

Direct Imaging of Fine Structures in Giant Planet Forming Regions of the Protoplanetary Disk around AB Aurigae*

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Circumstellar disks are usually formed around young stars and are intricately tied to the origin of planets (e.g., [1]). Giant planets have been considered to form via gas accretion onto rocky cores in such disks (e.g., [2]), which can successfully explain “normal” giant planets like ours. However, recent direct detections of companions with masses of a few up to a few tens of M_J at distances > 20 AU, beyond what had been thought to be the planet forming zone (e.g., [3]), pose a challenge for the standard core-accretion scenario where planets are formed *in-situ*. Thus, information on the detailed structures of the inner ($r < 50$ AU) regions of protoplanetary disks is crucial.

We report high-resolution $1.6\mu\text{m}$ polarized intensity (*PI*) images of the circumstellar disk around the Herbig Ae star AB Aur at a radial distance of 22 AU ($0''.15$) up to 554 AU ($3''.85$) [4], which have been obtained by the high-contrast instrument HiCIAO with the dual-beam polarimetry. We revealed complicated and asymmetrical structures in the inner part (< 140 AU) of the disk, while confirming the previously reported outer ($r > 200$ AU) spiral structure. We have imaged a double ring structure at ~ 40 and ~ 100 AU and a ring-like gap between the two (Fig. 1). We found a significant discrepancy of inclination angles between two rings, which may indicate that the disk of AB Aur is warped. Furthermore, we found seven dips (the typical size is ~ 45 AU or less) within two rings, as well as three prominent *PI* peaks at ~ 40 AU. The observed structures, including a bumpy double ring, a ring-like gap, and a warped disk in the innermost regions, provide essential information for understanding the formation mechanism of recently detected wide-orbit ($r > 20$ AU) planets.

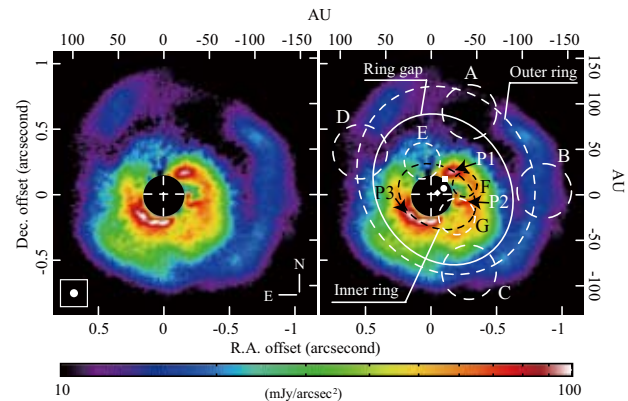


Figure 1: *PI* image with a coronagraphic occulting mask of $0''.3$ diameter (left) and the features (right). Central position (0, 0) is the stellar position. The outer and inner rings are denoted by the dashed ellipsoids. The solid ellipsoid indicates the wide ring gap. The dashed circles (A to G) represent small dips in the two rings. The filled diamond, circle, and square represent the geometric center of the inner ring, ring gap, and outer ring, respectively. The field of view in both images is $2''.0$ by $2''.0$. The solid circle in the left-bottom inset represents the spatial resolution of $0''.06$.

Reference

- [1] Shu, F. H., Adams, F. C., Lizano, S.: 1987, *ARA&A*, **25**, 23.
- [2] Pollack, J. B., et al.: 1996, *Icarus*, **124**, 62.
- [3] Marois, C., et al.: 2008, *Science*, **322**, 1348.
- [4] Hashimoto, J., et al.: 2011, *ApJ*, **729**, L17.

* Based on data collected at the Subaru Telescope, which is operated by the National Astronomical Observatory of Japan.