

# The Structure of the Asymmetric Multi-Ring Transitional Disk around 2MASS J16394544-2402039

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We revisit a double-ring transitional disk around 2MASS J16394544-2402039 (J16394544) to investigate the disk parameters and morphology. This object has recently reported by Cox et al. (2017) as a part of the 870-micron dust continuum survey in the rho Ophiuchus star forming region with Atacama Large Millimeter/submillimeter Array (ALMA). As will be described below, our detail analysis first reveals that the J16394544 disk has a wide and shallow gap structure, similar ring widths in both major and minor disk axis, and weak brightness asymmetry in the inner ring. At first, we construct an axisymmetric surface brightness model to estimate the disk parameters. The best-fit model is estimated by using Markov Chain Monte Carlo fitting in visibility space. Our modeling efforts reconfirm the double-ring structures, and first show the detail disk parameters, such as the system inclination of  $58.5 +0.3/-1.6$  degrees and the position angle of  $174.1 +1.0/-0.2$  degrees. The deprojected radii of two rings are  $68.1 +/- 3.5$  au and  $201.8 +/- 10.4$  au. A gap between the rings has the width of  $58.2 +/- 4.6$  au, and the gap surface brightness is  $27 +/- 3\%$  fainter than the ring disk. These properties show that the gap in J16394544 disk is one of the widest and shallowest gaps among the resolved disks by ALMA. Our modeling also shows that the deprojected widths of the rings coincide between the major and minor axes within 1-sigma error. The ring widths along major and minor axes are expected to be similar if the dust settle down to the disk midplane. Therefore, our measurements indicate that the J16394544 disk is geometrically thin and has low-level turbulence. By subtracting the axisymmetric model of the disk emission from the observed surface brightness, we first confirm the weak asymmetry at  $\sim 36$  au from the central star and the position angle of  $\sim 245$  degrees. The dust continuum emission at the asymmetry is brighter by a factor of 1.4 than the opposite side. The disk around J16394544 may serve as an important sample of disks having both multi-ring structures and brightness asymmetry to study such disk structures and their origins.

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