

Structure Formation in a Young Protoplanetary Disk by a Magnetic Disk Wind

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Recent observations with ALMA found that the ring-hole structure may be formed in protoplanetary disks even in the early stage of the disk evolution, when the disk is embedded in the envelope. The mechanisms of the gap formation in a young disk have not been investigated well. We present a one-dimensional model for the formation of a protoplanetary disk from a molecular cloud core and its subsequent long-term evolution within a single framework. Such long-term evolution has not been explored by numerical simulations due to the limitation of computational power. In our model, we calculate the time evolution of the surface density of the gas and the dust with the mass loss by MHD disk wind and the radial drift of the dust in the disk. We find that the MHD disk wind is a viable mechanism for the formation of ring-hole structure in young disks. We perform a parameter study of our model and derive condition of the formation of ring-hole structures within 6×10^5 years after the start of the collapse of the molecular cloud core. The final outcome of the disk shows five types of morphology and this can be understood by comparing the timescale of the viscous diffusion, the wind mass loss and the radial drift of the dust. We discuss the implication of the model for the WL 17 system, which is suspected to be an embedded, yet transitional, disk.

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