A SEARCH FOR PLANETARY SYSTEM CANDIDATES

Northern Nearby A Stars With Dust Disks And Circumstellar Gas

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Abstract. We report on our search for possible planetary system candidates in a volume limited sample of 62 nearby A stars. Since the evolutionary lifetimes of A stars ($\leq 10^9$ yrs) roughly correspond to the era of planet formation and subsequent "heavy bombardment" in our solar system, our study could provide valuable insight into the origin of our own Solar System. From our ground-based visual and IUE high-resolution spectroscopy of all the northern nearby A stars, we have identified at least 12 stars with circumstellar gas. Combining these results with our previous IRAS survey we are probing the link between stars with circumstellar gas and those showing circumstellar dust disks. Our aim is not just to identify stars with gas, or stars with both gas and dust, but to identify systems with dynamic spectral activity similar to β Pic, a well known proto-planetary system candidate. By measuring the gas dynamics in the disks of these β Pic-like stars, we can begin to study the physics of accretion disks of young evolving systems.

Key words: Protoplanetary Systems – Circumstellar Gas – A Stars – Ca II

1. IR/IRAS Survey

We first performed a careful analysis of the Faint Source Survey database assembled from IRAS infrared data for a large sample of A stars. Specifically, we examined all the 62 A stars in the Woolley catalogue of stars within 25 pc of the Suny (Cheng et al. 1992). Among these program stars, we found 11 stars having [12]–[25] and [25]–[60] colors consistent with circumstellar dust. Any newly identified dusty A stars provide additional comparisons for β Pic or Vega, the two well-known proto-planetary system candidates having very different IR colors. If a dusty system has a gaseous disk similar to β Pic and viewed approximately edge-on, it should have a similar Ca II spectrum, with a narrow absorption feature near the bottom of the photospheric line. The detection of strongly redshifted, variable absorption in the circumstellar lines of ionized elements such as Ca II, Mg II, Fe II, and Al III might be explained (Beust and Tagger 1993) by the evaporation of large bodies falling onto the star .

2. Visual/Ground-based Survey

Using high-resolution ($\lambda/\Delta\lambda \approx 125,000$), high S/N ($> 300$) spectra obtained at the National Solar Observatory's McMath–Pierce telescope, we are able to detect narrow absorption features and measure the amount of gas in the line of sight. This could be either circumstellar (CS) or interstellar (IS) gas, but we can discriminate between them in several ways. For example, ratios of the equivalent widths of various lines can be used to discriminate between CS and IS origin. Different line ratios can arise from abundance differences or from differences in density or temperature. example, the Ca II/Na I equivalent width ratio for IS clouds is between The CS gas around β Pic has a Ca II/Na I ratio of ~9.5 (Lagrange-Henri et al. 1990).

We have completed seven observing runs (42 nights) at the McMath-Pierce telescope for our ground-based survey. All of the 42 A stars in the northern hemisphere part of our survey have been observed in both Ca II K line and Na I D line regions. At least 12 of these stars show discrete, probably circumstellar absorption features in their Ca II K lines. We have measured the the velocity and equivalent width of these features.

3. UV/IUE Survey

Using IUE observations of targets identified in our ground-based survey, we are able to resolve any ambiguity between CS and IS lines. The fine-structure lines of Fe II of the resonance UV1 multiplet near 2600 Å are excellent diagnostics of CS gas. The narrow Fe II absorption line seen in the core of the photospheric feature arising from the zero-volt level, λ2599.396, could have contribution from both the IS and the CS gas. However, absorption from excited J-levels in the ground configuration (λ2607.0876 from 667.683 cm^{-1} and λ2611.8743 from 384.79 cm^{-1} above ground) would only be seen in the CS gas. For densities in excess of 10^3 cm^{-3}, the excited levels in the ground configuration of Fe II should be significantly populated, approaching LTE values. Therefore, a fairly pronounced sharp absorption feature should be apparent for circumstellar Fe II absorption comparable to that seen in β Pic (Boggess et al. 1991; Cheng et al. 1994). We have examined all the existing IUE high-dispersion spectra of the 12 candidate stars identified to date by our ground-based survey.

References

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