ESPaDOnS at CFHT

Notes for spectroscopic and spectro-polarimetric nighttime observations

For:

Semester ________________

RunID __________________

PI Name ________________

December 20, 2005

LOGIN INFORMATION, CONTACT INFORMATION

- **ESPaDOnS session** / **Observer's account (data reduction)**

Instrument control ONLY		Libre-ESpRIT, telnet, Netscape, etc.		
computer:	maka	computer: akua, NOT maka		
login:	espadons	login:	"runID"	e.g.: *03bf11*
password:	______________	password:	______________	
detector:	EEV1	email:	"runID"	e.g.: *03bf11@cfht.hawaii.edu*

NOTE: this information is also written on the board in the control room.

- **Support Astronomer:** ____

  Office: ___________________
  Home: ___________________
  Pager: 925-7473
  Astro cell phone: 936-0885
  email: ___________________@cfht.hawaii.edu
  Notes: ____

- **Other phone numbers:** CFHT offices, Hale Pohaku: 935-9001
  Summit: 961-2630 or 961-2639
  CFHT office, Waimea: 885-7944

- **IMPORTANT NOTE:** Please do not forget to complete the **Run Completion Form** at the end of your run:

  `http://www.cfht.hawaii.edu/ObsInfo/Forms/obsrpt_e.html`

  I would also appreciate getting **photocopies of your log sheets**. Give them to the Observing Assistant.

  If you have any other comment (positive or negative) about the instrument, your observing run, etc., please send me an email!

SAFETY

1. **At no time is anyone allowed to be alone in the CFHT Observatory building.** If you have to go the summit during the daytime, make sure someone will accompany you (another observer) or confirm that someone from the CFHT staff (daycrew or OA) will be there with you the entire time. Note that the daycrew or other CFHT staff occasionally leave as early as 14h, so you might not always be able to rely on their presence.

2. CFHT has Suburban 4x4 vehicles ("Subs") that must be used to drive to the summit; no rental car is allowed past Hale Pohaku. Make sure you have at least 1/3 of a gas tank. **THE SPEED LIMIT IS 25 MILES PER HOUR.**

3. When you get to the summit, hang your vehicle keys on the board next to the elevator, and place a magnetic label (Observer A, etc.) on the board.

4. At Hale Pohaku, leave the vehicle keys on the board next to the window.

ACKNOWLEDGEMENT

1. Proper CFHT Acknowledgement for ESPaDOnS publications based on CFHT data is as follows: asterisk by the author's name to refer to a footnote stating: *Based on observations obtained at the Canada-France-Hawaii Telescope (CFHT) which is operated by the National Research Council of Canada, the Institut National des Science de l'Univers of the Centre National de la Recherche Scientifique of France, and the University of Hawaii.

2. Proper acknowledgement should be made if you use the data reduction software Libre-ESpRIT. The final phrasing has not been determined yet, but something like this should be sufficient: The ESPaDOnS data were reduced using the data reduction software Libre-ESpRIT, written by J.-F. Donati from Observatoire Midi-Pyrenees, and provided by CFHT.

3. Proper reference should be given for Libre-ESpRIT:
   Donati et al., 1997, MNRAS 291, 658
   Donati et al., 2005, MNRAS (in preparation)

STARTUP, BEGINNING OF NIGHT - SPECTROPOLARIMETRY

1. **LOGIN** onto *maka* using the session login *espadons*. A "Director" window will appear and show messages related to the instrument's initialization. The Top Menu Bar for the Graphical User Interface (GUI) will also appear.

2. **CONFIGURE the instrument at the beginning of every night**:

   - Click on the GUI's Top Menu Bar button "Configure".
   - Click on the Top Menu Bar button "Status".
   - In the Configure window, enter your runID, PI name, name of observer. That information is used for FITS headers.
   - In the Configure window, select your "Observation mode" and the "CCD read-out mode".
   - In the Configure window, **click on the button "Apply Changes" to configure the instrument, every night**; in the Status window, you will see components move.

3. After each Configuration, and only after the dewar has been filled and the OA has rebooted his computer, **FOCUS** the instrument. In the Configure window, click on "AutoFocus". Four exposures will be taken and analyzed. After reporting the old and new optimal focus values in a pop-up window, the camera focus is moved to the appropriate value. When done, on the Configuration window, click on the "Close window" button.

4. After each Focus, take the appropriate **CALIBRATIONS**:

   - Click on the Top Menu Bar button "Calibrations"
   - In the Calibrations window, click on the check boxes so the following frames are selected:
     - 3 bias (only one is needed for the reduction)
     - one 30-sec Thorium exposure
     - 10-20 flat fields, 2-4 sec each, around 40,000 counts; check that the flats are not saturated
     - one 4-sec Fabry-Perot exposure in all modes **except** the 'star+sky' spectroscopic mode
   - In the Calibration window, click on "Go".
   - When the calibrations are done, click on the "Close window" button.

5. You are now ready to observe science targets.

OBSERVATIONS

1. Get ready for science observations:
   - Click on the Top Menu Bar button "Guider":
     - Click on the button "Set Defaults" to configure the guider window.
     - Click on the button "Apply Changes" to make it so.
     - Select the mode "Acquisition" with exposures of 0.5 seconds, and click on the button "GO". The guiding camera will start acquiring images.
   - Click on the Top Menu Bar button "Expose"
     - Verify that the RunID, PI name, Observer, Observation mode and CCD readout mode are the correct ones.
     - Select the Exposure type "Star".
     - Select the Stokes parameter(s) you want to measure. Select 'I' in spectroscopic modes.
     - Enter the name of your first object and any comment you would like.
     - Click on the button "Ready for Science". You will see in the Status window that some of the components are moved in preparation for the observations.
     - If you want to use the ADC, click on the button "Use ADC". Correction will start immediately and is performed every 30 seconds.
   - Click on the Top Menu Bar button "Exposure Meter" (optional)
     - Click to turn ON the exposure meter
     - Click to OPEN the shutter
     - Click to get the Graph
   - Click on the Top Menu Bar button "TCS info", then on the "Status" button at left in the small window that has appeared (optional)
     - Click on "Tiny Information"
     - Click on "Dome Display"
     - Click on "Guiding strip +/- 1 arcsec"
2. Give the coordinates of you first target to the Observing Assistant. Wait until the telescope and dome are ready.
3. Your target should appear in the Guider display. You may increase the exposure time or change the neutral density filter if you need to.

4. Change the telescope focus as needed using the hand paddle; keep the "ENABLE" button pressed down while you move the focus up or down; the focus value is indicated by the "Cass" number in the Tiny Information TCS window. The focus goes up when the airmass goes up.

5. To get a seeing estimate, the star must be close to the hole but not in it; set the guiding zone big enough to encompass the star, select "Calculated Guiding Corrections" and click GO. Seeing and magnitude estimates will appear in the Guider window.

6. To put your target in the aperture hole, in the Image Display window, click on the button "Center star". A Star symbol will appear: center on your star and click on it. This will drag the target into the hole.

7. To guide, in the Guider window, select "Calculate guiding corrections and guide on guiding zone", and click "GO".

8. After your observations, stop the guiding by clicking on the "Stop" button.

9. Each object file has a FITS keyword, CMMTSEQ, that shows the progress of your observations, in particular, which Stokes parameter was being measured, and which exposure for that Stokes parameter was being taken.
   For example: CMMTSEQ = 'Q exposure 3, sequence 1 of 1'

10. At the end of the night, after all your scientific targets and before the OA fills the dewar, take another series of calibrations.

11. At the **END OF THE NIGHT**, click on the "End of night" button, to put the instrument to sleep. You do not have to exit the session.

USEFUL INFORMATION

- **Printers:** The summit printer is called “sps”; the printer at Hale Pohaku is called “hpps”. Use the command “lpr -Psps” for example.
- **Log Sheets:** PostScript files for the log sheets are available in your observer account or on the ESPaDOnS webpage. Print with the command `lpr -Psps`.
- If you need to go in the **Coudé Room**, please use booties to cover your shoes.
- **EEV1** CCD:
  - 2048 px × 4608 px × 13.5μm
  - Xslow readout speed: gain=0.77e-/ADUs Noise=3.30 e- Readout time 90 sec
  - Slow readout speed: gain=1.18e-/ADU Noise=3.4 e- Readout time 67sec
  - Normal readout speed: gain=1.32e-/ADU Noise=5.2 e- Readout time 40sec
  - Fast readout speed: gain=1.64e-/ADU Noise=11.7 e- Readout time 25sec
  - Saturation ≈ 60 000 in all modes except Fast readout mode (saturation ≈ 40 000), not recommended to go over ≈ 40 000 ADUs
- **How to send coordinates electronically to the OA:**

  You can prepare a list of targets and coordinates, and send it by email to your Observing Assistant; this can speed up the observations. The file should have one line per target, with the following format where fields may be separated by either spaces or tabs:

  n RA Dec Eq “Name“ pmRa pmDec

  n is a number to identify the target. Can be anything.

  RA and Dec should have colons, as in 12:34:56.78. If there are negative Dec’s, the minus sign must be snug against the numbers. Spaces are bad.

  Eq can be a number for equinox, or “appa” for apparent. The number can be integer if desired.

  name is the name’s target. Must be in quotes if there are spaces. It’s safer to put it all in quotes.

  pmRa pmDec are optional proper motion values.

- **SkyProbe and attenuation measurements**

  The SkyProbe camera is a small (500 x 700 pixels) SBIG camera with a 50 mm lens, which observes a large field of view (roughly 5 x 7 degrees) to a depth around 12 magnitudes. The camera is roughly co-aligned with the telescope, and takes an image every 60 seconds. It provides a measurement of the atmospheric attenuation at a frequency of roughly one sample per minute. The measurement is valid for the field at which the CFHT 3.6m telescope is currently pointing, and is stable to 0.3%. Note that telescope slews cause artificial jumps in the attenuation plots. Please see the page `http://www.cfht.hawaii.edu/Instruments/Skyprobe/` for more information and real-time plots.

- **Data backup**

  CFHT does not permit standard remote access into CFHT (rlogin, rsh, telnet, ftp (other than anonymous), sftp are not accepted; we do have "scp" which is distributed with the SSH package). Thus, you can't depend on retrieving data once you have left CFHT even if it was possible to save your data on disk. You are responsible for backing up data to tape.

  Note that there are no CFHT restrictions from CFHT out to the Internet.

USEFUL RESOURCES

- ESPaDOnS Web page: `www.cfht.hawaii.edu/Instruments/Spectroscopy/Espadons/`
- NOAO Spectral Atlas Central `www.noao.edu/kpno/specatlas/`
- EEV1 CCD `www.cfht.hawaii.edu/Instruments/Detectors/CCDs/EEV1/`
- Sky Calendars `www.cfht.hawaii.edu/Temporal/SkyCalendars/`
- Weather `www.cfht.hawaii.edu/ObsInfo/Weather/`
- Summit view of CFHT `www.cfht.hawaii.edu/webcam/`
- Summit view of Gemini `www.cfht.hawaii.edu/misc/summitview.html`
- Mauna Kea forecast `mkwc.ifa.hawaii.edu/forecast/mko/`
- Other tools and Information for Observers `www.cfht.hawaii.edu/ObsInfo/`

DATA REDUCTION
SETUP FOR ALL MODES
Donati script

1. **Setup machine, display, directories, etc.**

   - Use the machine akua **only**: `rlogin akua`
   - Setup your display: `d onohi` (for example)
   - The script only works with the tcs Shell: `tcsh`
   - Setup paths: `source .cshrc`
   - Create a raw direction if needed: `mkdir raw`
   - Create one subdirectory per night in the directory raw: `mkdir raw/11Jul05`
   - Run the script, read the instructions: `libre_esprit`
   - Run the script for a given night: `libre_esprit 11Jul05`

2. **Subdirectories structure**
   Libre-ESpRIT works with 4 directories that have to be in the user's home directory:

   - *raw*: for the raw data (FITS files)
   - *spec*: for the results of the data reduction (reduced spectra)
   - *logs*: for the log file of each reduction
   - *reds*: for some of the output files of Libre-ESpRIT

3. **Content of each subdirectory**

   - The *raw* directory should contain one subdirectory per night. Each subdirectory contains the raw data, copied by hand from `/data/noeau/espadons/raw/[NIGHT]/`.

   - The *spec* directory should contain one subdirectory per night. Each subdirectory contains the Master Flat Field, the input and output files for the tasks *geometry* and *wcal*, and subdirectories for the reduced spectra (named for example *pol_Normal*). The reduced data consists of *.s files (for the spectra) and *.out files (for the output of the data reduction for that particular set of files).

   - The *reds* directory should contain one subdirectory per night. Each subdirectory contains lists of files used for the data reduction.

   - The *logs* directory contains one file per night.

DATA REDUCTION
Libre-ESpRIT

ESPaDOnS records 40 curved orders with a tilted slit (it's not parallel to lines). The curvature of the orders and the tilt of the slit have to be taken into account (fit) by the software. Libre-ESpRIT will reduce the data obtained 3 modes: spectroscopy star only, spectroscopy star + sky, polarimetry.

1. **Selection of exposures**
   Libre-EpRIT only needs 1 bias, 1 Thorium exposure, and 1 Fabry-Perot exposure. If there are more than one, the software will pick the middle one of a series, without doing any check for saturation, noise, etc. Libre-ESpRIT can take up to 100 flats but not more. The best bias (one that does not show noise) should be manually selected. Flats should be checked for saturation. Unwanted exposures should be moved to another directory so Libre-ESpRIT does not try to use them.

2. **Calibrations (geometric calibration, wavelength calibration)**
   Libre-ESpRIT starts by performing calibrations:
   - The first step consists in performing a **geometrical analysis** from a sequence of calibration exposures. The position and shape of each order is derived from a mean flat field image. The shape and orientation of the slit is fit using a Fabry-Perot exposure. This step uses a routine called **geometry**.
   - The second step of the calibrations consists in finding the details of the **wavelength-to-pixel relationship** along and across each spectral order, using a comparison frame (Thorium). This step uses a routine called **wcal**.

3. **Data extraction**
   The data extraction is performed using the routines **extract** (spectroscopy star only, polarimetry if desired), **extract_sky** (spectroscopy star + sky), **polar** (polarimetry). This step performs an optimal extraction of each object spectrum, using the geometrical information found in the previous step. Polarimetric spectra processed with Libre-ESpRIT include not only the flux and polarization information, but also two check spectra N and N2 (to help identifying spurious polarization signatures) and error bars at each wavelength point in the spectrum. The wavelength correction also uses telluric lines in the scientific spectra.

4. **Reduced data format**
   In **spectroscopic mode star only**, the reduced spectra looks like:

```
***Reduced spectrum of 'test object'
 177362 2
  394.2864  1.6939e-01  5.3358e-02
  394.2889  3.3149e-01  5.8227e-02
  394.2914  2.8727e-01  5.6242e-02
  394.2939  2.8232e-01  5.5319e-02
```

   The number 177362 indicates the number of lines in this file. The first column has the wavelength in nanometers, followed by columns for the flux and the error bar on the flux.

   In **spectroscopic mode star + sky**, the reduced spectra has 7 columns: wavelength, star spectra (sky subtracted), star + sky spectra, sky spectra, and the error bars for each column.

   In **polarimetric mode**, the reduced spectra has 6 columns: wavelength, spectra (intensity I), polarization (Stokes Q, U, or V), 2 check spectra, and the error bar.

5. **Units of the polarization column**
   The units of the polarization column in the reduced spectra depend on the use or not of the option -c:

   - **Normally and for the vast majority of cases, the -c option is not used.** In that case, the column gives the **UN-NORMALIZED Stokes parameter** (for example, V/I * I, where I is the intensity). Therefore, it can go from -I to I:
     - the un-normalized Stokes parameter will be between -1 and 1 if $I < 1$ (i.e. for the continuum or absorption lines, WITH the continuum normalized to 1 of course)
     - the un-normalized Stokes parameter will higher than 1 in EMISSION lines (where the intensity is higher than 1)
   - When the -c option is used (to get the continuum polarization), the column gives the NORMALIZED Stokes parameter (for example, V/I), and will be between -1 and 1 (so, 0.10 is 10% polarization)

For more information, please consult the webpage

`http://www.cfht.hawaii.edu/Instruments/Spectroscopy/Espadons/Espadons_esprit.html`

PLOTTING THE RESULTS USING SuperMongo

The result files produced by Libre-ESpRIT (e.g.: mwc1055_q_01.s) can be plotted and printed using SuperMongo.

To start SuperMongo, simply type: `sm`. To load the file with the SuperMongo macros prepared to plot ESPaDOnS data, type `load2 Espadons_v8.sm`. A list of available macros will appear. Once the file is loaded, you can get that list again by typing `helpme`. You may type `!pwd` to see in which directory you are, `cd` to change directory, and `ls` to see the files in the current directory.

Macros generally come in 3 flavors: only data points are plotted, data points are plotted and connected to each other, data points are plotted with the error bars.

The most useful macros are:

- spectroscopic mode "star only": `spectra`
- spectroscopic mode "star + sky": `star`, `starsky`, `sky`
- polarimetric mode: `polarIP_NORM` and `polarIP_UN` (Intensity and Stokes parameter)
- polarimetric mode: `check_NORM`, `check_UN` (to check for spurious polarimetric signals).

To save a plot in a PostScript file, you have to first "open" the PostScript device, run the macro, then close the device by re-opening the screen device:

```
device postfile NameOfGraph.ps
polarIconn
device x11
```

You may then print the PS file at the summit with a command like `lpr -Psps NameOfGraph.ps`.

NM - December 20, 2005