350 AU SCALE CIRCUMSTELLAR ROTATING GASEOUS DISK AROUND DM TAURI

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1. Introduction

We undertook a survey of the CO emission from protoplanetary gas disks around T Tauri stars using the Nobeyama 45m telescope. The purpose of these observations was to study the structure and evolution of the gas disks and study the process of planet formation. Through the survey, CO emission was found toward DM Tau (Handa et al. 1995). The following observations of DM Tau were made using the Nobeyama Millimeter Array (NMA) to investigate the distribution and kinematics of molecular gas associated with DM Tau. Here, we present the results for DM Tau. DM Tau is a single classical T Tauri star in the Taurus region(140 pc). The stellar mass and age are estimated to be 0.48 $M_{\odot}$ and 1 x 10^6 yr from the H-R diagram.

2. Observations and Results

2.1. NOBEYAMA 45M TELESCOPE

Figure 1 shows the profile maps of ^{12}CO, ^{13}CO, and C^{18}O obtained toward DM Tau with the Nobeyama 45m telescope. It shows clearly two components; one narrow component at V_{LSR}=9 km s^{-1}, and the broader one at 6 km s^{-1} that is consistent with the systemic velocity of the DM Tau-obtained optical observation. The 6 km s^{-1} component is seen just toward DM Tau, though the 9 km s^{-1} component is extended. These facts suggest that the 6 km s^{-1} component is physically associated with the star. The 6 km s^{-1} feature in ^{13}CO emission shows a double symmetric peak suggesting a rotating disk (Handa et al. 1995).

2.2. NOBEYAMA MILLIMETER ARRAY (NMA)

Figure 2a shows a map of the ^{12}CO intensity integrated over the velocity range 4.4 to 6.8 km s^{-1} obtained with the NMA. The map clearly shows that the compact disk-like structure is associated with the star. The radius of the disk is estimated to be 300 - 350 AU by the separation of the peaks of the blue- and red-shifted emission in Figure 2b (Saito et al. 1995).

3. Discussion

The observed CO kinematics are interpreted as indicating the presence of the rotating disk, based mainly on three observational results. First, the ^{13}CO spectrum obtained by the 45 m telescope has a clear symmetric double-peaked profile, as expected from the Keplerian rotating disk. Second, there exists the velocity gradient along the major axis of the disk. Finally, the velocity width of the ^{12}CO emission is much smaller than typically observed for outflow sources and the ^{12}CO emission is positioned close to the star.

The line-of-sight rotational velocity is 0.6 km s^{-1} from the ^{12}CO intensity weighted V_{LSR}. As there exists the velocity structure, the disk inclination is not face-on, and is estimated to be roughly 40° (the inclination is 0° for face-on). The obtained parameters are roughly consistent with the line-of-sight velocity of Keplerian rotation at r = 350 AU, 0.70 km s^{-1} which is estimated assuming i = 40°.

We estimated that the H_2 mass of the disk is 0.019 $M_\odot$ from the flux density at 2.6 mm, 23 mJy. Although the disk around DM Tau is larger than the solar system, the disk may be a protoplanetary disk from the viewpoint that the mass of the disk is comparable to the minimum mass of the solar nebula ($\sim$ 0.01 $M_\odot$) and the kinematics of the disk is consistent with Keplerian rotation.

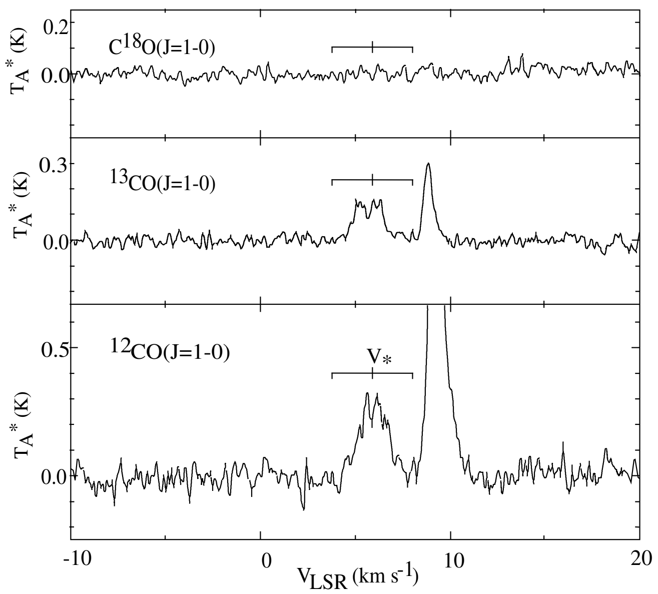

Figure 1. ^{12}CO, ^{13}CO, and C^{18}O profile maps of DM Tau obtained with the Nobeyama 45m Telescope.

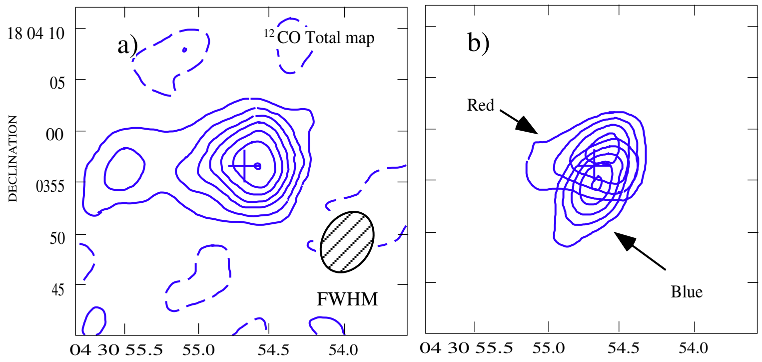

Figure 2. a) Map of ^{12}CO emission around DM Tau integrated over a velocity range of 4.0 - 7.3 km s^{-1} with NMA. b) Map of superposition blue- (4.0 - 5.6 km s^{-1}) and redshifted (5.6 - 7.3 km s^{-1}) ^{12}CO components around DM Tau.

References

Handa, T. et al. 1995, ApJ, in press

Saito, M., Kawabe, R., Ishiguro, M., Miyama, S. M., Hayashi, M., Handa, T., Kitamura, Y., and Omodaka, T. 1995, ApJ, in press