end up onto the ZAMS with rotational velocities between 40 and 150 km s^{-1}, as observed for half of ZAMS, solar-type stars. CTTS, in contrast, are braked down to low velocities up to the point where they disperse their disk. The disk survival time is estimated to be of the order of 10^7 yr at most, i.e., the star is still some 2 10^7 yr away from the ZAMS. From thereon, having lost its disk, the star will spin up as would a WTTS. However, if the star was braked down to a velocity of a few km s^{-1} at the end of the accretion phase, it will still reach the ZAMS with a velocity of less than 20 km s^{-1}, thus accounting for the other half of ZAMS stars observed to have small velocities.

Admittedly, the above description of how CTTS evolve into slowly rotating ZAMS stars while WTTS are the progenitors of rapidly rotating ZAMS dwarfs may be a little over-optimistic. Many issues have to be addressed more quantitatively. For instance, are CTTS really braked by their disks down to small enough velocities, i.e., a few km s^{-1} at most, so that they reach the ZAMS with a *v*sin*i* of less than 20 km s^{-1}? The answer to this and other pending questions awaits further observational and theoretical work. Other campaigns such as COYOTES I will have to determine the rotational periods of stars with an age intermediate between T Tauri stars and ZAMS dwarfs, which will allow one to trace observationally the evolution of angular momentum of solar-type stars prior to the main sequence. Observations will also have to provide better estimates of both the strength and surface coverage of magnetic fields in T Tauri stars and bring clues to the field structure (dipole vs. multipole?). Helped by these new constraints, theoreticians will have to develop more realistic models of the interaction between the accretion flow and the star's magnetic field, thus enabling more accurate predictions as to the impact of disk accretion onto the angular momentum evolution of young stars.

6. Conclusion

The unexpected results obtained from the COYOTES I campaign clearly illustrate how powerful coordinated observations of T Tauri stars are, even from such a site as La Silla where performing (relatively) accurate photometry of Taurus stars (Dec. ≃ +15°) with the bright moon not very far from the target stars is (almost) an art. At the time this contribution is being written, COYOTES II has been completed. It took place during the winter 1992–1993 and involved the same participants as COYOTES I plus a few more. The results are under analysis. A complete description and analysis of COYOTES I results are being published in two papers in A&A.

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TY CrA: a Pre-Main-Sequence Binary

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The southern young star TY CrA, embedded in the reflection nebulae NGC 6726/7, has a strong far-IR excess which is attributed to circumstellar cold grains, larger than the usual interstellar grains, cf. Cruz-Gonzales et al. [1984] and Bibo et al. [1992]. Photometric variability has been found by Kardopolov et al. [1981], and the photometric curve is known to be the one of an eclipsing binary system, with a 2.888777-day period.

Spectroscopic observations of this object have been performed in the period 1990–1992 with the CES and the 1.4-metre CAT at La Silla. Lines of CA II K, Ca II triplet, Mg II, Ti II, Hα, He I, O I and Na I were investigated (Lagrange et al. [1993] and we show in Figure 1 some of the spectra which were obtained.

The three main results are the following:

- Contrary to what is generally observed for Herbig stars, no strong emission is seen in any of the investigated lines. This had already been noticed by Finkenzeller and Mundt [1984] for the Hα line. However, it is still possible that this line, as well as the Ca II line, do have absorption that is partly filled by emission. Moreover, we detected for the first time transient, blue-shifted emission in the O I triplet lines.
- Narrow absorption lines are observed with FWHM ≤ 8 km s^{-1} in the CA II K, Ca II triplet, Ti II, Na I, O I, as well as cores in the Hα and He I lines. The Na I line additionally exhibits a broad absorption profile.
- The narrow absorption lines are periodically variable in velocity; this is shown in Figure 2, where a 2.888777d phase diagram has been constructed for the radial velocities of all the narrow lines. The radial velocity period is the same as the photometric period previously reported by Kardopolov et al. [1981].

Our data thus provide the first direct evidence that TY CrA is a spectroscopic binary. As the radial velocity variations of *all* the narrow lines can be phased together, we can conclude that all these lines have a common origin. In contrast, the broad components of the Na I lines exhibit radial velocity variations that are anti-correlated with those of the narrow component. This then argues for a different origin.

From Figure 2, we get a radial velocity semi-amplitude for the primary of ≃ 75 km s^{-1}. Assuming an eccentricity of 0 and sin*i* = 1 since it is an eclipsing system, and knowing the 2.888777-day period, we derive a semi-major axis of 4.56 $R_\odot$ for this component. For a mass ranging between 4 and 7$M_\odot$ for the B7 primary star, Kepler's third law implies a mass between 1.8 and 2.5 $M_\odot$ for the secondary, and a total semi-major axis between 15.4 and 18.1 $R_\odot$. This range of mass for the second component corresponds to spectral type A. Other observations will now be performed to further investigate the spectral types of both components.

The observations described above show that TY CrA is a spectroscopic binary. To our knowledge, this is the first spectroscopic binary observed among the Ae–Be Herbig stars. The origin of the narrow components, however, remains puzzling. If they are of photospheric origin, it would imply a spectral type B7 for the primary (somewhat earlier than B8-9 as previously reported) with $v \cdot sin(i) \leq$

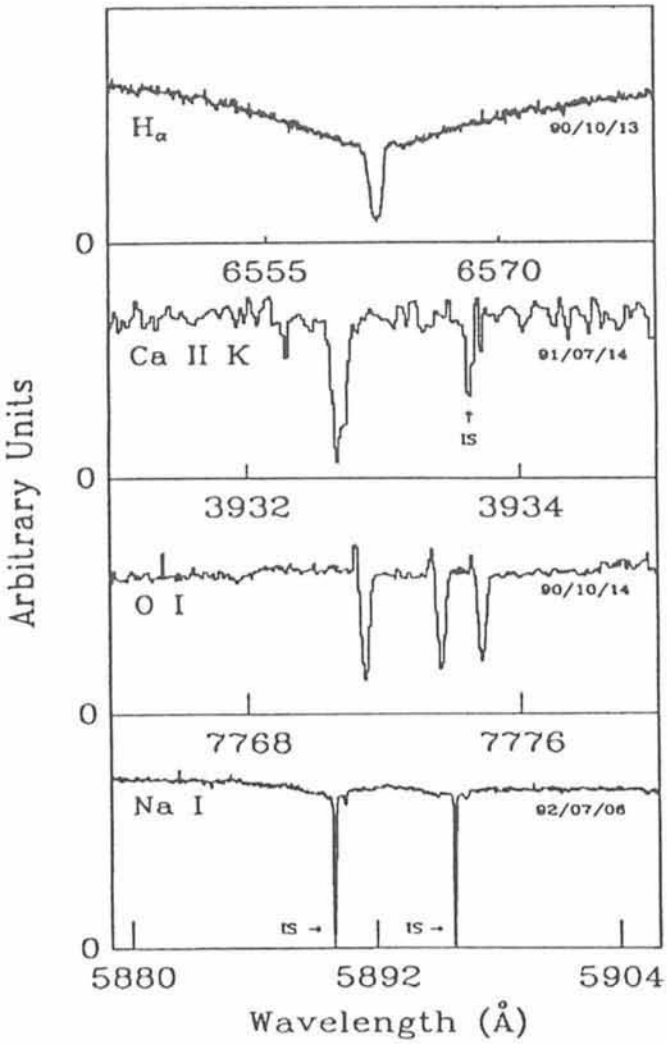
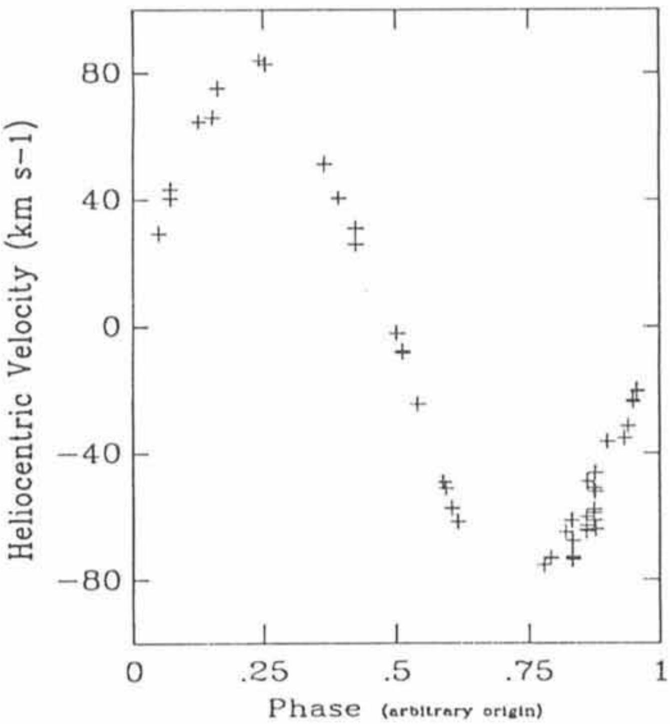


Figure 1: *Examples of high-resolution spectra of TY CrA with lines of Hα, Ca II K, O I, Na I. Narrow absorption lines are observed, and there is a narrow core at the bottom of the Hα line; see the text. They are all variable in velocity except those of IS origin (indicated with an arrow). Note the narrow absorption feature and the broader absorption in the Na I line.*

Figure 2: *Heliocentric velocities of all observed narrow lines (FWHM ≤ 50 km s^{-1}), folded in phase with a period of 2.888777 days.*



8 km s^{-1}. Since we are dealing with an eclipsing binary system, this means that the true rotational velocity of this B7 star is close to this value: but such a value does not fit with the rotational velocity expected for a 3 $R_\odot$ object, if the rotational and 2.9-day orbital motions are synchronized (55 km s^{-1}).

Another possibility is that the narrow lines originate in a circumstellar shell (CS) that surrounds the primary component. In fact, these narrow lines are very similar to the ones observed for the A-type main-sequence star βPictoris, which are clearly due to CS gas. TY CrA's spectrum is more similar to that of βPictoris than to those of usual Herbig stars. This may indicate that this star is more evolved than the latter objects, perhaps very near the end of its pre-Main-Sequence evolution. Further observations are needed to pursue the investigation of this possibility.

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Atomic Processes and Excitation in Planetary Nebulae

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Introduction

Owing to their relatively simple geometry and physical conditions, Planetary Nebulae (PNe) are potentially an ideal laboratory to study various atomic processes important in gaseous nebulae. O III Bowen fluorescence lines, excited by the ultraviolet pumping of the $2p^2\ ^3P_2{-}2p3d\ ^3P^o_2$ line of O III at 303.799 Å by the He II Lyα line at 303.780 Å (Bowen 1934, 1935), are observed in a variety of astrophysical sources, as diverse as PNe, Seyfert galaxies, the Sun, and X-ray binary and burster sources (Schachter et al. 1989, 1990, 1991; Sternberg et al. 1988 and the references therein). These lines are interesting because they provide a powerful diagnostic probe of the physical environment in which they appear. Charge transfer (CT hereafter) of O^{3+} ions in collisions with hydrogen atoms, $O^{3+} + H^0 \rightarrow O^{2+} + H^+$ populates excited states of O^{2+} (Dalgarno, Heil and Butler 1981, DHB hereafter), and con-