MBM12: A Younger Version of the TW Hydrae Association?

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Abstract. We present optical and infrared photometry of stars near the MBM 12 dark cloud. The optical data indicate that there are about 40 candidate pre–main sequence stars in the same area currently occupied by eight bona–fide PMS stars. Analysis of 2MASS data suggests that 60% of PMS candidates had been detected. Some of these show evidence of optically thick disks. Our study of the 2MASS data also reveals a large enhancement of sources within the MBM 12 cloud, indicating that it is still actively forming stars.

1. Introduction

MBM 12 is a dark, high latitude cloud located about 65 pc from the sun (Hobbs, Blitz & Magnani 1986, but see Hearty et al. 2000). From the early 1970s through early 1990s, five Classical T Tauri stars (cTTs) and three naked T Tauri stars (nTTs) were discovered associated with the cloud (see Hearty et al. 1999 and references therein). These sources have been discovered through a combination of Hα objective prism surveys and X-ray surveys. Such a close, young, isolated association would be in a league with the TW Hydrea Association (Kastner et al. 1997) and Eta Cha (Mamajek et al. 1999 and Lawson et al. this volume). However, the co–existence of the cloud and several stars with disks implies this is a very young association of stars which are very close to the earth. The 10-Myr old TW Hydrea group has proved a fruitful region for high resolution imaging of disks and close binary companions (Jayawardhana 2000). At an estimated age of about 1 Myr, in MBM 12 brown dwarfs/Jupiters would be brighter and disks should be more numerous.
Figure 1. An optical color–magnitude diagram for the observed regions near MBM 12. The crooked line indicates the location of the Pre–main sequence for 10-Myr-old stars at 65 pc (from D’Antona & Mazzitelli, 1997). Stars above this line are marked with plus signs. The arrow indicates 1 $A_v$ of reddening.

As a close, possibly active region of star formation, still nestled near its natal cloud, MBM 12 vitally requires a census of its young stellar population. Here, we present the results of our study of the photometric properties of stars in this region.

2. Optical Photometry

We observed the stars near the cloud in optical light during December 1998 with the 48"

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{Stars_Near_MBM_12.png}
\caption{An optical color–magnitude diagram for the observed regions near MBM 12. The crooked line indicates the location of the Pre–main sequence for 10-Myr-old stars at 65 pc (from D’Antona & Mazzitelli, 1997). Stars above this line are marked with plus signs. The arrow indicates 1 $A_v$ of reddening.}
\end{figure}

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Figure 2. An infrared color–color diagram, the plus signs indicate optically selected PMS candidates near MBM 12 from figure 1. Stars marked with diamonds are known cTTs. Stars marked with squares are known nTTs. Stars from the HIPPARCHOS catalog are marked with asterisks and are used for reference. A 5 visual magnitude reddening vector is indicated.

photometry was performed on each night’s worth of data on a per chip basis. This way, each chip had its own set of standard stars so that effects induced by a chip would be confined to that data set. Cross–referencing of stars observed on multiple chips showed chip to chip variations of less than 1%. The overall photometric accuracy was about 3% fainter than V=21. The data are complete to about V=21 and I =17.5.

The main results of these observations are shown in figure 1. About 10,000 stars were detected in V, R and I bands. Brighter than V=21, all but about 40 of these stars fall well below the demarcation for 10 Myr old stars at 65pc. We define these as our PMS candidates. There is a small (∼0.5 mag.) break between the main body of stars and the PMS candidates. This could be the effect of clustering but is most likely an effect of volume limiting. The volume of space a star could be in, and occupy a given location on the color–magnitude diagram becomes relatively small this close to the sun.

Spatially the candidates are spread among the 6 fields fairly evenly. The field near MBM 13 does have fewer PMS candidates than the other 5 fields, but this number is still within 2σ of the mean. We do not see any candidates along the edge of the cloud. This could be due to high extinction. But a very small fraction of the observed regions (only about 5%) overlaps the MBM 12 cloud. So this result could simply be happenstance.
Figure 3. A plot of the density of 2MASS sources as a function of position relative to the MBM 12 cloud. All measurements are made within a degree of the same galactic latitude. The density of sources is fairly steady at 800 stars/square degree except for the center of the MBM 12 cloud.

3. 2MASS Photometry

We obtained several nights to survey MBM 12 from the Whipple Observatory using the STELLIRCAM near–infrared camera. Unfortunately the weather did not cooperate. Fortunately, the second incremental release of the 2MASS database covers the MBM 12 region. We queried the database in the region of the optical surveys (within 3600 arcsec radius of RA:3h57m DEC:20°15′ J2000). This returned about 5500 sources. We then filtered out all the sources with errors greater than 10% or any bad quality flags. This left a little under 4000 sources with which we correlated with our catalog of ∼40 PMS candidates looking for matches within 3″. We found 24 matches. To this we added the previously known TTs in this region; these stars were too bright to be measured with our optical photometry. Six of these 8 were in the 2MASS catalog. We also used 3 HIPPARCHOS stars as reference for normal stars along the line of sight.

The results are given in figure 2. Two stars are found in the lower–right region of the diagram, which indicates the existence of circumstellar disks. About half of the PMS candidates are found in the region of the diagram which indicates a normal photosphere with significant ($A_V > 1$) reddening. Being found in this region does not mean that these stars do not have disks; in fact the four known cTTs are found in this region as well. Nor does the substantial reddening found in the IR mean that the optical data are misleading. The reddening vector in figure 1 is parallel to the (pre–) main sequence, so reddening only affects the
mass estimate. For this reason, we refrain from attempting any sort of mass function at this point. The remaining stars lie close to the main sequence locus.

The large sky coverage of the 2MASS database allowed us to study the spatial distribution of sources. Using the second incremental release point source catalog, we created pencil beam samples of the infrared sky at various locations along the same latitude as MBM 12. Each pencil beam was 20″ in radius and so covered 0.35°2. One pencil beam was centered on the MBM 12 cloud itself, one on the field near MBM 13, and others were spread further out, but always on areas with warm dust as seen by the IRAS 60μm survey. Figure 3 shows that the pencil beam centered on the MBM 12 dark cloud has a much greater density of sources than the other regions. Using a 20″ pencil beam, the enhancement along MBM 12 is about 10σ. However, this result becomes even more significant if smaller pencil beams are used. The total enhancement is about 70 objects more than expected in the 20″ pencil beam.

4. Conclusions

The proximity and extreme youth of stars near the MBM 12 cloud makes them of great interest. While the known membership of the cluster is small, we have found evidence for dozens of additional cluster members near the cloud and perhaps 70 embedded within the cloud. Over the coming observing seasons, we hope to be able to follow up on this photometric survey with spectra which will confirm the PMS nature of the candidates. These new data will help us better ascertain the number and age of these nearby stars.

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