formed for a number of CP stars. Most of the concerned spectra have their re-
sonance lines in this range. However, line identification is generally hampered by
the high density of competing trans-
itions.

Fuhrmann devoted special interest to
the well-known CP 2 star HR 465, while
others like HR 7775, HR 4072, X Cnc, 
\( \alpha \) Cen, HD 101065, as well as their "normal" congener of Cet, v Cap and 
Vega were preferably used for compar-
sion purposes. The spectra show a huge
number of absorption lines, most of
which belong to FeII and CrII. Other
elements – like MgII or SiII – have only
few, but strong transitions. In the spec-
a of the CP 2 star \( \alpha \) Cen a remarkable
number of ions with \( Z < 20 \) is not well
pronounced. This is most obvious in the
case of neutral and ionized carbon.

As far as the Rare Earth elements are
concerned there are identifications for
some second spectra (e.g. HoII, GdII, 
\ldots ) in the tracings of HD 101065 –
Przybylski’s star. The spectra of the
somewhat hotter HR 465, however, show only marginal contributions from
this group of elements. IUE spectra are
well suited to show the definite pres-
ence of heavy elements like platinum
and mercury, as well as the overabun-
dances proposed from optical spectra.
Additionally, absorption lines of BiII are
observable. There is also strong evi-
dence for transitions due to gold (AuII).

In the visible, Gerbadli and Faraggia-
na have been extending the investiga-
tion of abundances to elements not eas-
ely observable with photographic plates.
They have derived intriguing results from
observations of the neutral lithium
resonance line at \( \lambda 6707 \) now easily ac-
cessible with modern detectors. The
first observations made by them at ESO
with CES and Reticon of the Ll 6707
line in cool Ap stars, raised several
problems since the feature at this
wavelength shows an asymmetric pro-
file different from star to star and an
intensity which is not related to the at-
mospheric parameters of the stars. Sur-
prisingly, the only rough relation de-
tected was that between the equivalent
width of \( \lambda 6707 \) and the number of
other, mainly unidentified lines present
in this spectral range (Gerbadli,
Faraggiana, 1986). Subsequent obser-
avations at the Observatoire de Haute-
Provence, complementary to those per-
formed at ESO, indicate that a line of
another element, so far unidentified, is
present at a wavelength very close to
the Li line.

Spectroscopic studies of HgMn (CP3)
stars were carried out by Schneider
(1986), who showed that more than 60
per cent of these stars are binaries. Us-
ing new observations he raises this val-
ue to more than 70 per cent. This fact
puts the CP 3 group close to the CP1
(Am) stars, in contrast to the CP 2 stars
with a binary frequency of only about 30
per cent. The CP3 stars show a con-
centration towards circular orbits for
short periods and a lack of periods less
than two days. Stars with periods less
than 10 days tend to synchronize rota-
ton with \( v \sin i \) of about 30 km/s.

Abundance analysis of some CP3
stars were carried out by Ansari who
carefully studied the effect of rotational
broadening of spectral lines on the de-
riv ed abundance values.

References
phys. Suppl. 67, 147.

AK Scorpii: A New Pre-Main-Sequence Spectroscopic Binary

J. ANDERSEN, Copenhagen University Observatory, Denmark, and Center for Astrophysics,
Cambridge, Mass., USA

H. LINDGREN, ESO

M. L. HAZEN, Center for Astrophysics, Cambridge, Mass., USA

M. MAYOR, Observatoire de Genève, Switzerland

While we know that perhaps \(~ 25 \% \) of
normal main-sequence stars are
spectroscopic binaries, very few of their
progenitor systems have yet been de-
tected among (low-mass) pre-main-se-
quence stars: Mathieu’s (1988) review at
the recent IAU General Assembly lists
only 11, and for only three had orbits
been published at that time. This
meagre yield must be due mainly to
selection effects mitigating against
the discovery of pre-main-sequence
binaries. These stars are intrinsically
faint and generally found in highly ob-
scured regions, so systematic and
accurate radial-velocity observations
were impossible until the advent of ef-
cient cross-correlation techniques. Due
to their importance for the under stand-
ing of star formation processes in gen-
eral, pre-main-sequence binaries are now
being searched for very actively, and the
sample will no doubt increase sharply
over the next few years. We would like
to share with readers some of the fun we have had with one of these new systems, AK Sco (full details will appear in Astron. Astrophys.).

**AK Sco:**

AK Sco is an 8th magnitude mid-F type variable star located near the southern outskirts of the Sco-Cen association. Herbig and Rao (1972) found it to have a strong Hα line at 6707 Å as well as strong Χα emission with a central reversal, showing it to be very young. It shares its large-amplitude light variations and infrared excess with a large number of very young stars. It shares its large-amplitude light variations and infrared excess with other interesting parameters, and other interesting parameters may also be involved. For example, the presence of a binary component. (Walter et al. 1988), which may owe their origin to accretion from an envelope, and they reasonably be? Speetroseopically, AK Sco looks like a classical T Tauri star with the ESO 1.5-m telescope on La Silla and determined its spectroscopic orbit as shown in Figure 1. The orbital eccentricity is \( e = 0.47 \), the period is 13.6093 days, both minimum masses \( m \sin^2 i \) are 1.06 \( \pm 0.01 \) solar masses, and the orbital semi-axis major is about 31 solar radii. The origin of the phases plotted in Figure 1 is where a primary eclipse would occur; the phases of a possible secondary eclipse and ofperiastron passage are also indicated.

Unless we can determine the inclination of the orbit, we cannot find the absolute masses of its components, and unless the system eclipses, we cannot directly determine their radii either. Now that we know when to look for eclipses in AK Sco, do they in fact occur? We searched for the answer in a nearby “gold mine”, the vast Harvard plate collection going back about a century. And yes indeed, it holds more than 2,000 plates on which AK Sco can be measured! The period 1910–12 had a particularly dense coverage of plates (83), so we estimated the brightness of AK Sco on these plates and plotted the resulting magnitudes against spectroscopic phase. Alas, no correlation whatever! So, while shallow eclipses might still be discovered by careful photoelectric photometry, most of the \( \sim 1 \)-magnitude variations we do see must have some other origin, probably in nearby dust clouds.

**A Model of the Binary**

If we cannot actually determine the masses and radii of AK Sco, what might they reasonably be? Spectroscopically, the components of AK Sco look just like F5 main-sequence stars. Popper’s (1980) review indicates that reasonable ZAMS masses and radii are 1.3 \( M_\odot \) and 1.26 \( R_\odot \); the orbital inclination is then \( i = 69^\circ \). If the orbital and axial rotation periods are equal, we expect to measure rotational velocities of \( v \sin i = 4 \) \( \text{km s}^{-1} \). However, due to tidal effects, convective stars in eccentric systems are expected to rotate faster than this, about 2.5 times faster for the orbital parameters of AK Sco. This revises our prediction to \( v \sin i = 11 \) \( \text{km s}^{-1} \) for both stars.

What we actually measure from the width of the CORAVEL cross-correlation profiles is \( v \sin i = 19 \pm 1 \) \( \text{km s}^{-1} \), so the stars either spin faster or have larger radii than first assumed. Consideration of the time-scales for synchronization suggests that the former is unlikely, especially since the stars were probably even larger and easier to synchronize when they were younger. Hence, the stars in AK Sco are probably well above the ZAMS.

Published models of pre-main-sequence evolution are relatively old and still largely untested, so we searched instead in Popper’s (1980) review for a real, suitably evolved binary as a “role model” for AK Sco. The F5-type system RZ Cha (1.5 \( M_\odot \), 2.2 \( R_\odot \)), an old friend of ours from early days on La Silla, seems to fit the bill (and the rotation) for an inclination of \( i = 63^\circ \). In this model, the stars still narrowly fail to eclipse. Assuming an effective temperature of 6,500 K, AK Sco is about 200 pc distant, consistent with membership in the Sco-Cen association.

**The Environment of AK Sco**

Although, spectroscopically, AK Sco itself looks rather ordinary, it appears to live in quite a lively place, judging by its irregular variability, which seems too large \( (=1 \) mag) to be reasonably explained by star spot activity. The UVBRJ photometry of Kilkenny et al. (1985) shows that the star gets redder as it gets fainter, with a ratio of total to selective absorption \( R = A_V / (B - V) = 4.6 \). This is much larger than in ordinary interstellar matter \( (R = 3) \), as often occurs in circumstellar dust and is usually considered due to a relatively large grain size.

There is additional evidence for circumstellar dust from infrared photometry of AK Sco: Figure 2 shows the energy distribution derived from the UVBRJHKL photometry of Kilkenny et al. (1985) and the 12, 25, and 60 \( \mu \text{m} \) IRAS fluxes. The fluxes have been corrected for an average amount of extinction. Three black-body curves have been fit to the data. In addition to the flux from AK Sco itself, they show the

---

**Figure 1:** Spectroscopic orbits for AK Sco. Phases are counted from a hypothetical primary eclipse; the phases of secondary eclipse (II) and periastron (P) are indicated. Cross: coudé spectrum; dots: CORAVEL observations; circles: single-lined CORAVEL observations, not used in the solution.
Weil as in other galaxies, H I structures (shells, bubbles, holes, etc.) on scales of 0.1–1 kpc are recognized to be common features; see e.g. the comprehensive review by Tenorio-Tagle and Bodenheimer (1988). The larger ones are usually named with the prefix “super”. The estimated energies which are required to produce such large objects are high – up to some 10^54 erg. These energetic events must exert a significant influence upon the gaseous galactic disk and corona.

In our Galaxy, the disk and the corona are believed to be evolutionarily coupled in a recycling process, although there is no common opinion about details of the

Supershells and Galactic Fountains

B. M. SHUSTOV\(^1\), Astronomical Council, Moscow, USSR

\(^1\) Visiting astronomer, ESO – Garching.