolarized starlight. Polarimetry also allows us to better constrain the disk geometry and to explore the properties of dust such as grain size and composition.

AB Aur is one of the most well-studied young stellar objects, located in the Tau-Aur star-forming region. The star is classified as a Herbig Ae star, and its age is estimated to be ∼3 Myr. The previous imaging studies have shown that AB Aur is surrounded by a circumstellar disk with its radius of several hundreds of AU and an outer envelope (Mannings & Sargent 1997; Grady *et al.* 1999; Fukagawa *et al.* 2004). One remarkable feature of the disk is its morphology: the trailing spiral arms have been found in the

outer region ($r > 100$ AU). Recently, Oppenheimer *et al.* (2008) and Perrin *et al.* (2009) reported the imaging polarimetry for the inner part ($r > 40$ AU) using the extreme adaptive optics and the *HST*.

2. Imaging Polarimetry with Subaru/HiCIAO

We observed AB Aur with Subaru/HiCIAO in the polarization differential imaging (PDI) mode with adaptive optics (AO188) in October 2009, as part of the ongoing high-contrast imaging survey of exoplanets and disks (SEEDS) (Tamura 2009). The images were obtained in J, H, and Ks bands with the coronagraphic mask of 0.3 arcsec in diameter. The spatial resolution achieved was close to the diffraction limit, 8 AU.

The inner disk ($r \gtrsim 30$ AU) was successfully detected in the polarized light in all the three bands (e.g., Hashimoto *et al. submitted*). The images reveal quite complex nebulosity including an azimuthal depletion at a position angle of $\sim 330°$ and a radius of ~ 100 AU. The azimuthal dip was also found in the previous polarimetry (Oppenheimer *et al.* 2008; Perrin *et al.* 2009), and it was suggested that the dip could be attributed to an unseen planet at that location or simply a geometric scattering effect for a smooth inclined disk. Our images are still not conclusive on the existence of planets, but the disk at 100 AU is not uniform at all in azimuthal direction, as an arm-like emission is recognized in the northeast. In addition, the HiCIAO images show a radial gap at ~ 80 AU clearly seen in the northern direction as well as the inner emission near the mask edge. Note that the location of the outer ring outside of the gap is consistent with the disk wall inferred from the mid-infrared and submillimeter thermal imaging (Honda *et al.* 2010). The observed fine and irregular structure may favor planets in the disk.

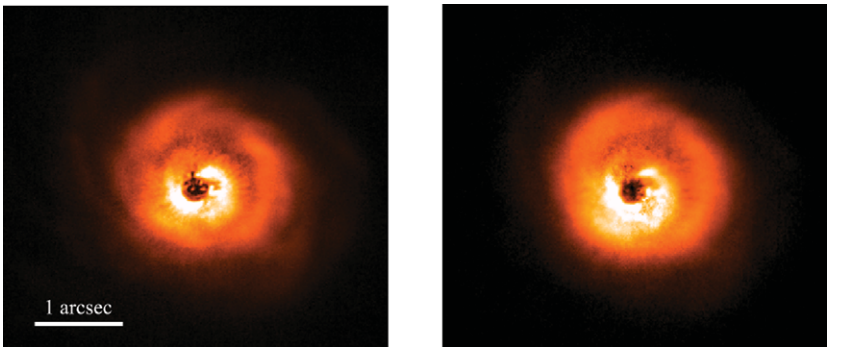

Figure 1. Polarized intensity images for AB Aur in H ($left$) and Ks ($right$) bands. North is up, east is to left.

References

Grady, C. A., Woodgate, B., Bruhweiler, F. C., Boggess, A., Plait, P., Lindler, D. J., Clampin, M., & Kalas, P. 1999, *ApJ*, 523, L151

Fukagawa, M., *et al.* 2004, *ApJ*, 605, L53

Honda, M., *et al.* 2010, *ApJ*, 718, L199

Mannings, V. & Sargent, A. I. 1997, *ApJ*, 490, 792

Oppenheimer, B. R., *et al.* 2008, *ApJ*, 679, 1574

Perrin, M. D., Schneider, G., Duchene, G., Pinte, C., Grady, C. A., Wisniewski, J. P., & Hines, D. C. 2009, *ApJ*, 707, L132

Tamura, M. 2009, *American Institute of Physics Conference Proceedings*, 1158, 11

https://doi.org/10.1017/S1743921311020618 Published online by Cambridge University Press