Probing Planet Formation Among Nearby Young Stars

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1. Introduction

The recent identification of several groups of young stars within 100 parsecs of the Sun has generated widespread interest. Given their proximity and possible age differences, these systems are ideally suited for detailed studies of disk evolution and planet formation. Here I discuss recent results and prospects for the near-future.

2. TW Hydrae Association

At a distance of $\sim 55$ pc, the TW Hydrae Association (Kastner et al. 1997) is almost three times closer than the Taurus molecular clouds, and its estimated age of $\sim 10$ Myr fills a significant gap in the age sequence between previously known 1-Myr-old T Tauri stars and 50-Myr-old nearby open clusters. The group consists mostly of low-mass stars, typically a few tenths as massive as our sun, and includes several binary systems as well as one remarkable quadruple system (HD 98800). There is only one early-type star (HR 4796A). The origin of the TW Hydrae Association remains a bit of a mystery. There is no obvious parent cloud and the stars are dispersed across some 20 degrees on the sky and 20 pc in radial distance making it difficult to determine their birthplace. Nevertheless, they do offer the prospect of better constraining timescales for disk evolution and planetary birth.

Over the past two years, we have obtained mid-infrared observations of TW Hya stars using the OSCIR instrument on the Keck II and CTIO 4-meter telescopes. During this program, we imaged a spatially-resolved dust disk around the young A star HR 4796A (Jayawardhana et al. 1998). The surface brightness distribution of the disk is consistent with the presence of an inner disk hole of $\sim 50$ AU radius, as was first suggested by Jura et al. (1993) based on the infrared spectrum. Our results for HR 4796A and other stars in the group indicate rapid evolution of inner disks (Jayawardhana et al. 1999b). However, it is unlikely that there is a universal evolutionary timescale for protoplanetary disks, especially when the influence of companion stars is taken into account. For example, we have detected thermal emission from a dusty disk around the primary, but not the secondary, in the Hen 3-600 binary system (Jayawardhana et al. 1999a). Comparison with the median spectral energy distribution of classical T Tauri stars suggests that the disk around Hen 3-600A may be truncated by the secondary.
3. Other Nearby Groups

The all-sky survey done by the ROSAT satellite has been particularly useful in identifying isolated young stars through their X-ray emission. Of the other recently discovered stellar groups, MBM12 and Eta Chamaeleontis appear particularly interesting. At about 65 pc, MBM12 is the nearest known star-forming cloud, containing only 30-100 solar masses of gas. It does not appear to be gravitationally bound, and may be breaking up on a timescale comparable to the sound-crossing time. Thus, in a few million years, the young stars in MBM12 may appear to be isolated objects, not associated with any cloud material—very similar to how the TW Hydrae stars appear at present. Hearty et al. (2000) have identified eight low-mass young stars associated with MBM12. Most of them are classical T Tauri stars, and are likely to be a younger population than the TW Hydrae members. Eta Cha is a cluster of a dozen young stars, first identified in X-rays (Mamajek et al. 1999). As with the TW Hydrae group, Eta Cha is far from any substantial cloud. However, its members are much less dispersed than the TW Hydrae stars, and may represent an epoch intermediate between MBM12 and TW Hydrae Association. The comparison of disk statistics and properties among MBM12, η Cha, and the TW Hya Association may provide additional insight on disk evolution.

4. Prospects for Imaging Young Planets

If planets have indeed formed around these stars, it may be possible to detect them using large ground-based telescopes. Adaptive optics allows one to search within several AU of these nearby stars for planets a few times as massive as Jupiter (Jayawardhana 2000). Since newborn planets are quite warm, such objects would be sufficiently luminous to be detected at distances of 50-100 pc. In other words, we should be able to look for newborn giant planets located at distances from their parent stars similar to those of giant planets in our own solar system. Already, at least one brown dwarf has been found in the TW Hydrae Association (Lowrance et al. 1999) and searches for still lower-mass objects are underway (e.g., Neuhauser et al. 2000).

References

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