THE 1998 LA PALMA INTERNATIONAL TIME PROJECT ON EXO-PLANETARY SYSTEMS

C. Eiroa[1], A. Alberdi[2], A. Cameron[3], J. K. Davies[4], H. J. Deeg[5], R. Ferlet[6], F. Garzon[7], C. A. Grady[8], A. Harris[9], K. Horne[3], B. Merín[10], L. F. Miranda[2], B. Montesinos[10], A. Mora[1], R. Oudmaijer[11], J. Palacios[1], A. Penny[12], A. Quirrenbach[13], H. Rauer[9], J. Schneider[14], E. Solano[10], Y. Tsapras[3], P. R. Wesselius[15], and D. de Winter[16]

[1]Universidad Autónoma de Madrid, Spain, e-mail:carlos@xiada.ft.uam.es
[2]Instituto de Astrofísica de Andalucía, Spain
[3]University of St. Andrews, UK
[4]Joint Astronomy Center, Hawaii, USA
[5]Centro de Astrobiología, Spain
[6]CNRS, Institute d'Astrophysique de Paris, France
[7]Instituto de Astrofísica de Canarias, Spain
[8]Eureka Scientific, USA
[9]DLR Institute of Planetary Exploration, Germany
[10]L.A.E.F.F., VILSPA, Spain
[11]Imperial College of Science, UK
[12]Rutherford Appleton Laboratory, UK
[13]University of California San Diego, USA
[14]Observatoire de Paris, France
[15]SRON, The Netherlands
[16]TNO/TPD-Space Instrumentation, The Netherlands

ABSTRACT

The 1998 International Time of the Canary Islands Observatories was devoted to the project "Planetary Systems: their formation and properties", carried out by an European/American team - EXPORT (*EX*o*P*lanetary *O*bservational *R*esearch *T*eam). A total of ≈75 observing nights distributed among four observing runs and five different telescopes were used to address the following topics: 1. Formation and evolution of planetary systems, by carrying out observational studies of protoplanetary disks and solid bodies around PMS stars and MS Vega-type objects. 2. Search for spectral signatures of extra-solar planet atmospheres, concretely in the spectra of τ Boo and 51 Peg 3. New planet searches by means of microlensing techniques and photometric transits in clusters. We were able to collect an enormous data set, including high and intermediate resolution optical spectroscopy, optical photopolarimetry, near-IR photometry, and optical CCD images. Some preliminary results of the EXPORT project are presented in this contribution.

Key words: PMS stars; MS stars; circumstellar disks; planetesimals; exoplanets.

1. INTRODUCTION

Studies of exoplanetary systems have received considerable impuls since the discovery of a Jupiter-like planet orbiting 51 Peg (Mayor and Queloz 1995). Up to now more than 20 Jupiter-like planet candidates around nearby solar-type stars have been reported. A main result is that our Solar System constitutes only one particular scenario of planetary systems.

The European Space Agency, ESA, has identified IRSI/DARWIN as a mission for its long-term scientific program. The main scientific goal of IRSI/DARWIN is the search for Earth-like planets around nearby stars and their physical characterization. However, the knowledge we currently have on planetary systems other than our own is very limited, and there is a strong need to understand the formation and evolution of planetary systems in many different scenarios, from both observational and theoretical point of views. In this context, observations of protoplanetary pre-main sequence (PMS) and main-sequence (MS) disks and follow-up studies of stars with exo-planets achieve their sound scientific significance. These kinds of studies help to optimize the IRSI/DARWIN scientific mission.

Table 1. Log of EXPORT observations

Telescope	Instrument/Observing mode	May	July	October	Jan. 99
WHT (La Palma)	UES R ∼ 50000 ∼ λλ 3700-6100Å	14-17	28-31	23-26	28-31
INT (La Palma)	IDS R ∼ 10000 ∼ λλ 5800-6700Å	14-17	28-31	24-28	29-31
NOT (La Palma)	TurPOL Opt. photopolarimetry UBVRI	14-17	28-31	23-27	29-31
CST (Izaña)	IR Phot. + CAIN IR photometry JHK	15-17	28-31	23-26	28-31
JKT (La Palma)	CCD Camera Photometry R		25-31	24-1(Nov.)	

2. EXPORT-OBSERVATIONS

Table 1 presents a log of the EXPORT-observations. ≈ 75 telescope nights were used (∼15 nights/telescope). In addition, the IAC 80cm telescope on Izaña (Tenerife) was used during summer for microlensing. Weather and sky conditions were satisfactory. Spectroscopic data were obtained in all nights; only few hours were lost due to poor observing conditions. Most of the nights were useful for polarimetry and near-IR photometry, while optical photometry was possible during 9 nights.

- ∼ 550 spectra of ≈80 stars (∼55 PMS, ∼25 Vega-type/MS) were taken with the INT. Most of the stars were monitored in time scales of hours, days or months. ∼ 200 UES high resolution spectra of ≈ 50 stars were also taken. Optical photopolarimetry and near-IR photometry were obtained for most of the stars. The photometric and spectroscopic data were taken simultaneously, or very close to simultaneity.

- High resolution spectra of the stars τ Boo and 51 Peg were taken during the WHT May and October runs respectively. The stars were observed in two consecutive nights: during transit of the planet and when the planet was not in the line-of-sight.

- The JKT runs were used to take R-band images, 10 minutes exposure each, of two open clusters with roughly 1000 stars within the field of view. Several hundred of images were obtained. Appropriate algorithms to analyse light curves in a large number of stars are being developed and tested. Eventually, they would allow us to detect planet transits in front of the cluster stars, in case they exist.

3. RESULTS

3.1. PMS/Vega-type stars

Simultaneous spectroscopic and photopolarimetric observations are justified since spectroscopic signatures attributed to solid bodies ('planetesimals') in the protoplanetary disks around these types of stars are transient. It is also well known the variability of young PMS stars. At present, a detailed analysis of the data taking into account stellar ages and masses, as well as the relevance of the circumstellar gas/dust disks is being carried out. It will provide insights into the evolution of protoplanetary disks and the formation of planetesimals/planets. Some very general preliminary results are as follows:

Most of the observed PMS stars are variable. Variability is detected for a wide range of spectral types -from late B to K- and ages, being larger for the youngest objects. Spectroscopic variability is seen in several lines, Hα, HeI, NaI, CaII, etc. Vega-type and the rest of MS stars observed are not variable, excluding some spectroscopic features associated with the circumstellar gas around some of the Vega-type objects. As examples, Figures 1 to 3 show UES spectra of two PMS objects, UX Ori and VV Ser, and one Vega-type star, HR 10. Transient blue- and red-shifted absorption components in several metallic lines (e.g. NaI and CaII) are observed in the spectra of several PMS objects and at least one Vega-type star. These absorption components are similar to those observed in β Pic and UX Ori, which are interpreted as the spectroscopic signatures of moving solid bodies/planetesimals embedded in the protoplanetary disks around these stars (e.g. Beust et al 1998, Grinin et al. 1996). In several stars of our sample, these are the first indication of such absorption components.

Figure 1 shows the EXPORT monitoring of UX Ori

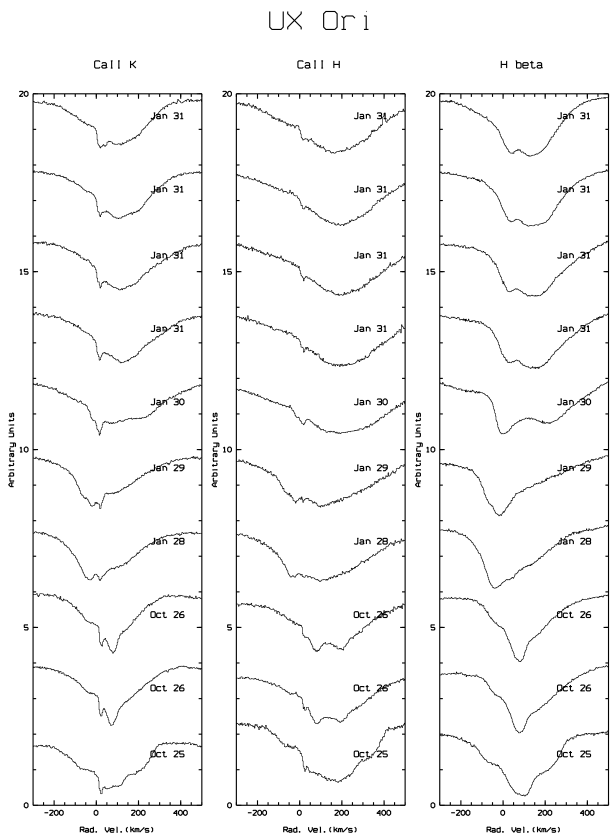

Figure 1. UES CaII H and K and Hβ monitoring of UX Ori. Flux units are arbitrary.

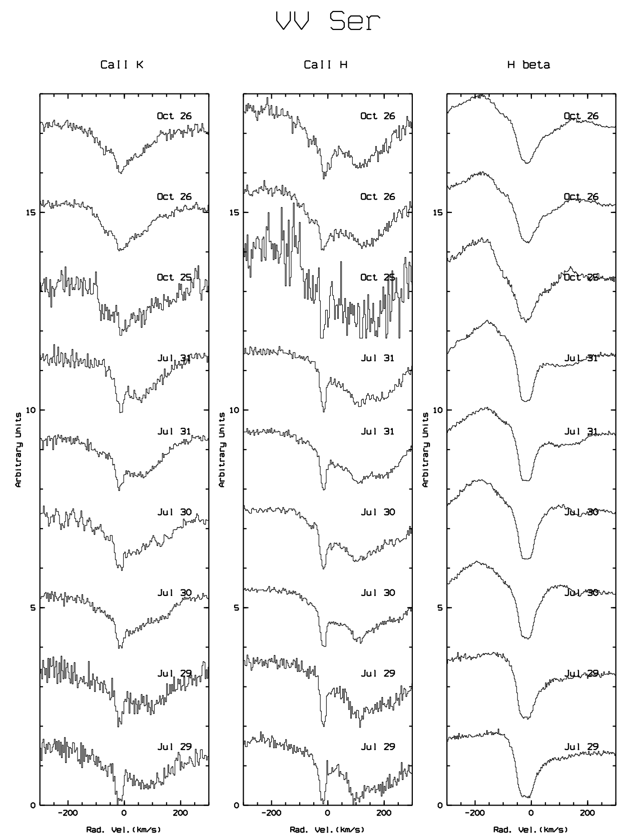

Figure 2. UES CaII and K and Hβ monitoring of VV Ser. Flux units are arbitrary.

in the CaII H and K and Hβ lines. Drastic changes are seen at different time scales, with the appearance and disappearance of blue- and red-shifted absorption components. These transient events indicate a large activity of planetesimal evaporation in the UX Ori protoplanetary disk. Figure 2 shows the same lines for VV Ser, a very young HAeBe star, whose spectral type is dubious, ranging from early B to early A. V magnitude during these observations was $\sim$11.9. As in the case of UX Ori, drastic changes in the CaI H and K and Hβ lines are observed. Variable blue- and red-shifted absorption components are present. Similar sporadic events are also seen in other lines, e.g NaI D lines. Figure 3 shows the observed UES CaII H and K lines of HR 10, a Vega-type star which is known to exhibit substantial changes in the circumstellar absorption lines (e.g. Welsh et al. 1998). Our spectra show that the narrow central CaII absorption component changes its radial velocity by an amount of $\sim$ 8 km/s when comparing the Oct25 and Jan28 spectra. In addition, an absorption red-shifted by $\sim$ 20 km/s with respect to the 'main' circumstellar absorption is observed in the Oct25 spectrum. This kind of sporadic events are interpreted in terms of the infalling evaporating comet model developed for β Pic (e.g. Beust et al. 1998).

The photopolarimetric behaviour of the sample is the 'normal' one. Most of the PMS stars are polarized and have near-IR colour excesses. Photometric variability up to $\approx$1.8 mag in V and $\approx$0.8 mag in K are detected. Changes in the polarization are also noticeable. These characteristics are attributed to the protoplanetary dusty disks around these stars. Vega-type and the rest of MS stars in our sample normally are unpolarized and have no near-IR excess. There are few exceptions. Some Vega-type stars are polarized, e.g. BD +31°634; in addition, at least one star (51 Oph), and probably a second one, have H-K excess. These results indicate that dust disks in some Vega stars are still prominent in our wavelength range. As an example, Figure 4 shows the two colour near-IR diagram of the stars in our sample. The near-IR excess of most PMS stars is clearly distinguished, whereas most MS stars are located at the position correponding to their intrinsic colours. The distinct position of both group of stars in the diagram reflects the difference in evolutionary terms of the stars and of their circumstellar environments.

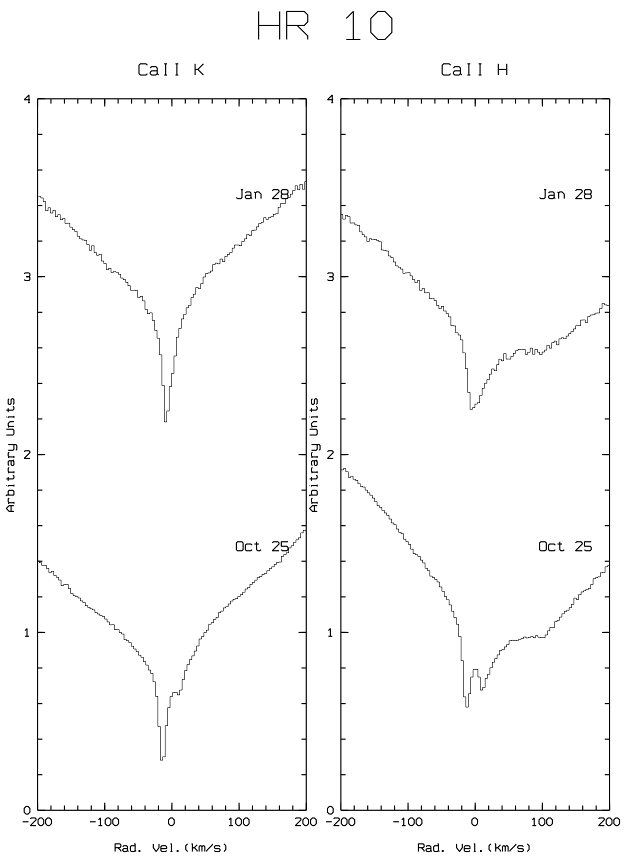

Figure 3. The CaII H and K line variability in the UES spectra of the Vega-type star HR 10. Flux units are arbitrary.

3.2. Espectroscopic signatures of planets: τ Boo and 51 Peg

The nature of massive planets orbiting close to their parent stars is an open question. It most likely that they are large Jupiter-like planets, although large solid planets cannot be ruled out. If they are gaseous, atoms and molecules of their atmosphere may escape and fill a large volume around the planet, which could leave weak signatures in the stellar spectra. τ Boo and 51 Peg were observed during on and off planet transit. The achieved spectra have very good signal to noise ratios. Figure 5 shows UES spectra of τ Boo during transit and off-transit. The spectra are essentially identical, with no differences which could be attributed to the detection of any planetary atmosphere signature. Similar results were obtained in the case of 51 Peg. The expected signal from the planet with respect to the parent star is extraordinary small and very deep analysis of the data are still in progress with the aim of, at least, constraint the properties of the planet atmospheres

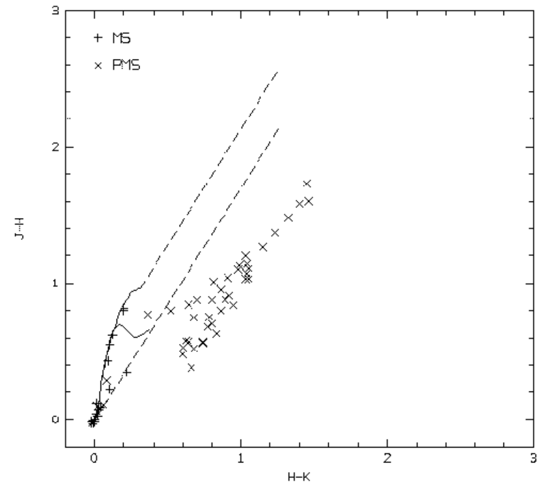

Figure 4. J-H/H-K diagram of the EXPORT Targets. The colours correspond to the observed mean magnitudes. The curved line corresponds to intrinsic colours of main sequence stars. The dashed lines correspond to the interstellar reddening lines for K0 and A0 stars.

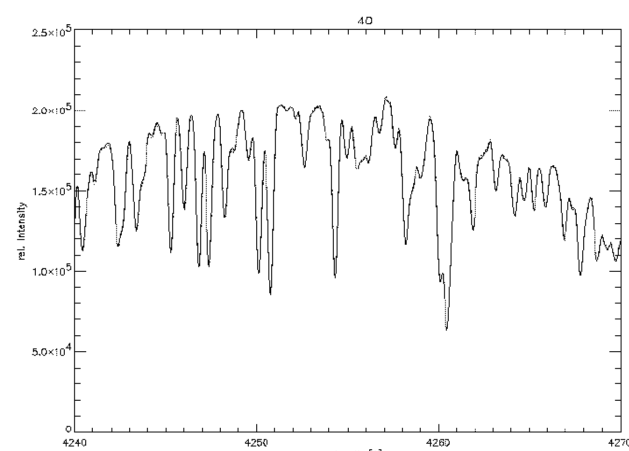

Figure 5. WHT/UES spectrum of τ Boo. Solid line: spectrum taken during transit of the planet through the line-of-sight. Dotted line: spectrum taken off-transit. Both spectra are practically identical

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