ADAS603: Zeeman multiplet line fitting

The code fits multi-Gaussian line profiles, a background and optionally one detailed Zeeman/Paschen-Back feature primitive to an observed spectral segment. It uses a maximum likelihood method together with statistical analysis to calculate the integrated counts under the features along with their estimated standard errors and 95% confidence limits of the fitting parameters. The Zeeman/Paschen-Back feature is resolved into the separate π and σ component integrated counts. The multi-Gaussian fitting part of the code is due to Jim Lang and David Brooks and operates in a similar manner to ADAS602. The Zeeman/Paschen-Back code (originally called 'xPaschen') is due to John Hey and Manfred Korten and has been integrated by Ricky Martin as an ADAS code with an IDL user interface. It has been designed to interface easily with SOHO satellite, JET Joint Undertaking and KFA-Juelich data organisations although a simple interface is also provided. A stand alone, IDL interfaced, version of xPaschen may be requested from the originating authors John Hey and Manfred Korten.

Background theory:

In the fitting of observed spectra for diagnostic analysis, it is generally the relative intensities of a set of connected spectrum lines which allow inference of underlying plasma parameters. From a spectral analysis point of view, connected spectrum lines which are close together in a fairly small wavelength segment are least influenced by calibration errors and so most useful. Such connected spectrum lines are properly called *feature primitives*, *features* or *super-features* depending upon whether the connections are via pure branching ratios, via an excited level population balance or via an ionisation balance. Ionisation balance in this context may include transport and /or transient influences. The generic name *feature* is used for all three types of connection. In spectral measurements on real plasmas, additional unconnected spectrum lines, called *ordinary lines*, from different ions or elements may lie in the observed spectral segment possibly overlaying the connected group. Special spectral feature fitting distinguishes the ordinary lines and background, and a special feature and conducts a non-linear search for the parameters of both simultaneously.

The ordinary lines and background: The representation is as a constant, linear or quadratic background together with several Gaussian shaped lines, that is

$$I_k^O = b_0 + b_1 x_k + b_2 x_k^2 + \sum_{i=1}^{L} h_i \exp[-((x_k - xo_i)/w_i)^2] \qquad 7.3.1$$

L is the number of ordinary lines in the spectrum to be fitted with xo_i the pixel position of the centre of the line i and w_i is its half width.

The Zeeman/Paschen-Back special feature: The name is used here to describe the connected set of spectrum lines from magnetic field perturbation of multiplet components, that is the set of lines $\lambda_{\gamma LSJM-\gamma L'S'J'M'}$ for specified $LS \rightarrow L'S'$ occurring in the spectrum of an ion X^{+z}. These lines separate into those of linear, left and right circular polarisation depending on whether $M = M', M+1, M-1$ respectively. The emissivities of the lines per steradian are given by

$$\begin{aligned}
&\frac{1}{4\pi}\sin^2\theta\, A_{\gamma LSJM\rightarrow\gamma L'S'J'M'} N^{+z}_{\gamma LSJM} && \text{for } M = M' \\
&\frac{1}{8\pi}(1+\cos^2\theta)\, A_{\gamma LSJM\rightarrow\gamma L'S'J'M'} N^{+z}_{\gamma LSJM} && \text{for } M = M'+1 \qquad 7.3.2 \\
&\frac{1}{8\pi}(1+\cos^2\theta)\, A_{\gamma LSJM\rightarrow\gamma L'S'J'M'} N^{+z}_{\gamma LSJM} && \text{for } M = M'-1
\end{aligned}$$

where θ is the angle which the viewing line-of-sight makes with the magmetic field direction and $N^{+z}_{\gamma LSJM}$ is the population of the upper state of the transition in a plasma and A is the

Einstein coefficient. If the populations of the sub-states of the same level may be assumed statistical then

$$N^{+z}_{\gamma LSJM} = \frac{1}{(2J+1)} N^{+z}_{\gamma LSJ} \qquad 7.3.3$$

For light ions, if the levels of the same term may also be assumed relatively statistically populated then

$$N^{+z}_{\gamma LSJ} = \frac{1}{(2L+1)(2S+1)} N^{+z}_{\gamma LS} \qquad 7.3.4$$

and the relative intensities of the whole set of Zeeman/Paschen-Back components of the multiplet are independent of the population of the upper term. In the present terminology, they constitute a feature primitive.

The line-of-sight intensity of a Zeeman/Paschen-Back component may be written as

$$\frac{I_{\gamma LSJM \to \gamma L'S'J'M'}}{\mathcal{N}^{+z}_{\gamma LS}} = \mathrm{E}_{\gamma LSJM \to \gamma L'S'J'M'}(\theta, B) \qquad 7.3.5$$

where $\mathrm{E}_{\gamma LSJM \to \gamma L'S'J'M'}(\theta, B)$ is a function of the two parameters θ and B with B the magnetic induction.

Evidently the line of sight intensity is a function of the three parameters θ, B and $\mathcal{N}^{+z}_{\gamma LS}$ where $\mathcal{N}^{+z}_{\gamma LS}$ is the line-of-sight integral of $N^{+z}_{\gamma LS}$

Introduce a common spectral profile for each line of the Zeeman/Paschen-Back multiplet, indexed by c of natural wavelength, $\lambda_c(B)$, of the form $\psi_{\lambda - \lambda_c(B) - \Delta\lambda}(T_i, b)$. In general T_i is the ion temperature and b is a second parameter of the profile shape. $\Delta\lambda$ is a further parameter which is displacement of the centroid of the Zeeman/Paschen-Back multiplet from its exact theoretical value.

Thus the theoretical count rate at detector pixel position x_k is

$$I^F_k = \mathcal{N}^{+z}_{\gamma LS} \sum_c \mathrm{E}_c(\theta, B) \psi_{\lambda_k - \lambda_c(B) - \Delta\lambda}(T_i, b) \qquad 7.3.6$$

where E denotes a generic emissivity functional from the equations above.

Calculating the wavelengths and emissivities:

We consider the magnetic field perturbation of the field free isolated ion exact level eigenenergies $E_{\gamma LSJ}$. With the magnetic induction $\underline{B}$ direction chosen as the z-axis of quantisation, the perturbing term in the Hamiltonian

$$\underline{\mu} \cdot \underline{B} = \frac{e\hbar}{m_e c} \sum_i (L^i_z + 2S^i_z) B = \frac{e\hbar B}{m_e c} (L_z + 2S_z) \qquad 7.3.7$$

is commutes with the J_z but not with J^2. This gives matrix elements of the Hamiltonian

$$E_{\gamma LSJ} \delta_{\gamma LSJ, \gamma LSJ'} + \frac{e\hbar B}{m_e c} [g_l M \delta_{J,J'} + (g_s - g_l) \langle \gamma LSJM | S_z | \gamma SLJ'M \rangle] \qquad 7.3.8$$

where we have introduced the mass and relativistically corrected Lande factors

$g_l = 1 - m_e / \mathcal{M}$ and $g_s = 2 + \frac{\alpha}{\pi} - 5.946 \frac{\alpha^2}{\pi^2}$ where $\mathcal{M}$ is the nuclear mass. Also, in terms of Wigner and Clebsch-Gordon coefficients

$$\langle \gamma LSJM | S_z | \gamma SLJ'M \rangle = (-1)^{S+J'-1-L} \sqrt{S(S+1)(2S+1)(2J'+1)} \; W(SS, JJ'; 1L) C^{J'1J}_{M0M} \qquad 7.3.9$$

Thus the Hamiltonian matrix partitions into blocks of specified M and is tridiagonal. The eigenvalues and eigenvectors are obtained by the usual QR transformations.

Profile functions: Four profile forms are used to represent the combined influence of thermal Doppler broadening in the plasma and the instrumental profile, namely, single Doppler, Doppler/Lorentz, Voigt and double Doppler. For each of these the second parameter b is fixed relative to Doppler broadening width from the ion temperature T_i, The specifications are as follow:

The fitting algorithms: The observed data are fitted to the equation

$$I_k = I_k^O + I_k^F \qquad 7.3.10$$

where I_k is the observed count rate at a particular detector pixel position x_k and I_k^O, I_k^F represent the ordinary line + background and the special feature parts respectively.

Statistical variation in I_k is assumed to have the normal form. With variance proportional to the mean value of I_k. Hence

$$\sigma_k^2 = Var\, I_k = \sigma^2 E(I_k) \qquad k = 1,2,\ldots,P \qquad 7.3.11$$

where σ^2 is an unknown constant of proportionality, P is the number of pixel positions and E denotes the expected value. Under these conditions, the likelihood function can be formed and values which maximise it also maximise its (natural) logarithm. Thus to maximise the $\log$ likelihood to estimate the N variables $b_0, b_1, b_2, h_i xo_i, w_i$ the need is to minimise the function

$$\sum_{k=1}^{P} \left[\frac{I_k}{\sigma_k} - \frac{1}{\sigma_k}(I_k^O + I_k^F) \right]^2 \qquad 7.3.12$$

The σ_k^2 are unknown. Assuming however that the counts per sampling interval follow the Poisson distribution, the σ_k^2 are equal to the true unknown mean count per sampling interval divided by the number of sampling intervals. If the unknown mean count rate is estimated by I_k, then an estimate of σ_k^2 follows, namely I_k divided by the number of intervals where the number of intervals is the dwell time in seconds. A standard numerical routine will find the unconstrained minimum of the function 7.4.4, i.e. minimise

$$F(x) = \sum_{i=1}^{P} [f_i(x)]^2 \qquad 7.3.13$$

The functions $f_i(x)$ (the residuals), their first derivatives and a starting point must be supplied. The starting point was obtained from the observed spectrum by indicating the number of lines to be fitted and estimating their peak positions and full-width half-maxima. The background was also obtained from the spectrum and estimates of b_0, b_1, b_2 made. Once estimates of $b_0, b_1, \ldots.$ (denoted by $\hat{b}_0, \hat{b}_1, \ldots.$) have been found a second routine is used to find the diagonal elements of the variance-covariance matrix C. This routine depends on the use of the standard result of maximum likelihood theory which states that the variance-covariance matrix of the estimates is approximately given by the negative of the inverse of the expected value of the matrix of second derivatives of the logarithm of the likelihood. In the routine it is assumed that the Hessian (i.e. matrix of second partial derivatives) of $F(x)$ at the solution can be approximated adequately by $2J^TJ$ where J is the Jacobian (i.e. matrix of first partial derivatives) of $F(x)$ at the solution. C is then given by

$$C = \hat{\sigma}^2 (J^T J)^{-1} \qquad J^T J \text{ non-singular} \qquad 7.3.14$$

where $\hat{\sigma}^2$ is the estimated variance of the residual at the solution ($\hat{x} = \hat{b}_0, \hat{b}_1, \ldots.$) and is given by

$$\hat{\sigma}^2 = F(\hat{x}) / (P - N) \qquad 7.3.15$$

The square root of the diagonal elements of C give the estimated standard errors of the corresponding elements of $\hat{x}$. A 95% confidence interval for each of the elements of $\hat{x}$ is obtained using $\hat{x}_j \pm t_{P-N;97.5}(C_{jj})^{1/2}$ where $t_{P-N;97.5}$ denotes the upper 97.5% point of the Student's t distribution with $P - N$ degrees of freedom. Note that the approximation of the Hessian by $2J^T J$ is justified as follows: the Hessian matrix $G(x)$ is of the form

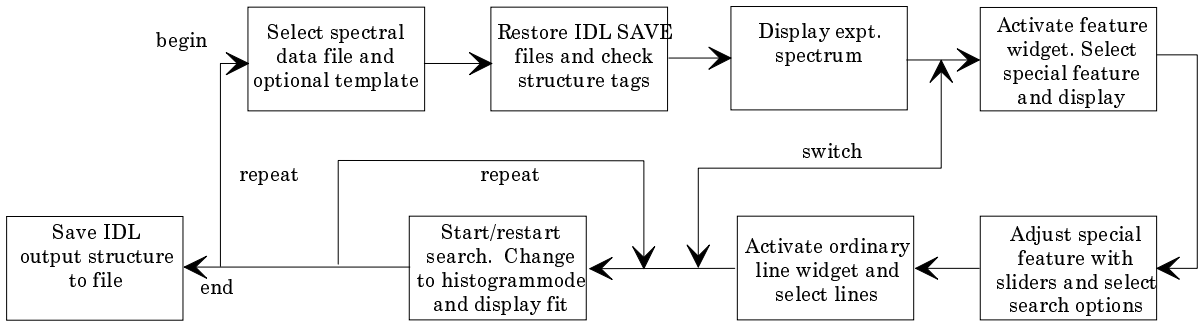
$$G(x) = 2[J^T(x)J(x) + \sum_{i=1}^{P} f_i(x)G_i(x)] \qquad 7.3.16$$

where $G_i(x)$ is the Hessian matrix of $F(x)$. In the neighbourhood of the solution $\|f(x)\|$ is often small compared to $\|J^T(x)J(x)\|$, for example when $f_i(x)$ represents the goodness of fit of a non-linear model to observed data. In such cases $2J^T(x)J(x)$ may be an adequate approximation to $G(x)$. This avoids the need to compute or approximate second derivatives of the $f_i(x)$.

Program steps:

These are summarised in the figure below.

Figure 7.3



Interactive parameter comments:

Move to the directory in which you wish any ADAS created files to appear. These include the output text file produced after executing any ADAS program (*paper.txt* is the default) and the graphic file if saved (e.g. *graph.ps* if a postscript file)

The **file selection window** has the appearance shown below

1. The form of the primary input spectral data is selected at a). Input data sets are expected to be in the form of IDL 'SAVE' files. Forms allowed are as follow:

   a) The form *Standard* comprises a single array and a 'header' defined as

   spectrum : *dblarr()*

   header : '' or *structure (ie.={a:a, b:b,...})*

   spectrum contains the spectral counts as a function of pixel position. The array length must be <=1024. The array may be two-dimensional in which case the first index is the pixel number in the dispersion direction and the

second the pixel number in the spatial (or other) direction. This latter case allows the cycling option described in section 5.2.

header is an optional string of the user's choice or may be a structure

b) The form *Processed* is that of the output structure from ADAS603 itself. This form allows re-entry of output data for re-analysis. The input file contains a structure *lstr* defined as:

lstr.b0 :	*0.0*	*lstr.eseb0:*	*0.0*
lstr.eclb0 :	*0.0*	*lstr.b1:*	*0.0*
lstr.eseb1 :	*0.0*	*lstr.eclb1:*	*0.0*
lstr.b2 :	*0.0*	*lstr.eseb2:*	*0.0*
lstr.eclb2 :	*0.0*	*lstr.w:*	*dblarr(10)*
lstr.esew1 :	*0.0*	*lstr.eclw1*	*0.0*
lstr.xo :	*dblarr(10)*	*lstr.esexo:*	*dblarr(10)*
lstr.eclxo :	*dblarr(10)*	*lstr.h:*	*dblarr(10)*
lstr.eseh :	*dblarr(10)*	*lstr.eclh:*	*dblarr(10)*
lstr.esewv :	*dblarr(10)*	*lstr.eclwv:*	*dblarr(10)*
lstr.flux :	*dblarr(10)*	*lstr.esef:*	*dblarr(10)*
lstr.eclf :	*dblarr(10)*	*lstr.getfit:*	*intarr(6)*
lstr.exptime :	*0.0*	*lstr.info:*	*0*
lstr.header :	*‘’*	*lstr.xmin:*	*0*
lstr.xmax :	*0*	*lstr.x:*	*indgen()*
lstr.y :	*dblarr()*	*lstr.ya:*	*dblarr()*
lstr.nsize :	*0.0*	*lstr.numline:*	*0*
lstr.nfxl :	*0*	*lstr.bchl:*	*0.0*
lstr.bchr :	*0.0*	*lstr.lineid:*	*strarr(10)*
lstr.getxp :	*intarr(6)*	*lstr.lineidxp:*	*‘’*
lstr.bfxp :	*0.0*	*lstr.esebfxp :*	*0.0*
lstr.eclbfxp :	*0.0*	*lstr.tixp:*	*0.0*
lstr.esetixp :	*0.0*	*lstr.ecltixp :*	*0.0*
lstr.iwxp :	*0.0*	*lstr.eseiwxp :*	*0.0*
lstr.ecliwxp :	*0.0*	*lstr.angxp:*	*0.0*

with the meaning of the variables as follow:

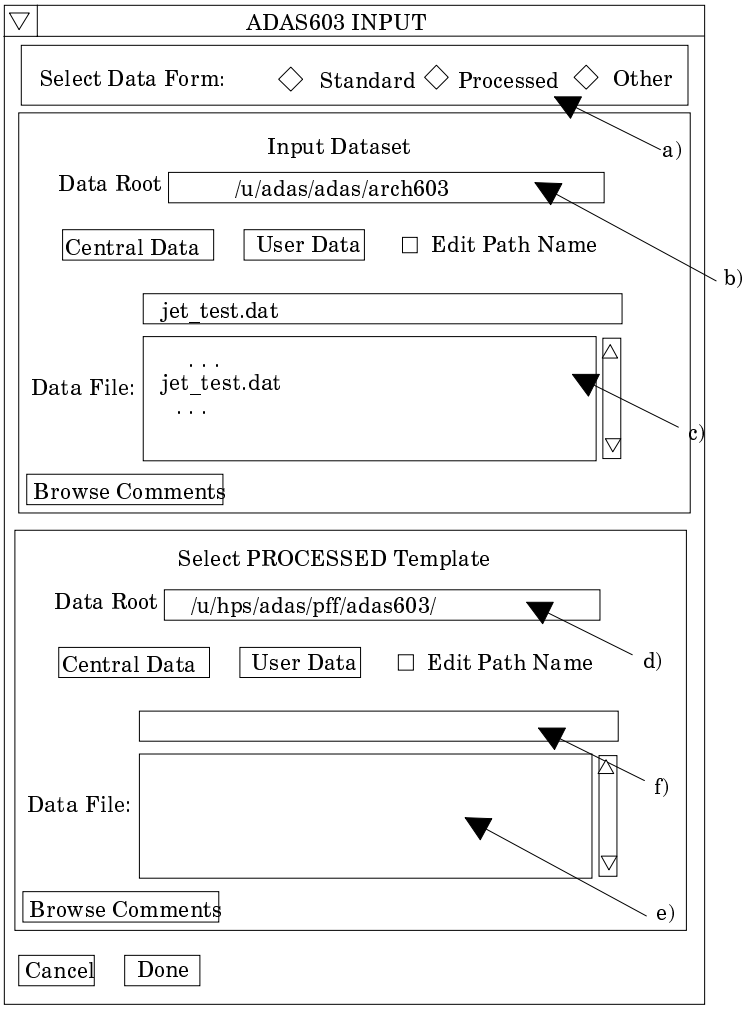
b0	fitted constant part of the background
eseb0	estimated standard error in *b0*
eclb0	estimated 95% confidence limit in *b0*
b1	fitted linear part of the background
eseb1	estimated standard error in *b1*
eclb1	estimated 95% confidence limit in *b1*
b2	fitted quadratic part of the background
eseb2	estimated standard error in *b2*
eclb2	estimated 95% confidence limit in *b2*
w	fitted line widths
esewl	estimated standard error in *w* (fixed)
eclwl	estimated 95% confidence limit in *w* (fixed)
xo	fitted line centroid positions
esexo	estimated standard error in *x0*
eclxo	estimated 95% confidence limit in *x0*

h	fitted line heights at centroid
eseh	estimated standard error in *h*
eclh	estimated 95% confidence limit in *h*
esewv	estimated standard error in *w* (variable)
eclwv	estimated 95% confidence limit in *w* (variable)
flux	fitted line flux (counts under profile)
esef	estimated standard error in *flux*
eclf	estimated 95% confidence limit in *flux*
getfit	options selected (see code)
exptime	the exposure time (1.0 if expval not set)
info	error from MINPACK routine (see XXDER1)
header	comment
xmin	minimum pixel for fitting range
xmax	maximum pixel for fitting range
x	pixel values
y	spectral data
ya	fit to data
nsize	spectral range width
numline	number of fitted lines
nfxl	number of fitted lines with fixed positions
bchl	initial estimate of background
bchr	inistial estimate of background
lineid	preliminary line identification labels
getxp	options selcted for xPaschen (see code)
lineidxp	xPaschen multiplet name from list
bfxp	fitted magnetic field strength
esebfxp	estimated standard error in *bfxp*
eclbfxp	estimated 95% confidence limit in *bfxp*
tixp:	fitted ion temperature (eV)
esetixp	estimated standard error in *tixp*
ecltixp	estimated 95% confidence limit in *tixp*
iwxp	fitted instrumental width (A).
eseiwxp	estimated standard error in *iwxp*
ecliwxp	estimated 95% confidence limit in *iwxp*
angxp:	specified observation angle

c) The form *Other* is not yet implemented and we are open to suggestions for it (eg. an ascii tabulated version of *lstr* as *spectrum/header*?)

2. Data root b) shows the full pathway to the appropriate data sub-directories. Click the *Central Data* button to insert the default central ADAS pathway to */../adas/adas/arch603*. Note that there are only some sample data in this sub-directory (viz. a standard data set '*...clean*' and a processed data set '*fit....*') as there is

no formal central ADAS data of archive type. Click the *User Data* button to insert the pathway to your own archived data for ADAS603.



3. The Data root can be edited directly. Click the *Edit Path Name* button first to permit editing. Available sub-directories are shown in the large file display window b). Scroll bars appear if the number of entries exceed the file display window size.

4. Click on a name to select it. The selected name appears in the smaller selection window c) above the file display window. Then its sub-directories in turn are displayed in the file display window. Ultimately the individual data-files are presented for selection.

5. Clicking on the *Browse Comments* button displays the information header associated with the selected data-set.

6. A second data set may be selected at d), e) and f). Such a data set must be in the form of a processed output data from ADAS603. Its purpose is to provide initial selection values for analysing the new data set. This facility is important for repetitive analysis of data from the same spectral region where the same set of lines is being picked out. Note that the default pathway is to the */.../adas/pass* directory in this case. Note also that if a processed file is selected **it will be used** to fit the new data.

7. Once a primary data file is selected, the buttons at the bottom of the main window become active.

8. Clicking the *Done* button moves you forward to the next window. Clicking the *Cancel* button takes you back to the previous window

The **processing options window** has the appearance shown below

9. The spectrum (counts Vs pixel number or wavelength) is displayed at a) and a title for the hard copy of the graph may be entered at b).

10. In general, one wishes to select only a segment of the spectrum for fitting and to adjust the y-scale. This is done by entering appropriate values at c) in the X-min, X-max, Y-min and Y-max boxes. Note that the entries have effect immediately so the graph can be adjusted rapidly to requirements. The x-scale of the graph may be pixels or wavelength. Select the required choice at c).

11. There are two parts to the theoretical spectrum, a conventional set of ordinary line features and a Zeeman/Paschen-Back feature primitive for an identified multiplet. The initial conditions for the two parts are set up in turn by activating the appropriate button at f). These are exclusive buttons and the associated sub-widget is displayed immediately below the buttons. The choice shown in the main figure is the xPaschen sub-widget. The conventional line fitting sub-widget is shown separately in the subsequent figure.

12. Specifying the xPaschen feature primitive:

a) The magnetic field effects have been calculated for a large number of multiplets and archived for selection. The available choice may be scrolled through in the multiplet selection widget at h) Click on a multiplet to select it. The selected multiplet is shown in the window at g).

b) At i), choose if the magnetic field is to be treated as a variable search parameter in the final spectrum fitting.

c) At j), choose if the ion temperature (eV) is to be treated as a variable search parameter in the final spectrum fitting. This parameter determines the thermal Doppler width of the components of the Zeeman/Paschen-Back multiplet.

d) At k), choose if the instrumental width (Angstrom) is to be treated as a variable search parameter in the final spectrum fitting. This parameter determines the Lorentzian width of the components of the Zeeman/Paschen-Back multiplet or contributes to the Voigt profile if a Doppler part is also present.

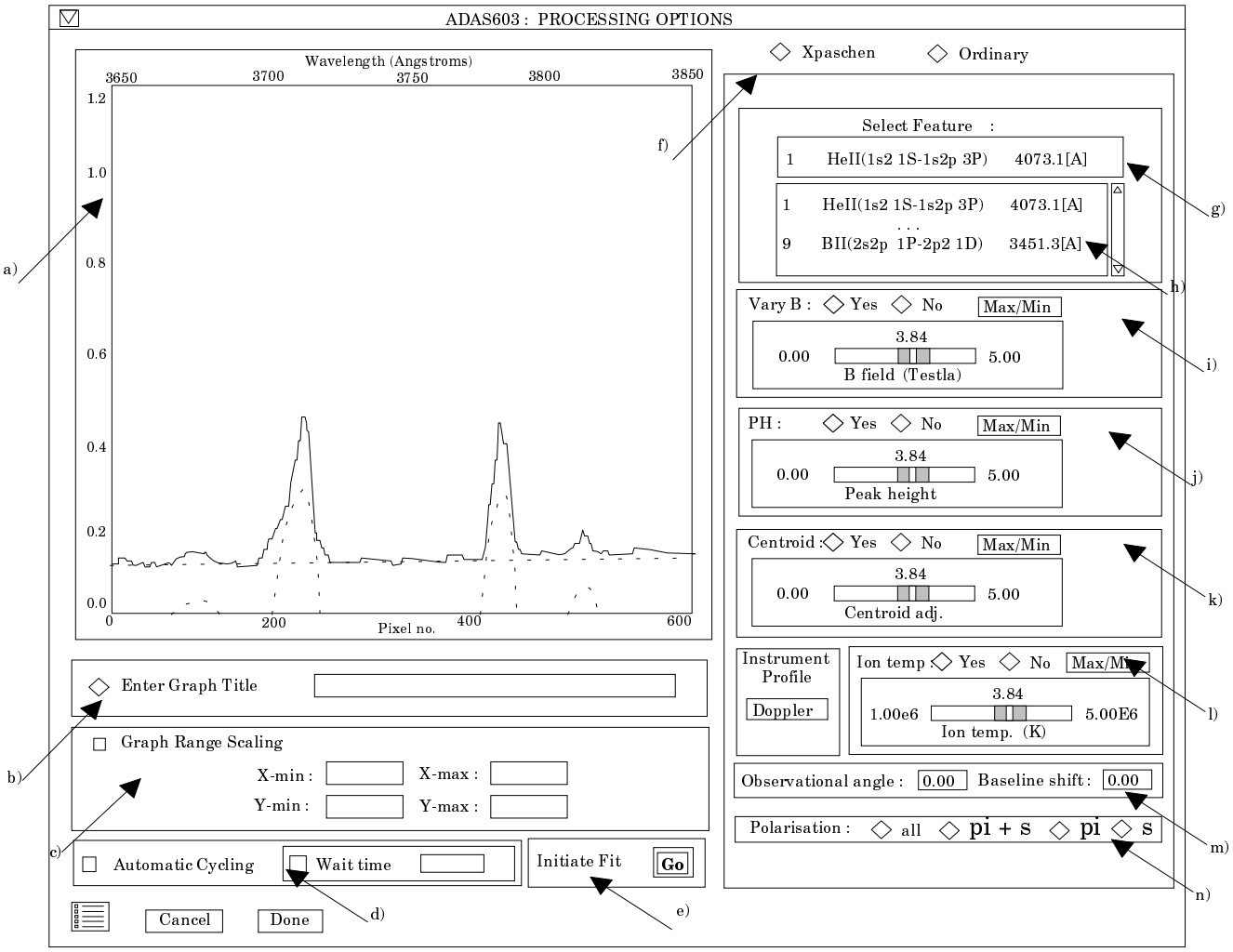
e) At l), choose if the multiplet centroid position (Angstrom) is to be treated as a variable search parameter in the final spectrum fitting.

f) At m), choose if the peak height for the multiple is to be treated as a variable search parameter in the final spectrum fitting.

g) At n), enter the observation angle (degrees) relative to the magnetic field direction. This is not a variable parameter.

h) In setting up the initial conditions, you can choose whether to display the whole theoretical multiplet or the component of a particular polarisation. Activate the appropriate button at o)

i) To start the setting up of the initial conditions of line positions and widths, click the large button at p). The displayed graph changes at this point to histogram mode. The mouse cursor position on the graph screen becomes meaningful and the left and right mouse buttons active. The theoretical multiplet is displayed in solid outline on the graph and the various sliders on the right at i), j), k), l), m) and n) become active. Adjust the sliders to set up your initial conditions.



13. Specifying ordinary features:

a) At g') select the number of line features you wish to fit to the spectrum. A maximum of ten is allowed. At h'), select the exposure time if the data are in counts. Omit this if they are in counts/sec.

b) It is possible to constrain the position of any of the line features in the fitting procedure. To do so, click the *Fix Line Positions* button at i') and enter the pixel positions at which you wish the features locked. It need not be all of the features.

c) A facility is also present to attach a name to a line feature which is helpful for known lines. These names are carried through to the output data structure. Click the *Identify Lines* button at j') and enter the names in the appropriate fields below.

d) Control of line widths is provided at k'). Select first of all whether you wish the line widths to be permitted to vary from the initial values during the fitting or not. If not is selected, a common line width must be entered. Then chose if you wish all the lines to have the same (but varying) width or if each line width can vary separately.

e) At l') select the form of background shape you wish to allow. Note that if you prepare the data with no background then the fitting to no background is allowed by deactivating the *Background Options* button

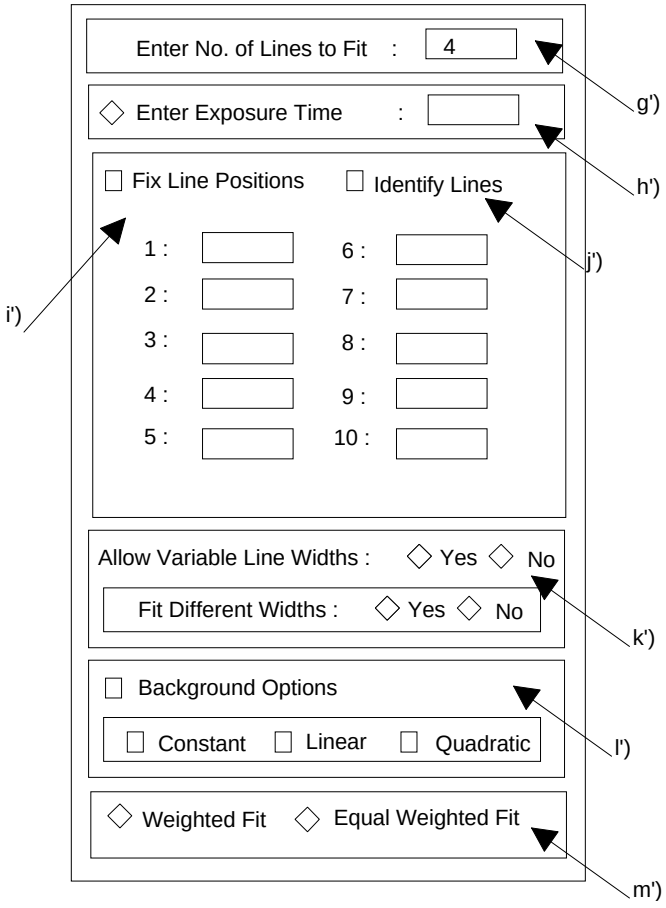
f) The way the experimental pixel count data is weighted during the fit optimisation may be chosen at m'). The *Weighted Fit* button weights a count with the square root of the count. The *Equal Weighted Fit* button imposes the same weight on the data at each pixel position.

g) To start the setting up of the initial conditions of line positions and widths, click the large button at n'). The displayed graph changes at this point to histogram mode. The mouse cursor position on the graph screen becomes meaningful and the left and right mouse buttons active. Advisory information of the action currently expected is given above the graph depending on the processing options chosen. In general one clicks to mark the peak, left half width position and right half width position for each feature in turn. A small square marks each selected position. Finally one marks the lowest and highest levels of the background. Clicking the right button can restart the process from the beginning. After completing the required marking, the fitting optimisation takes place.

14. If there are multiple spectra in the input data set, then the fitting procedure can be made to cycle automatically through each data set in turn using the initial settings from the first fit. Activate the *Automatic Cycling* button at d)

15. Finally click the button '*Go*' at e) to initiate the fitting process.

16. The figure is redisplayed with the fitted ordinary line Gaussians, the background and the Zeeman/Paschen-Back multiplet superimposed in dotted outline.

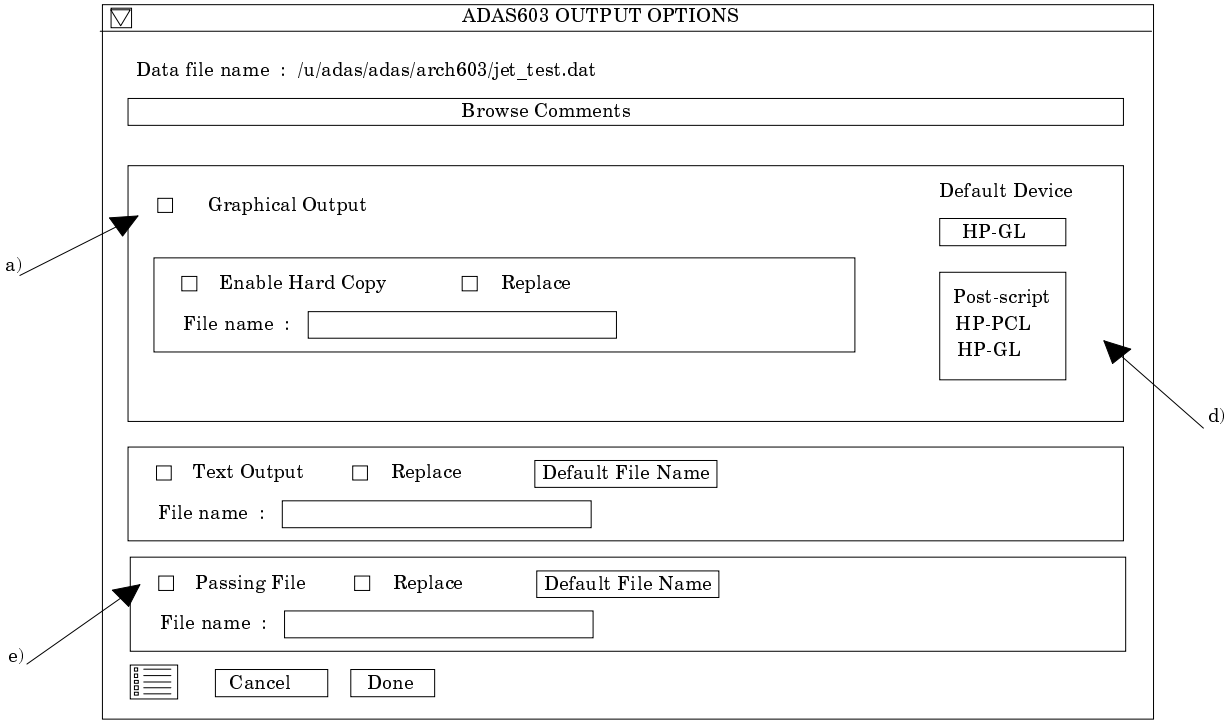


17. At the base of the window, the icon for *Exit to Menu* is present. This quits the program and returns you to the ADAS series 6 menu. Remember that *Done* takes you forward to the next screen while *Cancel* takes you back to the previous screen.

The **output options window** appearance is shown below

18. As in the previous window, the full pathway to the file being analysed is shown for information. Also the *Browse comments* button is available.

19. A graph hard copy is available by activation of the *Graphical Output* button a). The File name box then becomes editable. If the output graphic file already exists and the *Replace* button has not been activated, a 'pop-up' window issues a warning.



20. A choice of output graph plotting devices is given in the Device list window at d). Clicking on the required device selects it. It appears in the selection window above the Device list window.

21. The *Text Output* button activates writing to a text output file. The file name may be entered in the editable File name box when *Text Output* is on. The default file name 'paper.txt' may be set by pressing the button *Default file name*. A 'pop-up' window issues a warning if the file already exists and the *Replace* button has not been activated.

22. At e) output of the processing and analysis may be saved by clicking the *Passing File* button. The *Default file name* sends the output file to your */../adas/pass* directory as *adas603.pass.* Note that the output file is an IDL SAVE file structured in the manner described in section 5.1.1.2. Note that defaults are updated after each run.

23. At the base of the window, the icon for *Exit to Menu* is present. This quits the program and returns you to the ADAS series 6 menu. Remember that *Done* takes you forward to the next screen while *Cancel* takes you back to the previous screen.

Illustration

The example below shows the spectral interval of the BeIII (1s2s 3S – 1s2p ^{3}P) multiplet at 3721 A. The spectrum is taken by the KS3 visible spectrometer at JET observing the diveror region. The spectrum includes three weak lines to the long wavelength side of the multiplet which are treated as independent lines. A quadratic background is assumed.

Figure 7.03a

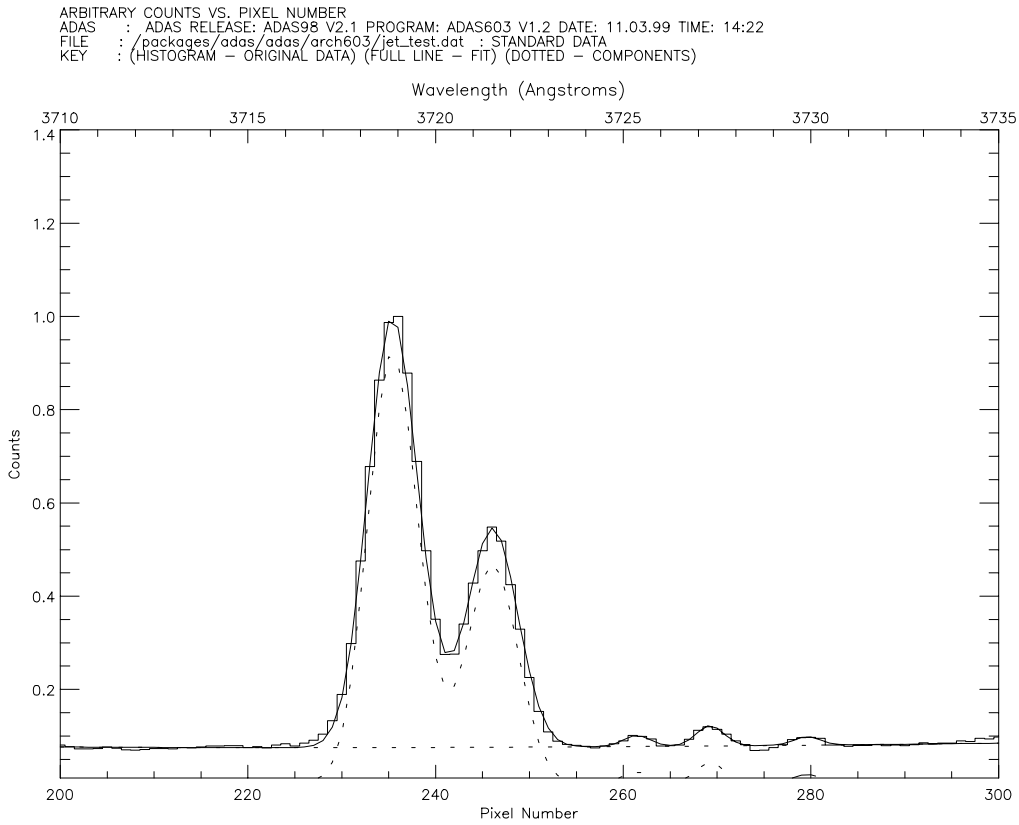


Table 7.03a

```
      ADAS RELEASE: ADAS98 V2.1 PROGRAM: ADAS603 V1.2 DATE: 11.03.99 TIME: 14:22
******* TABULAR OUTPUT FROM MAXIMUM LIKELIHOOD SPECTRAL LINE PROFILE FITTING PROGRAM: ADAS603 - DATE: 11.03.99 ******

 DATA FILENAME : /packages/adas/adas/arch603/jet_test.dat DATA TYPE : STANDARD
      TEMPLATE : NONE

--------- LINE WIDTH OPTIONS ---------
--------------------------------------
 ALL LINE WIDTHS FIXED ON INPUT   : N
 VARIABLE LINE WIDTHS WERE FITTED : N

--------- BACKGROUND OPTIONS ---------
--------------------------------------
 CONSTANT COMPONENT  : Y
 LINEAR COMPONENT    : Y
 QUADRATIC COMPONENT : Y

------------- OTHER OPTIONS --------------
 WEIGHTED FIT       : Y
 INFO ERROR FLAG FROM MINPACK ROUTINE : 2
 EXPOSURE TIME : 1.00000
 NO. OF LINES  : 3             NO. OF LINES WITH FIXED POSITIONS : 0


 KEY
-----
 ESE - ESTIMATED STANDARD ERROR (%)
 ECL - ESTIMATED 95% CONFIDENCE LIMIT (%)
------------------------------------------------------ OUTPUT TABLE -------------------------------------------

 DATASET : 1
--------------
 BACKGROUND
------------
 CONSTANT  : 0.162063        ESE : 35.4371        ECL : 70.5084
 LINEAR    : -0.000768179        ESE : 60.9617        ECL : 121.375
 QUADRATIC : 1.70374e-06        ESE : 54.9615        ECL : 109.428
 INDEX  POSITION                  HEIGHT                    FLUX                    WIDTH                  ID.
         (XO)   (ESEXO)  (ECLXO)   (H)    (ESEH)   (ECLH)            (ESEF)     (ECLF)         (ESEW)   (ECLW)
-------------------------------------------------------------------------------------------------------------------
   1   261.440   0.112   0.223    0.023   16.382   32.617    0.085   19.228   38.282   2.077   10.066   20.041  u
   2   269.263   0.062   0.123    0.044    9.711   19.334    0.162   13.986   27.847   2.077   10.066   20.041  u
   3   279.577   0.137   0.273    0.018   20.399   40.615    0.065   22.747   45.290   2.077   10.066   20.041  u
-------------------------------------------------------------------------------------------------------------------

 FEATURE
---------
```

```
SELECTED FEATURE          :  9              Be III(1s 2s 3S - 1s 2p 3P)  3721.7[A]
LINE PROFILE              : DOPPLER
POLARISATION  COMPONENETS : ALL
VIEWING ANGLE             : 0.000

FIT B FIELD      : Y   B VALUE        :  2.264       ESE : 0.086   ECL : 0.171
FIT PEAK HEIGHT  : Y   PEAK HEIGHT    :  0.525       ESE : 0.004   ECL : 0.007
FIT CENTROID POS : Y   DELTA CENTROID : -4.083       ESE : 0.021   ECL : 0.043
FIT TEMPERATURE  : Y   TEMPERATURE    :  1.400e+06   ESE : 6.515   ECL : *****
-------------------------------------------------------------------------------------------------------------
```

Notes