

relative image motion between the two images of a given couple is then directly related to the telescope focus motion via a simple calibration coefficient.

The steps used for focussing are now the following:

- 1) Insert the focussing mask in the beam.
- 2) Take an image with a long enough exposure time to show several stars in the field (a typical 60 second exposure is generally enough on any field even at high galactic latitudes).
- 3) Select the "cursor/region" options in the X-image display to be able to select a few stars (3-4 minimum) with the cursor.
- 4) Write the positions to the default file with the "write" X-image option.
- 5) Select "accept" in the CAF (Computer Aided Focus) form if the default image name and position file name are acceptable.

The routine will then compute the mean offset between the star images and their double and tell you the differential focus motion to apply in telescope encoder units. In the current configuration this last step takes 1 minute due to the need to create an IRAF format image file in order to use IRAF tasks in the background. This will be shortened for the next run to a few seconds by working directly on the FITS image created by the data acquisition computer.

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Scanning Modes on PALILA

PALILA is a focal reducer type spectrograph which uses scanning Fabry-Pérot etalons to explore a small wavelength range (4 to 90Å depending on the present etalon used) in the roughly 5 x 5 arcminute field.

We currently use three etalons manufactured by Queensgate Instruments Ltd. The distance between the plates is scanned by applying appropriate voltages to piezo-electric stacks. This in turn changes the wavelengths λ transmitted by the etalon. For a ray of angle of incidence i on the Fabry-Pérot their values are given by the (deceptively) simple equation:

$$2 n e \cos (i) = p \lambda (i)$$

where n is the air index of refraction and p any positive integer. Of course, in practice, an interference filter is used to select a wavelength range, and then sets a particular value of p .

In actual use, the voltages are put by sending a binary control value (BCV) to the etalons CS 100 controller, which can vary between -2048 and +2047. This changes e according to an accurately linear relationship.

Three different scanning modes can now be used.

(1) "Manual" Scanning

The etalon is put at the required BCV, and an exposure

window is opened. This is particularly useful during set-up procedures e.g. to measure the position of the rings center, and especially to obtain the value of the scanning constant C of the particular etalon used: At a wavelength λ_0 (given by a discharge lamp) a full interference order scan is obtained for a BCV change Δ_0 . $C = \lambda_0 / \Delta_0$ is nearly independent of wavelength, and can thus be used to compute the required BCV to scan an interference order at any wavelength λ .

(2) Full Automatic Scanning

Three parameters are entered: the scanning constant C , the central wavelength λ and the number of equidistant steps n . n identical exposures are then automatically made. A full interference order is scanned, through a total BCV scan of λ/C , centered on $BCV=0$. Two slightly different modes can be selected, a full scanning with overlap (i.e. the last channel is in phase with the first channel), or without overlap. Possible variations of atmospheric transmission (and of the strengths of the night sky emission lines) during the whole sequence are quite troublesome. To minimize their effect, the channels are scanned in an interlaced sequence.

This mode is generally used with high interference order etalons, like the CFHT $p=1162$ at H α , with a free spectral range (or full scanning range) of only 5.6Å.

(3) Partial Automatic Scanning

With a low order etalon, like the CFHT $p=72$ at H α , the free spectral range is so large (91Å) that it becomes more efficient to scan only a limited range, centered on the radial velocity of the galaxy studied. From a preliminary calibration with a discharge lamp, one enters the following parameters: λ_c the calibration wavelength and B_c the BCV value which puts λ_c at the center of the field. For observing, one enters the start wavelength λ_s , the end wavelength λ_e and the number of equidistant steps n .

The $(\lambda_s - \lambda_e)$ interval is then scanned with a similar interlaced sequence. To put a wavelength λ at the center of the field, the required BCV value is:

$$B = B_c + 1/C \{ \lambda * INT (p_c \lambda_c / \lambda) - p_c \lambda_c \} \text{ (modulo } \lambda/C \text{)} \quad (2)$$

A number of different algorithms have been developed, with the help (and friendly pressure) of B. Tully from the University of Hawaii, to avoid occasional large jumps in BCVs when possible (i.e. when the total wavelength range to scan is not too large).

In principle it is possible to calibrate this scanning procedure at any wavelength λ_c . However, there are small phase effects, due to chromatic variations of the plate separation e in such multi-layer coated etalons. It is thus highly recommended to use a calibration wavelength close to that of the object.

Following the use of a CCD detector early 1988, these three scanning modes have been put into use, through the HP9000 based DAIC system, in March 1990.

Further details on the operation of the system can be found in the appropriate User's Manual ("Scanning Fabry-Perot Spectrography with the PALILA focal reducer").

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