16/2/99

Course 3C32 - Field Trip

To l'Observatoire Haute-Provence

Orientation Report

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Astrophysics III

Abstract

A group of students from the University of London Observatory (ULO) will be visiting the Observatoire Haute-Provence (OHP) between the 16th and 26th of February 1999. They will be using the 0.8m and 1.52m telescopes at the OHP to observe three classes of object: chemically peculiar stars, spectroscopic binaries, and cataclysmic variables. This report details the facilities available at the OHP, and also discusses the objects to be targeted.

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L'observatoire Haute-Provence - Orientation Report

1. The observatory

1.1 Location

L'observatoire Haute-Provence (OHP) is situated in south-eastern France, near the start of the French Alps. It is at latitude 44°N and longitude 5.7°E. The elevation is 665m. It is about 90km east of Avignon, and 100km north of Marseille. The nearest town is St. Michel l'Observatoire.

1.2 History

The observatory was founded in 1937, as a national facility for French astronomers. The first observations were made with the 1.20m telescope in 1943, and the first research papers were published in 1944. The observatory has been available to non-French astronomers since 1949. Today it is at the forefront of astronomical research: the discovery of the famous planet orbiting 51 Pegasi was made at OHP, using the Élodie spectrograph on the 1.92m telescope.

1.3 Instruments

The OHP has four main telescopes, two of which will be used by the UCL group. The telescopes to be used are the 1.52m and 0.8m telescopes, and these are detailed below:

1.3.1 The 1.52m telescope

In use since 1967, the 1.52m telescope at OHP is used in conjunction with the Aurélie spectrograph, which is situated at the Coudé focus. The focal ratio of the telescope is f/27.6. It is identical to the 1.52m telescope at the ESO facility at La Silla, apart from the fact that it only has one focus. It is pointed manually, but all other functions are automated. The telescope is equipped with a CCD camera, used for acquiring the target and automatic guiding. The camera has a field of view of 3'x4'.

1.3.2 The Aurélie spectrograph

The Aurélie spectrograph, in use since March 1989, is a high-quality instrument which can obtain spectra at very high resolutions (up to $\lambda/\Delta\lambda = 110{,}000$). Its spectral range is 3900 to 10,000Å. The slit has an aperture of 600μm, which is equivalent to 3" on the sky. This keeps scattered light to a minimum given the average seeing conditions at OHP (see §1.4 below).

The detector attached to the spectrograph is a double linear array TH 7832, which consists of two identical independent arrays, only one of which is used by the spectrometer. This array has 2048 pixels, of which 2036 are usable. The linearity of the array is better than to within 1% above a signal 1000ADU (ADU = Analogue-to-Digital Unit). The odd-numbered pixels are coupled to a CCD register henceforth referred to as channel 1, while the even-numbered pixels are coupled to a register to be referred to as channel 2.

The different channels have different read-out noise, and slightly differing gains. Also, there is a flaw in the array between pixels 1500 and 1800. However, These effects are well corrected by flatfielding.

The filters available for use with the Aurélie spectrograph have band-passes centred at the following wavelengths: 3934, 4860, 5893, 6563, and 6707Å. The calibration lamps available are Thorium-Neon, Thorium-Argon, and Iron-Neon.

The diagram below, taken from the OHP website, is a schematic diagram of the Aurélie spectrograph.

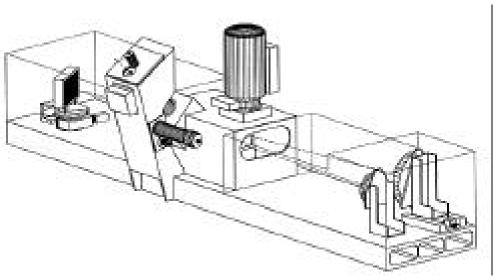


Figure 1 - schematic diagram of the Aurélie spectrograph

1.3.3 The 0.8m Telescope

Built in 1932, the 0.8m telescope was situated at nearby Forcalquier until 1945, when it was moved to the OHP. It is a Cassegrain telescope with a focal length of 12m, yielding a focal ratio of f/15. If necessary, it is possible to use the f/6 Newtonian configuration, but this is rarely done. The focal plane scale at f/15 is 58µm/arcsec^2. Over the last few years, the telescope has been undergoing refurbishment, and further modifications are expected to be made over the next few years.

The telescope is auto-guided by a CCIR camera with a SECAD card. All auto-guider functions are accessible from the computer which controls the telescope. The telescope can track an object for up to three hours, after which time the sectors need to be rewound.

1.3.4 The 0.8m Telescope CCD camera

The detector used with the 0.8m telescope is a Tektronix CCD camera, with 512x512 27µm pixels. The focal plane scale is 0.42 arcsec/pixel, and the field of view is 3.6'x3.6'. The anti-reflection coating is damaged along a diagonal line in one quarter of the chip, and the observatory recommends not placing interesting objects in this area. The numerical saturation count of the CCD is 37267ADU. Read-out noise is 10e$^-$, and gain is 6.4e$^-$/ADU.

The filter wheel used with the CCD camera accepts 6 50mm diameter filters. Available filters include Cousins BVR and Gunn uvgriz broad-band filters, as well as 9 narrow-band filters detailed below.

Central Wavelength (Å)	Bandwidth (Å)	Transmission (%)
3808	51	29
4785	52	83
4863	55	82
5016	44	81
5364	49	84
6450	45	81
6561	48	78
6737	39	72
9241	106	94

Table 1 - Narrow-band filters available on the 0.8m telescope

All filters are fitted with an optical compensator, so that no focussing adjustments are required when switching filters.

1.4 Observing conditions

The average size of the seeing disk at OHP is 2", which compares to the ULO average of 4-5". On an exceptional night, the seeing may reach 1". The average atmospheric extinction at OHP is approximately twice that at the ESO facility at La Silla.

Statistics from the years 1960-1993 indicate that February is one of the least favourable months to observe from OHP, from a climate point of view. Around 50% of nights are considered good, that is, are clear, or have only very slight cloud cover. This compares to the year-round overage of 60% good nights. Another problem in winter is the Mistral, a cold wind which blows from the north-west. It occurs on average on 45 nights of the year, mostly in winter, and causes a severe decline in the quality of the seeing. However, the Mistral usually clears up the sky, and good weather typically follows.

Taking the chance of a clear night as 50%, a graph can be drawn showing the probability of the number of clear nights in our eight-night observing run:

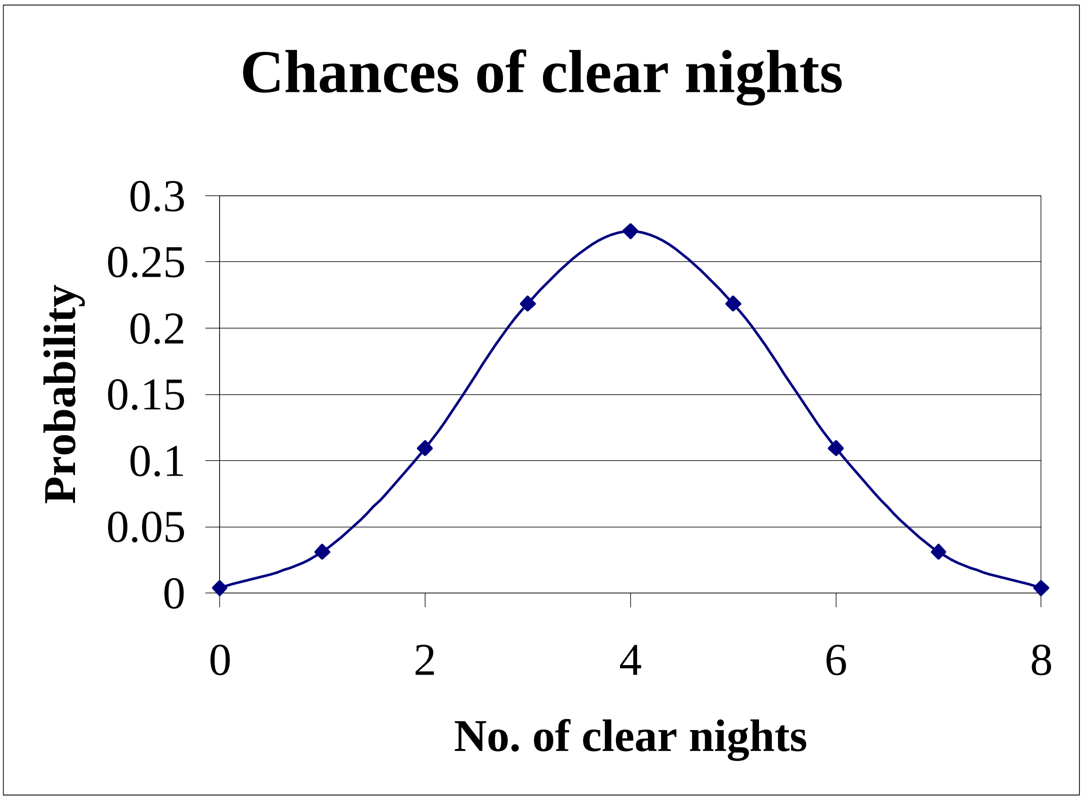


Figure 2 - Clear night probabilities for an 8-night observing run on February

From this graph, it can be seen that there is a 64% chance of more than 4 clear nights, an 86% chance of more than 3 clear nights, and a 96% chance of more than 2 clear nights. While it is pleasing to note that the probability of all nights being cloudy is only 0.39%, sadly we must also realise that the probability of eight clear nights is also only 0.39%.

2. The Targets

2.1 Cataclysmic variables

The 0.8m telescope at OHP is to be used by the UCL group to observe 5 cataclysmic variables, detailed in appendix 1.

All the stars to be examined are close binary systems. One member of the system is a white dwarf, while the other is a red giant. The outer layers of the red giant's atmosphere extend beyond the Roche lobe of the star, that is, extend beyond the zone in which the gravity of the red giant is dominant. Mass can thus be gravitationally torn away from the giant by the dwarf star. When enough mass has been transferred, a runaway thermonuclear reaction may occur on the surface of the white dwarf, causing a sudden increase in the brightness of the system. The increase is usually of the order of several magnitudes. Light curves for the stars to be observed are reproduced in appendix 1.

The aim of observing the target stars is to record several orbital cycles, to confirm the orbital period. Also, comparison with results obtained on last year's field trip will show up any long-term changes in the period or amplitude of the star's variations. Non-orbital variations in the systems will also be investigated. Such variations include outbursts, changes to the mass-exchange rate, development of bright spots in the accretion disks and at the poles of the system, and variations in the thickness and orientation of the accretion disks.

2.2 Chemically Peculiar Stars

The 1.52m telescope at OHP is to be used to compare Neon abundances in normal and Hg/Mn stars of spectral types A0 and B9. The Aurélie spectrograph is to be used in configuration 5, which gives a resolution of R = 70,000, and wavelength coverage of 40Å. This configuration will thus allow spectra to be taken of the target stars in which the lines due to both Neon (6402Å) and Silicon (6371Å) will be visible.

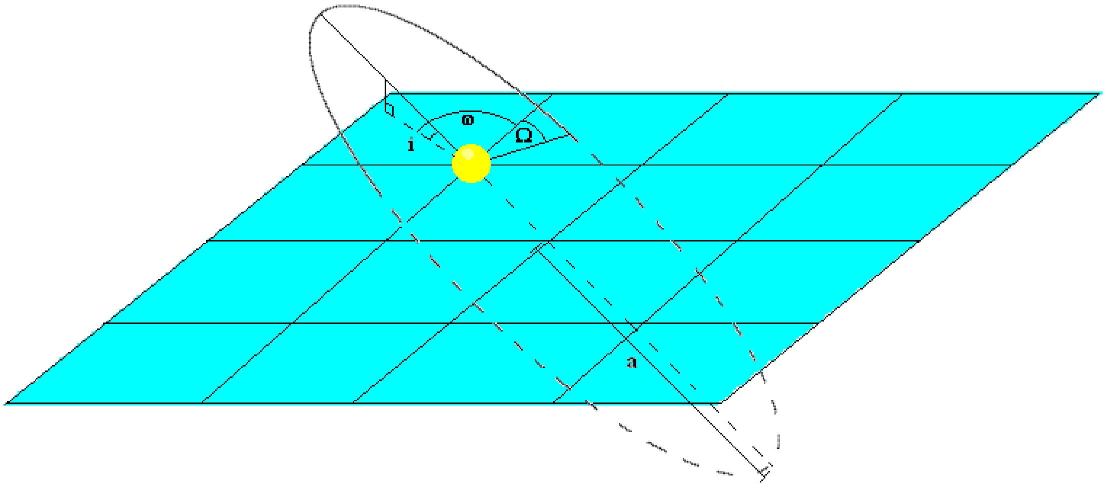
Hg/Mn stars are ideal for studying the effects of radiative diffusion and gravitational settling on the chemical make-up of stars. This is because they rotate slowly, have weak or absent magnetic fields (so that spectral lines are not broadened), and have relatively stable atmospheres.

The aim of the experiment is first to use the silicon line at λ = 6371Å to estimate the projected rotational velocity of the star, using a rotational model in conjunction with an ideal line profile. Next, the abundance of Neon in the atmospheres of the target stars will be calculated, by comparing observed line profiles at λ = 6402Å to model profiles generated using the program UCLSYN.

2.3 Spectroscopic Binaries

The secondary objective of the observing run on the 1.52m telescope at OHP is to observe some spectroscopic binaries. These are systems in which two stars are orbiting each other at a distance too small for them to be separated optically. The double nature of the system is revealed when one looks at the spectrum. If the two stars are of similar luminosity, then each spectral line will, twice over the course of one orbit, split into two, reach a maximum separation, and then move back together again. This effect is due to the orbital velocity of each member of the system Doppler-shifting its spectral lines. More commonly, though, one member of the system is bright enough to swamp the spectrum of the other, and only one set of oscillating lines is observed.

The object of observing the spectroscopic binaries at OHP is to determine the orbital elements of the system: the semi-major axis (a), eccentricity (e), period (P), inclination (i), angle of nodes (Ω), longitude of periastron (ω), and time of periastron (T):



By observing the binaries at as many epochs as possible, it is hoped that some or all of these orbital elements can be determined. The orbital period and the periastron time are easily determined if enough measurements can be made. The other elements require some serious number crunching, and a purpose-written computer program will be used to calculate these.

With the exception of α UMa, all the target stars have short periods. Thus over the course of an eight-night observing run, it should be possible, weather permitting, to observe the binaries over at least one entire orbit. The more of a curve is observed, the better the accuracy of the determined orbital elements.

In the case of α UMa, the period of the binary is 44 years, and though the orbital elements are currently poorly known, the trip to OHP coincides with the predicted periastron of the system. An observation with the high-resolution Aurélie spectrograph should separate the individual stellar spectra, which will be at or about their maximum separation.

References

1. *http://www.obs-hp.fr/* - official website of the OHP

2. *http://www.daec.obspm.fr/users/hui/astro/gb/* - Chemically peculiar stars

3. *Aurélie: the high resolution spectrometer of the Haute-Provence observatory* (Gillet *et al*, A&AS, 108, p.181)

4. *Universe* (Kaufmann, Freeman 1994)

5. *Introductory Astronomy and Astrophysics* (Zeilik, Gregory and Smith, Saunders College Publishing 1992)

Appendix 1: Cataclysmic Variables to benObserved at OHP

The 5 cataclysmic variables to be observed at OHP are detailed below:

Star	α_{2000}	δ_{2000}	m_V	P_{orb} (minutes)
YZ Cnc	$08^h10^m56^s.6$	+28°08'36"	14.1 - 15.5	125.0
Z Cam	$08^h25^m13^s.2$	+73°06'40"	13.6 - 14.8	417.370
DO Dra	$11^h43^m38^s.3$	+71°41'20"	10.6 - 15.1 (B)	238.8
UX UMa	$13^h36^m41^s.0$	+51°54'48"	12.7 - 14.1	283.206
AH Her	$16^h44^m09^s.9$	+25°15'01"	13.9 - 14.7	371.687

Table A1 - Cataclysmic variables to be observed at OHP

Indicated magnitude variations are orbital: during outburst, the stars may brighten by several magnitudes.

Light curves stretching over more than 30 years can be obtained for each of these stars from the website of the American Association of Variable Star Observers (AAVSO) at http://www.aavso.org/. Light curves over shorter lengths of time are reproduced below. All data are unevaluated, that is, they have not been properly scrutinised by the AAVSO. However, they are quite adequate for giving an idea of the behaviour of these stars. A point is a magnitude estimate, while a '∨' symbol means that the star was unobserved down to the indicated limiting magnitude.

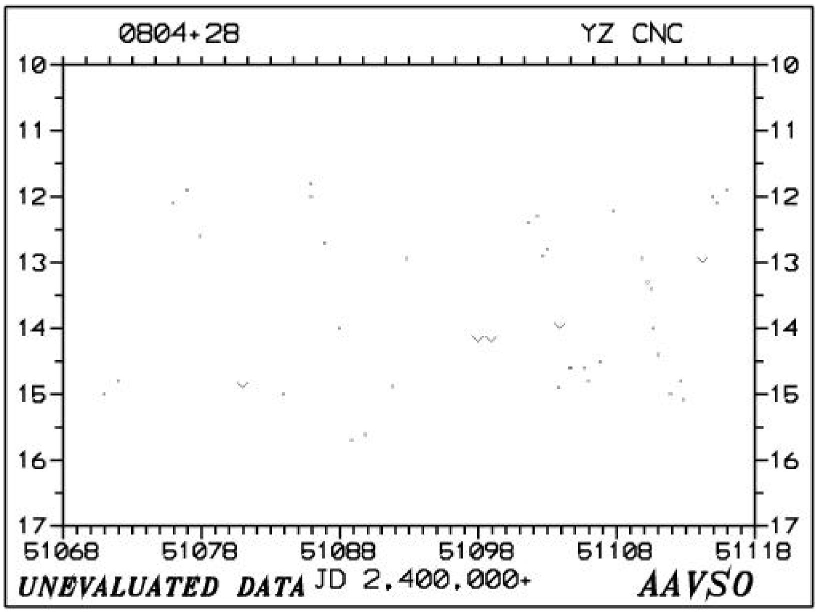


Figure A1 - light curve over 50 days for the star YZ Cancri

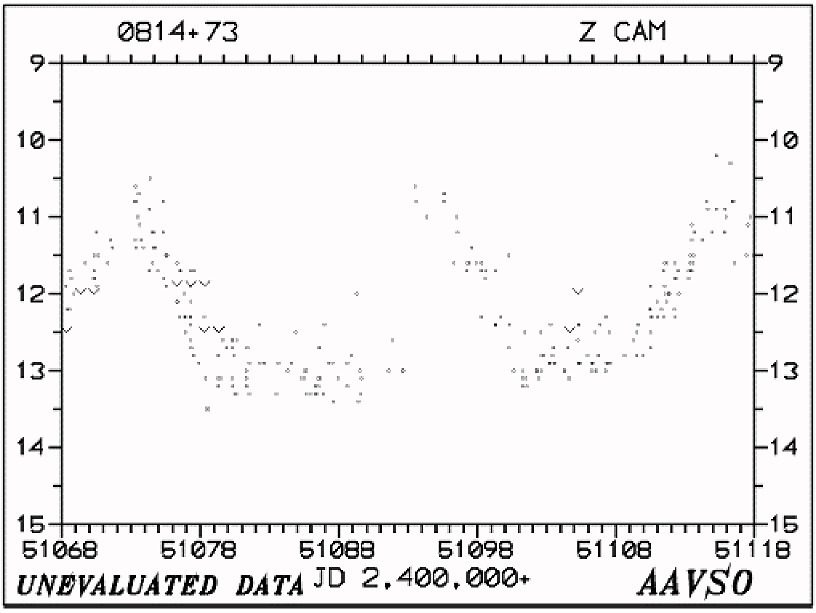


Figure A2 - light curve over 50 days of the star Z Camelopardalis

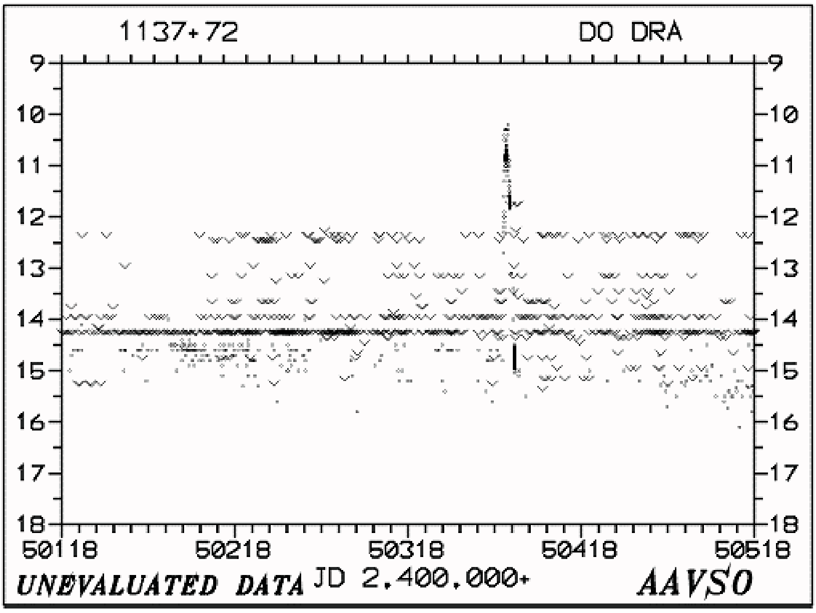


Figure A3 - Light curve over 400 days for the star DO Draconis

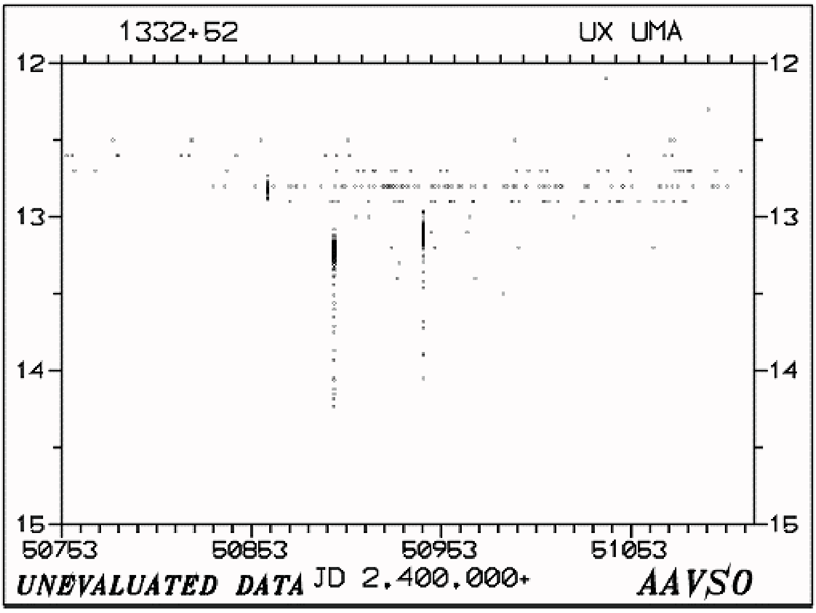


Figure A4 - Light curve over 365 days for the star UX Ursae Majoris

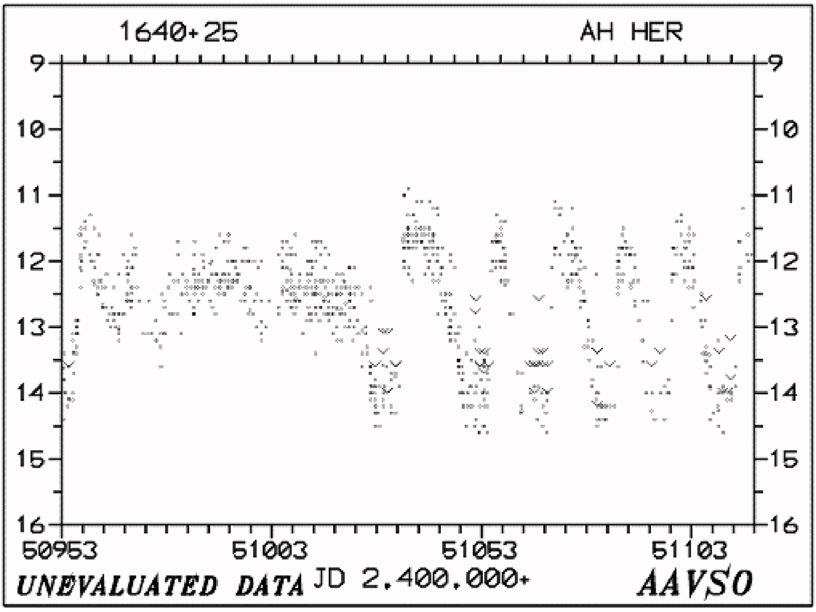


Figure A5 - Light curve over 365 days for the star AH Herculis

Appendix 2: Finder Charts for Objects to be Observed at OHP

This appendix gives finder charts for the following target stars:

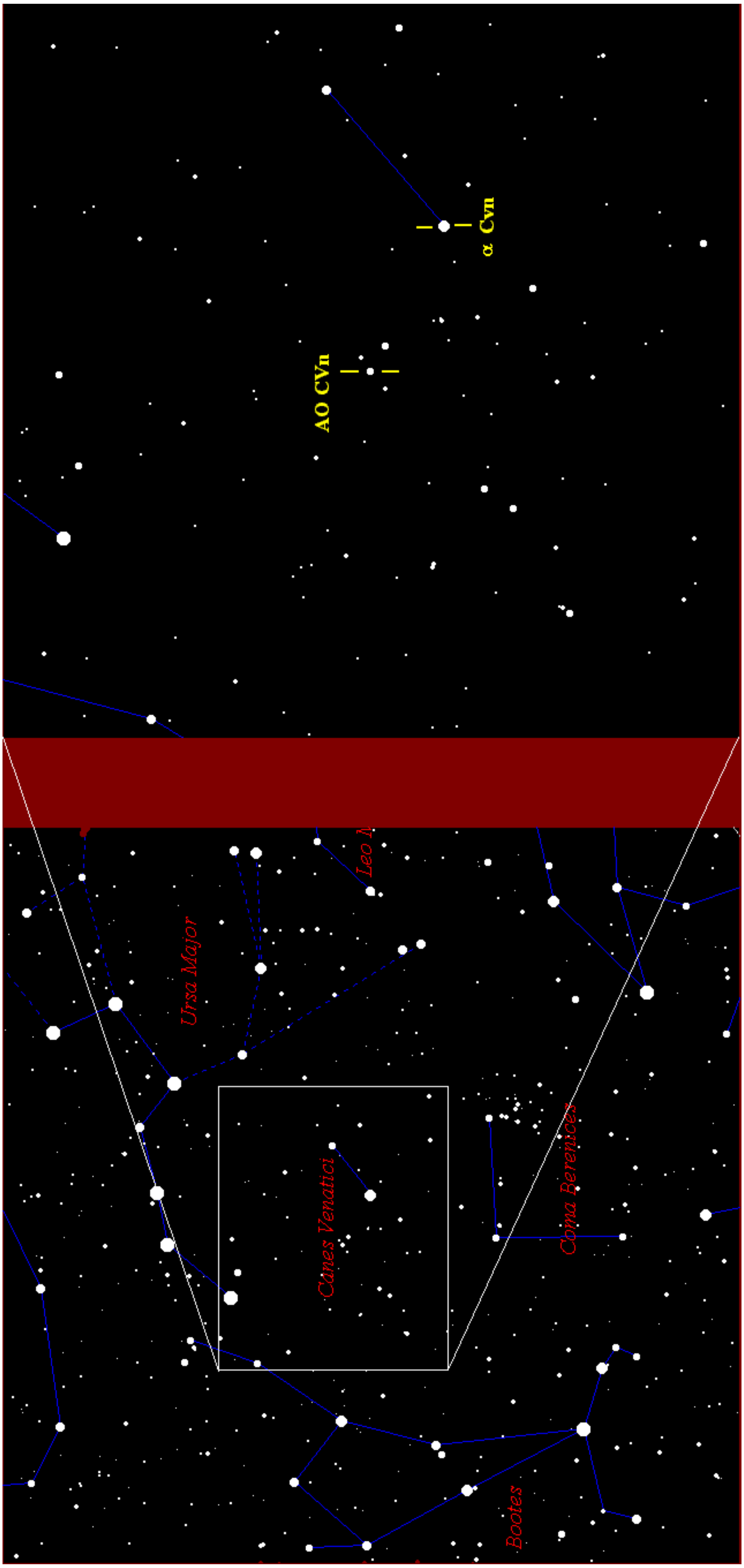
Star	α_{2000}	δ_{2000}	M_V	Finder Chart page
α^2 CVn	$12^h56^m01^s.7$	+38°19'06"	2.90	12
AO CVn	$13^h17^m32^s.5$	+40°34'21"	4.73	12
HR 2844	$07^h28^m51^s.6$	+48°11'02"	5.72	13

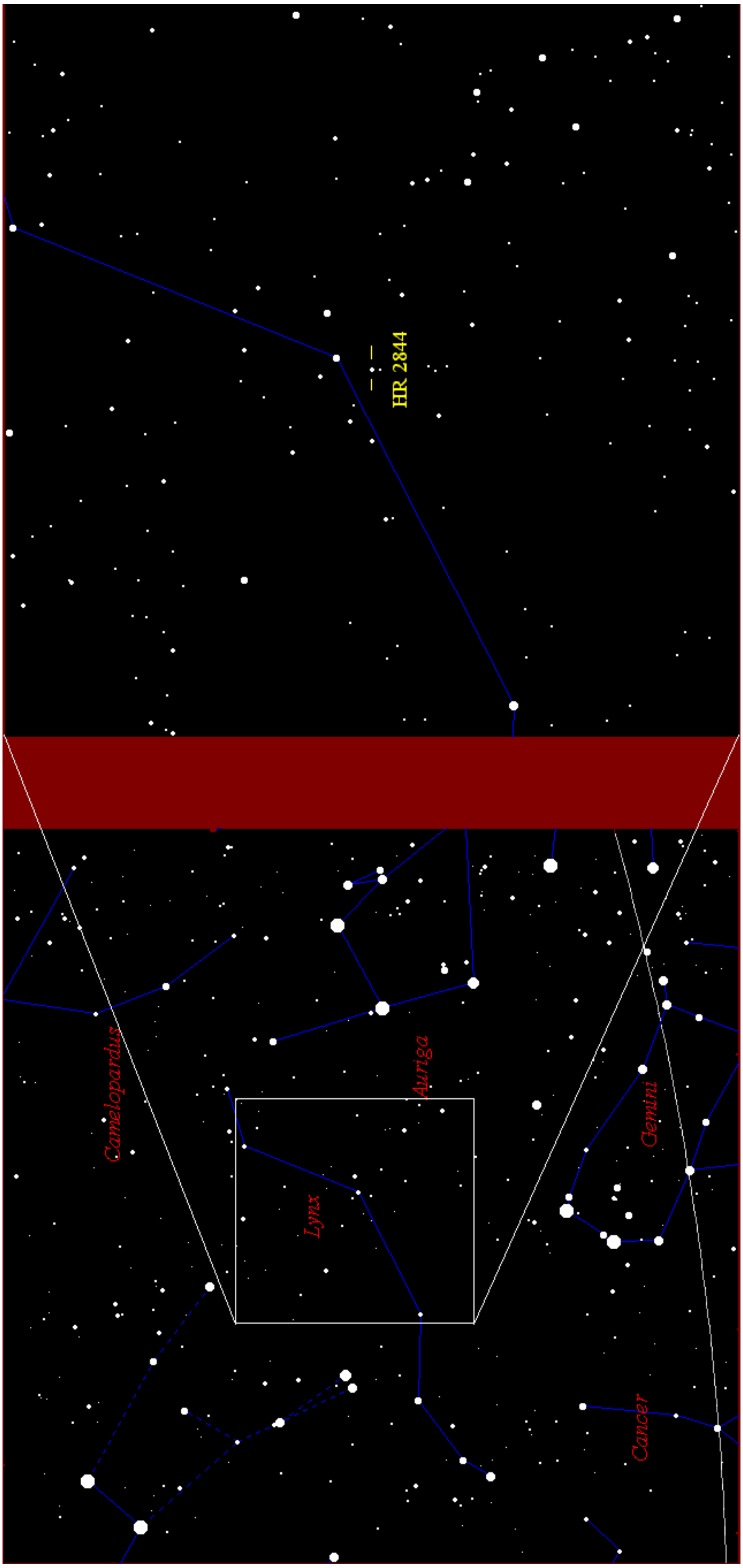
Table A2 - Target stars for which finder charts are provided

Details of other stars may be found in the orientation reports of other members of the group, as detailed below:

Group Member	Stars
Catherine Dandy	33 Gem KX Hya HD 93521
Andrew Fox	ν Cnc α UMa 20 Leo
Matt Harvey	α Cam V1032 Ori
Alex James	ν Her ϕ Her YX Cnc
Clare Jenner	HR 2676 π^3 Ori AH Her
Henrik Melin	ι CrB λ Tau ε UMa
James Macey	HR 1800 HD 112014 DO Dra
Sarah Nolan	53 Tau μ Lep HR 4072
Rob Purcell	36 Lyn ν Tau Z Cam
Thomasin Renshaw	κ Cnc α Aur
Ross Williamson	134 Tau UX UMa

Table A3 - Where to find information on target stars


α CVn
AO CVn
Ursa Major
Leo M
Canes Venatici
Coma Berenices
Bootes


HR 2844
Camelopardus
Auriga
Lynx
Gemini
Cancer