SPC (formerly S)
A spectral line reduction program
v3.8.3

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2001/11/14

Contents

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Part I

Introduction

SPC was originally written to process data written by SPECTRA, the spectral-line observing program of the Parkes radiotelescope. While SPC's data structure and many of its commands are Parkes-specific it has been adapted for use by a variety of other telescopes (e.g. the AT, Nobeyama). The latest version recognizes a number of data formats; the the original `.SPC` files still written by SPECTRA, RPFITS format data files written by the AT correlator, Single-dish FITS (SDFITS) files written by various utilities, including SPC itself, and the old memory-dump format produced by SPC(the `.SAV` files which may no longer be written).

The basic idea in using SPC is to load in a sequence of up to 110 spectra and then use various commands to operate on these spectra. The locations available in memory for holding spectra are referred to as *registers*. Some operations involve using a reference spectrum, for example, forming quotient spectra from a series of signal spectra and a reference. Register 111 is conventionally reserved for the reference spectrum. Reduced spectra may be written to a disk file (WRITE) for storage in single-dish FITS format. These `SDF` files can be read again into SPC for further processing. SPC registers may be appended to an existing `SDF` file thereby providing a convenient way of organizing spectral data.

SPC commands are minimum-match; i.e. the shortest unambiguous abbreviation (usually two letters) may be used. A brief list of the most often-used commands occur with the command prompt; the complete list is given in this document. Since the interactive format is question and answer, which can be a lengthy process, a shorter form of the command (ending in a period) may be used. This skips many of the questions, using the previous answer as the default. Previous answers are (almost) always kept as defaults for both full and short forms of a command.

Brief history:

Origins
: Rick Forster, project scientist for the construction of the Australia Telescope, designed and wrote the first version of SPC, then called S. He also wrote the first version of this manual.

Porting
: SPC was developed on a VAX and made liberal use of the VMS extensions to FORTRAN. When the ATNF migrated from a predominantly VMS-based computer system to predominantly unix-based the port of SPC was done by Henrietta May who also maintained it for many years after Rick Forster left the ATNF. The name change from S to SPC was required by the unix port.

Expansion
: In early 1992 a new Parkes correlator was installed which produced data with a larger number of channels. The channel limit in SPC was increased from 1024 to 4096 by Azimul Hoque.

PGPLOT
: The original version of SPC used in-house plotting packages (MIXPLOT and AUTOPLOT) and these were translated to the widely-used PGPLOT plotting package by Simone Magri.

Extension

Mark Calabretta became the SPC maintainer in 1997 and made further developments aimed at making it more generally applicable:

- Added Single-dish FITS reading and writing capability.
- Added RPFITS reading capability, including accumulation of spectra on input.
- Added support for Parkes multibeam data.
- Ported to the Linux operating system (with assistance from Chris Phillips).
- Corrected and updated this manual and converted it to LaTeX.

The SPC distribution kit is available from the ATNF (Australia Telescope National Facility) web page, *http://www.atnf.csiro.au/computing/software/spc.html*.

This document is composed of four parts:

Part I This introduction.

Part II General information for using SPC. How to load data, saving and reporting results, description of the working registers, etc. Also contains a section on how to make changes in SPC.

Part III A list of the commands available in SPC, listed by type and function, and also alphabetically. A brief description of the inputs and outputs and the command algorithm is given in the tables, and a complete description of the commands follows.

Part IV A description of the header information available. These items control things like the velocity axis for plotting, source name, etc. Header items can be edited if required.

Part II

Using SPC

startup

SPC is available on the Unix machines at Epping, Parkes, Narrabri and Mopra. On any of these machines, it can be started up by typing `spc` from any account.

commands

Commands in SPC are activated by typing a command name (case-insensitive, minimum-match) in response to the command prompt. Command names are written in this manual so as to indicate the minimum number of letters required, for example INFORMATION. A short list of useful commands is given with the prompt; the full set of commands is given in part III.

defaults

Control of SPC commands is via questions and answers. Defaults (generally indicated before or with the question) are accepted by hitting <CR>. The last answer to a question becomes the default value unless otherwise indicated.

short commands

Some of the questions can be avoided by putting a full stop "." after the command. For example, the command PL. avoids most plot setup questions, using the previous setups as defaults.

trouble

If you type a dash (-) as a file name (in DIRECTORY, LOAD, or WRITE) you return to the command prompt. Typing a dash or a zero in response to a LIST request also returns you to the command prompt. Typing ^C during execution of some commands (PLOT, NH3FIT, BASELINE, etc.) does the same thing. This can be useful if you've given a wrong answer to a question or launched a long but useless task (e.g. plotting 111 spectra).

help

VMS-style on-line help is available using the HELP command.

files

SPC does *not* alter SPECTRA (.SPC) files; it is even safe to load data from an open SPC file at Parkes, i.e. during the observation. Use the command DIRECTORY to list available sequence numbers in a data file to check what's there.

loading spectra

Use the LOAD command to load spectra into registers. You must give a list of sequence numbers to read from the input file, and an equal number of registers to hold the spectra.

registers

There are 111 registers available in SPC. All commands are performed on these registers. Data in the original files loaded are *not altered*, although SDF files may be appended to.

saving spectra

Reduced spectra are saved using WRITE. These SDF files are written sequentially, and successive writes to an existing file are appended to the old file. When loading a spectrum back into SPC from a SDF file, the "sequence" number required by LOAD is the sequence in which that spectrum was written to the SDF file; the sequence number from the original SPC file is retained as a header item. Use DIRECTORY to review what is contained in a SDF file.

quadrants

A register consists of 8260 real numbers. The first 8196 are spectral channels; the remaining 64 numbers are header items. The 8196 spectral channels may be composed of up to four *quadrants* representing the four possible IFs available simultaneously at Parkes. The quadrant are thereafter distinguished by channel range; e.g. 1-1024 = Q1, 1025-2048 = Q2, etc. The number of quadrants, channels per quadrant, velocities, etc. are contained in the header items. You can inspect (INFORMATION, STATISTICS), edit (EDIT, SHIFT, COPY) and plot (PLOT, XYPLOT) both header items and data.

S, R, Q

With SPC files, you may load either the average or individual checkpoint blocks (CPBs). A Reference, Signal or Quotient spectrum may also be selected, if present for that sequence number. This data structure does not apply to non-SPC files; what you saved is what you get.

frequency and velocity

The frequency scale in data from the telescope is referred to the observer's or *topocentric* frame of reference, sometimes referred to as *sky* frequency. The velocity scales are computed using the radio convention, $v_{\mathrm{radio}} = c(1 - \nu/\nu_0)$, where ν_0 is the rest frequency of the spectral line of interest.

SPC has a command, RVEL, to switch between the topocentric, geocentric, barycentric, LSR (kinematic) and LSR (dynamic) reference frames (the LSR-K frame being the one commonly used). The reference frame and the Doppler shift computed and used by SPC to rescale the frequency axis is recorded for each register and is reported by the INFO command. This information is recorded in output `SDF` files and recovered again when they are read.

Unfortunately, the telescope identification in the RPFITS header is often incorrect and this affects the geocentric (diurnal) velocity correction. The INFO command displays the telescope identification and if necessary this may be corrected with the EDIT command. The telescope identification code is recorded in SPC header item 17 as follows:

- 0: Parkes 64m,
- 0.1: Parkes 64m MultiBeam, beam no. 1,
- 0.2: Parkes 64m MultiBeam, beam no. 2, etc.,
- 1: ATCA 22m,
- 7: Mopra 22m,
- 8: Hobart, Mt. Pleasant 26m,
- 9: Ceduna 30m,
- 10: SEST.

Only Parkes, Ceduna and SEST are likely to be identified correctly, Mopra and Hobart are likely to be misidentified without user intervention.

Note that the station coordinates of these antennas are hard-coded in SPC.

log

SPC writes a file `SPC.LOG` containing all the information written to the terminal during your reduction session. On exit from SPC this file is printed if requested, otherwise it is deleted. It may be saved on disk only by exiting via ˆY. You can clear your log file, or print it without exiting, by using the command PRINT.

lists

Register or sequence lists may be specified using a shorthand notation where a dash indicates a continuous range of integers and a comma or a space may be used as a delimiter. For example,

$$1 - 3, 12\ 20 - 18 = 1\ 2\ 3\ 12\ 20\ 19\ 18$$

If the first item in a list is zero or a dash, the subroutine returns to the command prompt. This is often useful for getting out of a bad situation.

pairs

When a range or range list is required (usually channel ranges), any delimiter is accepted except an integer. If an odd number of integers are input, the last range is made to be the odd integer. For example,

$$\left.\begin{array}{l} 1-512, 1024 \\ 1\ 512\ 1024\ 1024 \\ 1-512-1024 \end{array}\right\} = (1-512)\ (1024-1024)$$

Pairs also have the zero convention; zero or dash = return.

plots

Plots can be directed to any device that PGPLOT has a driver for. The device for output is chosen during routines that involve plotting. However, some environment variables need to be set up to facilitate sending plots to printing and display devices; see, environment, below.

environment

Certain environment variables need to be defined in the SPC startup script as explained in the installation instructions.

Part III

Commands

Commands in response to the command prompt are minimum-match. If nothing matches, or the command is ambiguous, the prompt is repeated. A list of commands currently implemented is given below, along with a brief functional description. These commands are also listed alphabetically with page reference, in the last part of this section.

	INPUT	OUTPUT	ACTION
Input/output			
FITs			
Load	data file	Reg list	Loads data into SPC registers.
Write	Reg list	`SDF` file	Write spectra to `SDF` file.
Utilities			
CNvert	Reg list	same list	Converts between (α, δ) & (l, b).
Directory	data file	`SPCDIR.LOG`	Directory listing of file contents.
EXit	-	`SPC.LOG`	Exits SPC & prints log file.
GO	`COM` file	-	Runs pre-defined sequence of commands.
Help	help text	-	Writes VMS-style help to screen.
INformation	Reg list	log file	Prints header & spectral information.
PRint	Reg list	`SPC.LOG`	Prints & clears log file.
Editing			

ALign	Reg list	same list	Aligns spectra with a reference spectrum.
COpy	Reg list	any list	Copies data from register to register.
CUll	Reg list	AVERAGE reg	Removes bad spectra from an average.
EDit	Reg list	Reg list	Edit or list data & header items.
FIXpol	Reg list	any list	Used for dual-polarization data reduction.
SHift	Reg list	any list	Shifts & blends data from register to register.
Vcor	Reg list	same list	Corrects for various velocity errors.
Plots			
MAp	Reg list	plot	Draws contour plots.
PLot	Reg list	plot	Plots spectra in various formats.
SPotmap	`POS` file	plot	Spotmap of x, y positions & spectrum.
XYplot	Reg list	plot	Plots any x vs any y where x & y may be spectral points or header items.
Massaging			
BAseline	Reg list	same list	Removes a polynomial (up to 5th order) & a 5.8 MHz sine wave (if requested).
BIrdy	Reg list	same list	Removes central-channel birdies automatically.
CAlibrate	Reg list	same list	Corrects for atmosphere, focus & efficiency.
RVel	Reg list	same list	Change frequency & velocity reference frame.
SCale	Reg list	same list	Rescales spectra by quadrant.
SMooth	Reg list	same list	Hanning or Boxcar smoothing of spectra.
Zero	Reg list	same list	Zeros channels at band edges.
Analysis			
GAuss	Reg list	same list	Adds Gaussian features to spectra.
GFit	Reg list	output list	Fits Gaussian components to spectral features.
Kinematics	Reg list	log,spectra	Generates velocity moments.
Nh3fit	Reg list	output list	Fits ammonia spectra (up to 3 J levels).
POsition	Reg list	`POS` file	Finds positions & writes file for SPOTMAP.
SOlve	Reg list	6 reg's	Solves for linear polarization: I, Q & U.
STatistics	Reg list	log	Calculates statistics over channel range.
Mathematics			
ADd	Reg list	same list	$I = I + (A + BR)$.
AVerage	Reg list	Reference reg	Averages a list of spectra.
GEnerate			
MUltiply	Reg list	same list	$I = I^{e_1}(AR)^{e_2}$.
Quotient	Reg list	same list	Forms quotient from signal & reference.
XFm	Reg list	output list	Fourier transform (complex).

A more complete description of the commands available in SPC follows. The command dialogue and a brief explanation of each question is given in a box following the description. Questions listed in the top part of the box are omitted in the brief version of the command. If there is no break in the dialogue box, the short version does not omit any questions.

ADd

Adds a constant, plus a scaled version of the reference register to a list of registers. There is no channel or quadrant selection in this routine.

The algorithm is: $I = I + (A + BR)$ where I is the input list, A and B are real constants, and R is a reference register. The channel values in the input list are overwritten, and header values are not changed. A constant offset (A) may be added to the register list by entering zero for B or R.

```
Enter A, B, Reference  adds A + B*Reference register to list
Enter ADD list         registers to add the above to
```

ALign

Used to shift spectra by a non-integral number of channels (SHift does integral channel shifts only), or to automatically align spectra observed with different central velocities but the same correlator setup. This is useful if identical channel registration is required, e.g. in order to properly AVerage spectra observed with different velocities (also for SOlve, ADd, MUltiply).

If a reference spectrum is given, all spectra in the list are aligned to it, and the headers are updated to reflect any changes in the velocity axes. After alignment the spectra should have identical velocity axes. If 0 (zero) is entered for the reference register, manual inputs are accepted for each quadrant. In this case the headers are not changed. Fractional channel shifts are implemented by linear interpolation.

It is not necessary to ALign in order to plot spectra on a common velocity axis - in PLot answer yes to “plot versus velocity?” and “register plots on same velocity axis?”

```
REF register (0 for manual inputs):   give a valid register for auto
                                      alignment
   Channel shift for each quadrant: manual inputs (only if REF=0)
ALIGN list:                           enter list of registers to align
```

AVerage

Averages a list of registers, weighted to give the best signal-to-noise ratio. Registers are weighted by Integ/T_{sys}^2.

There is also an option for weighting by the amplitude of a particular spectral feature, but editing is required to switch it on. Header values are also averaged: this may result in a non-integer value for the Sequence Number. Spectra made by AVerage are tagged type `a`.

```
Enter register to hold average:  the average goes into this register
Enter list to average:  averages this list of registers
```

BAseline

Removes a polynomial (0th to 5th order) and a 5.8 MHz sine wave (if requested) from a list of registers. The 5.8 MHz sine wave is caused by standing waves between the dish and the feed.

You must provide a set of channel ranges which avoids any real signal in the spectrum (use PLot). The algorithm uses a least-squares fit to a polynomial over the selected channel ranges. You may specify channel ranges for all observed quadrants simultaneously. The baseline curves are calculated and removed independently for each quadrant; if you do not include a channel range within a particular quadrant, nothing will be done to it.

A non-advertised option is available for reducing $J = 1$ and $J = 2$ transitions of ammonia observed in two 10 MHz, 512-channel bands. The peak channel in the $J = 1$ quadrant (use STatistics or Kinematics) is used to automatically set channel ranges in both quadrants to avoid the hyperfine structure. In order to add this option to the dialogue, you must edit three lines in the module `base.f`, then rebuild spc.

```
Enter Baseline channel pairs:  give channel ranges to fit baseline to
Enter polynomial order and sine (3, no):  0 to 5 and yes, for sine wave
Enter BASE list:  enter registers to baseline.
```

BIrdy

Removes central channel birdies caused by LO breakthrough. The Parkes local oscillator signal generally breaks through the mixer and gets into the IF signal. A "birdie" may therefore appear in the quotient spectrum of each quadrant if there is a difference between the signal and reference spectrum.

The algorithm removes central channel birdies automatically by replacing the value of the centre channel in each quadrant with the average of the neighbouring channels. It does this for all quadrants observed; there is no quadrant selection provided.

```
Enter BIRDY register list:  give the list to de-Birdy.
```

CAlibrate

Makes several amplitude corrections appropriate to Parkes data (mainly at 22 GHz) and stores the gain applied in the header (register location 5015). This correction can be removed ("undo" option) in CAlibrate. The corrections are: (1) atmospheric extinction; (2) antenna beam efficiency; (3) focus error; and (4) constant scale factor. Beam efficiency and focus correction curves are available only for K-band; most other frequencies do not need them anyway.

CAlibrate contains curves giving the 22 GHz dish efficiency and the optimum focus position as a function of zenith angle, along with the fractional signal loss as a function of focus error. If efficiency and focus corrections are requested, the zenith angle (5004) and focus position (register location 5046) are used to calculate the gain correction required. If atmospheric correction is requested, you will need to enter the zenith opacity.

CALIBRATE has a facility for determining the atmospheric attenuation by using the measured T_{sys} values as a function of zenith angle. To use it, load in a sequence of observations which cover a large range in zenith angle, and which do not contain sources strong enough to affect T_{sys} appreciably. The T_{sys} values are least-squares fit to the function: $T_{sys} = T_{rcv} + T_{sky}/\cos(Z)$ for the parameters T_{rcv} (receiver temperature) and T_{sky} (radiation temperature of the atmosphere). Note that T_{sys} is measured in the units appropriate to the noise calibration source (use INFORMATION to check what T_{cal} is). The physical temperature of the atmosphere is $\sim 274\,\mathrm{K}$; if your cal temperature is in Jy, then multiply 274 by the appropriate Jy/K and enter this number for the "temperature" (Jy) of the atmosphere. The optical depth at the zenith is calculated from: $\tau = -\log(1 - T_{sky}/274)$, and the correction is: $exp[\tau/\cos(Z)]$.

The quality of the sky-dip measurements and the fit can be checked using XYPLOT and one of the curve overlay options. Write down the T_{rcv} and T_{sky} values for each quadrant from the SKY results, and run XYPLOT to plot T_{sys} for all quadrants versus zenith angle. Overlay curve 3 and enter T_{rcv}, T_{sky} in response to the prompt. Then enter 5004 5022 for the x, y axis list to plot T_{sys} of quadrant 1 versus zenith angle. Several quadrants may be plotted simultaneously if desired.

```
Undo previous gain corrections (no)?  yes, to undo all earlier
                                      calibration
   Enter CAL list:    give the register list to UNDO.
Solve for atmospheric attenuation (no)?  yes,
                                the solve for atmospheric opacity
   Enter atmosphere temp. (K or Jy):  atmos. temp. in $T\sub{cal}$ units
   Enter SKY list:    register list for opacity msmt.
Correct for: Atmosphere, Efficiency., Focus?  y y y,
                                to do all corrections
   Enter atmospheric opacity:  enter Tau (default = SKY result)
Enter constant scale factor:  scale all quadrants by this factor
Enter CAL list:  list of registers to calibrate.
```

CNVERT

Converts between equatorial and galactic coordinates and vice versa. The conversion algorithm is only good to a few arcseconds.

```
Register list:    enter list to convert.
```

COPY

Copies data from register to register. Names and headers alone may also be copied (useful for supplying headers to synthesized spectra made with GAUSS, SHIFT, ADD, etc.). You can copy channel ranges from one register to another, or within a single register. Only integral channel shifts are allowed (use ALIGN for fractional channel shifts).

COPY differs from SHIFT in that data in the destination channel range is *overwritten*, whereas the data are *blended* with SHIFT. COPY also writes headers to the destination registers, while SHift does not. Multiple ranges can be specified in the channel lists, but the "from" and "to" ranges must be the same length.

A typical use of COpy is to copy data to different places in the register stack. It can also be used to re-arrange the order of quadrants (e.g. channels 513-1024 go to channels 1-512), or to invert the channel direction (e.g. 1-1024 goes to channels 1024-1).

NOTE: Any header information present in a destination register is overwritten by the header from the origin register. Channel/velocity axis re-arrangements due to COpy are not accounted for in the headers.

```
Copy NAMES and HEADERS only?  if yes, only headers are copied
A channel list:  channel ranges to copy FROM
B channel list:  channel ranges to copy  TO

A register list: register list to copy FROM
B register list: register list to copy  TO
```

CUll

Removes bad spectra from an average. CUll provides for easy removal of bad Check Point Blocks (CPBs) from an average spectrum, allowing the removal of only affected quadrants. It has the advantage over AVerage of requiring only the averaged and the bad spectrum to be present, and of being able to clean up individual quadrants. CUll adjusts the header integration times to account for the removal of data.

In order to remove corrupt CPBs, load the *average* spectrum into register 111, and load the individual CPBs elsewhere. Use PLot, INformation or STatistics to determine the corrupt CPB register numbers and quadrants. Then use CUll to remove the bad spectra, listing them by register/quadrant pairs.

CUll can be used to remove bad spectra from *any* average, for example one made by the AVerage command. Simply load the average and the corrupt spectra into registers, and use CUll in the same was as above. This is sometimes useful for averaging data which has some corrupt quadrants.

```
Enter register to clean up:  register number containing the average
Enter CPB, QUAD pairs:  register/quad\# pairs with corrupt data.
```

Directory

Lists the contents of `SPC`, `SDF` and `RPF`files. For `SPC` files only quotients are listed; if all zeros are printed there is probably no quotient spectrum for that sequence number. The directory listing is printed out if requested; it is also saved in the log file.

You can save a directory listing on disk by typing ^Y in response to the question "Print directory?", but this causes you to exit spc. The disk file is called `SPCDIR.LOG`.

The file name used for Directory becomes the default for Load and vice versa.

```
Data file name (.SPC)         enter file name (.SPC understood)
   starting sequence number:  start listing at: (SPC files only)
Another file?                 yes, for more listings (default = last)
Print directory?              yes, if hardcopy wanted (default = no).
```

EDIT

Provides for listing or editing of source and file names, header items and spectral data. EDIT also lists the locations of all header items if requested.

Edited data is either *replaced* by a new value, or the value is *added* to the current value. Header items are specified by their location in the channel list; they are treated like spectral data but have locations in the range 8197-8260.

As many items as desired may be listed or edited. When editing, a new value must be entered for each item. The old and the new value is displayed for each item edited.

```
Change source NAMES?          yes, to change source or oldfile names
Enter EDIT list:              list of registers to edit
Enter new names:              give new source and file names
Would you like a listing of header items?  yes, to list of the header
                              locations
List or Edit data?  type L or E for Listing or Editing
Enter channels to list or edit:  give the channels or header locations
Add (a) or Replace (r)  ``a'' to \emph{add} new values,
                        ``r'' to \emph{replace}
Enter new values:  same number of values as channel list
Enter EDIT list:  give the list of registers to edit
```

EXIT

Exits SPC and prints the log file if desired, otherwise deletes it. If you want to save the log file on disk, exit by ^Y. The disk file is called `SPC.LOG`.

```
Print log?    yes, if printout of log file is wanted.
```

FIXPOL

Simplifies reduction of polarization data taken with two orthogonal linear polarizations simultaneously. By default, FIXPOL copies the second quadrant (channels 513-1024) of the input (A) register into the first quadrant (channels 1-512) of a new output (B) register and adds -90 degrees to the feed angle. This puts the data into the correct format for linear polarization analysis with SOLVE, which requires a contiguous stack of spectra with differing feed angles.

The channel range to copy and the feed angle offset may be specified manually. Note that the input list (A) remains unchanged unless a non-zero offset is added to the A-list feed angle.

```
Channel range list:  channel range to shift from A
Enter first channel to shift into:  first channel of range in B
Enter feed angle shifts:  feed offsets for A and B lists

Enter list A:    Input list to copy FROM
Enter list B:    Output list to copy  TO.
```

GAuss

Adds a Gaussian component to a register. The component is specified by centre channel, FWHM (in channels), and amplitude. It is useful for creating artificial spectra for testing or other purposes. GAuss does not write any header information; use COpy (headers only) if header information is needed.

```
Enter Gauss list:  register list to store Gaussians
Enter centre, FWHM, amplitude:  specify Gaussian to add

(GA. has no inputs: it just adds another identical Gaussian to the
register list)
```

GFit

Fits up to 7 Gaussian components simultaneously in each quadrant. If requested, GFit will store the fitted Gaussian models in specified registers (overwriting anything already there), and write the fit parameters (ampl, vel, FWHM) and their formal errors in the data range for each quadrant (useful for contouring in MAp).

The parameters (and errors, if kept) are written in the following sequence, beginning in the first channel of the associated quadrant: Amplitude, velocity, FWHM, Amplitude error, Velocity error, FWHM error (for component #1), ditto (#2), etc. If the errors are not kept, only 3 entries per component are written. These parameters are written to the original data registers, and also to the model fit registers if saved. Model fit registers are given type designation `MG` for Model Gaussian (PLot, STatistics).

A fit to the peak spectral feature in each quadrant can be automatically obtained by entering zero for "Guesses". Otherwise, up to 7 fits in each quadrant can be obtained by specifying guesses for the centre channel and halfwidth of each spectral component. Note that if fit parameters are written to the data, automatic fitting to the largest feature might try to fit data in this range. Use Zero to keep this from happening.

```
Save the fitted Gaussians? yes, to store fitted Gaussians in Regs
   Enter Model output list:    register list to hold Gaussians
Save the fit parameters and errors?  y y, to save fit and errors in
                                     the spectra
Enter GFIT list:  register list to fit
Guesses (centre, width) for components:  up to 7 pairs per
                                            quadrant (0 = auto)
```

GO

This routine guides the user through a pre-defined sequence of SPC commands stored in a disk file. GO is useful when doing interactive data reduction involving many essential steps. It differs from a VMS `.COM` file in that the SPC commands are automatically invoked, but the response to each command remains interactive.

Before using GO you should set up all defaults using the long version of each command, and use short versions in the GO file. The list of commands should be written in the file exactly as they would be typed in response to the command prompt, with one command per line. A GO file which loads, baselines, zeros, birdies, smooths, calibrates and writes would be:

```
l.
ba.
z.
bi.
sm.
ca.
wr
```

To escape from a GO sequence before completion use ˆC. You may have to respond to a final question or two before you are returned to the command prompt.

```
Enter GO filename:  Name of GO file (.COM understood)
(questions appropriate to command sequence follow)
```

INFORMATION

Provides a summary of the data contained in individual SPC registers, including frequency, obs. date, position, correlator setup, peak intensity per quadrant, etc. Information is displayed for each register in the input list sequentially, type a <CR> to go to the next one.

Type ˆY to cancel an INFORMATION list before completion.

```
Register list:    List of registers for INFO
```

KINEMATICS

Calculates velocity moments over a given channel range. You must give a channel range, and an amplitude cutoff for determining the minimum and maximum "signal" velocity. The calculated parameters are written into channels 1-10 if requested. There is no quadrant distinction in this routine. The 10 parameters are:

- channel of peak signal
- *median* velocity, $(V_{\max} + V_{\min})/2$
- amplitude of peak

- *mean* velocity, $(\Sigma V_i)/N$
- velocity of peak (km/s)
- 1st velocity moment, $(\Sigma A_i V_i)/\Sigma A_i$
- velocity of minimum signal (> cutoff)
- 2nd velocity moment, $(\Sigma A_i^2 V_i)/(\Sigma A_i^2)$
- velocity of maximum signal (> cutoff)
- Integrated intensity, $\Sigma A_i dV$

where A_i = amplitude of channel i; Σ denotes the sum over channel range for $A_i >$ cutoff; V_i = velocity of channel i; dV = velocity increment.

```
Enter channel range:  calculations restricted to this range
Enter amplitude cutoff:  minimum amplitude for real signal
Save results?    yes, to write results into channels 1-10

Enter KINEMATICS register list:
                          list of registers for moment calculation
```

LOAD

Loads data from SPECTRA, Single-dish FITS RPFITS or old `.SAV` files into SPC-registers. `SPC` files made with SPECTRA may be accessed during the observations; LOAD opens `SPC` files for *read only.* The following file suffixes are recognized (case-insensitive):

`.SPC`
: ...SPECTRA output format

`.SDF*`
: ...SDFITS binary table

`.RPF*`, `.HPF` or `.MBF`
: ...RPFITS

`.SEST`
: ...SEST FITS

`.SAV` or `.DAT`
: ...SPC dump format

The `.HPF` and `.MBF` suffixes are recognized specifically for Parkes multibeam RPFITS to save having to rename the files produced by MULTI.

A listing of the contents of a data file can be obtained with the command DIRECTORY. Reduced spectra are saved with WRITE.

Signal, Reference and Quotient, and "Check Point Blocks" (CPBs) apply only to `SPC` files; other files do not have this data structure. If you have forgotten how many CPBs are present, you can load two (loading only one gives the average spectrum) and compare their integration times with the integration time of the average. Each CPB requires a register - the total required is the number in the sequence list times the number of CPBs.

Unless you want to load individual CPBs, or you require signal or reference spectra, you should use the short version of LOAD (L.).

If your data was taken during a period when a recognized velocity error was present in SPECTRA, a warning is given to use the command VCOR. This warning persists for old `SAV` files even if VCOR has already been applied, and in those cases it should be ignored.

```
Enter Signal, Reference or Quotient:  S, R, or Q can be loaded, if
                                      available
Read individual Check Point Blocks?   yes, if individual CPB's are
                                      desired
   Number of CPB's:                   Enter \# of CPB's in average
Data file name (.SPC)                 file name (SPC extension assumed)

SEQUENCE list:                        list of sequence \#s to load
REGISTER list:                        list of registers to load data
                                      into.
```

MAP

Draws a contour plot of spectral data taken on a grid of sky positions. The observed positions need not be on a uniform grid; MAP interpolates the data onto a grid before contouring. You must provide a grid spacing and the FWHM beamwidth for interpolating onto the grid. A reasonable grid spacing is about FWHM/2, but this can be varied to suit the data. The maximum and minimum amplitude of the raw data is printed, along with the range in x and y. The amplitude range after gridding is also given (with the prompt for contour level type). A comparison of these values gives an indication of the smoothing caused by gridding.

There are four choices for entering contour levels: *default* gives 10 contour levels evenly spaced over the maximum and minimum amplitude range; *absolute* plots absolute levels entered manually (minimum and maximum values are listed with the prompt); *relative* plots levels relative to the maximum (e.g. 0.2 0.4 0.6 0.8 0.95); *range* plots levels defined by a minimum, maximum and interval (e.g. 0 1.5 0.3).

A single channel or the average over a range of channels may be plotted. Contour plots of Gaussian fit components (amp, width, vel, errors) may be obtained by first running GFIT and storing the results in the spectrum. NH3FIT and KINEMATICS results may also be mapped.

```
Enter grid spacing (arcmin):  grid spacing for interpolation
Plot data, grid points?  y  y,  to see data and grid locations
Enter register list to contour:  enter list of registers to map
Channel range:    maps the average over channel range
Enter FWHM (arcmin):  beamwidth for interpolation
Enter contour type (d,a,re,ra):  choose type for contour levels
Graphics device/type (? to see list, default /xdisp):
                                    choose plot device for map
Replot contours (no)?  yes, to replot gridded data.
```

MUltiply

Multiplies a register by a constant times a reference register. MUltiply also provides for division, square roots and other exponents in both the input and reference registers.

The algorithm is $I = I^{e_1}(AR)^{e_2}$ where I is the input register list, e_1 and e_2 are exponents on the input and reference registers, and A is a constant. In order to multiply the input registers by a constant (A), enter zero for the reference register and ones for e_1 and e_2. There is no channel or quadrant selection, the input spectra are overwritten with the new values, and headers are left unchanged.

```
Enter e1, A, REF, e2  I = I**e1 *(A*REF)**e2      (I = channel ampl.)

Enter list to multiply:  Register list to multiply by the above
```

Nh3fit

Fits ($J = 1, 2$ and 3) lines of ammonia for peak intensity, velocity, halfwidth and optical depth. The best-fit model spectra may be written to output registers, and the fit results may be stored in the associated data arrays for mapping or storage. Nh3fit will also generate model NH_3 lines, using headers taken from the observed spectra.

To generate model spectra (yes to "make a model profile?"), enter a list of registers for header information, and a list of registers to hold the model spectra. You will be prompted for the model parameters.

Nh3fit assumes that each input register contains up to three $J-$levels of the ammonia lines in ascending order (ie. $J = 1$ line of 1024 channels; two 512-channel spectra containing $J = 1$ and $J = 2$ lines; or three spectra consisting $J =$ 1, 2 and 3 of 512, 256 and 256 channels respectively.

Nh3fit will automatically fit all quadrants individually, using the peak channel in each quadrant as its starting point. The data should be baselined and zeroed before fitting, although provision is made for avoiding endpoints, and for subtracting a linear baseline.

The routine does an initial fit assuming zero optical depth (low-tau), then fits for the optical depth. Initial guesses for amplitude and velocity may be automatically generated (based on the peak signal), or entered manually (yes to "inject your own guesses"). Guesses are solicited at each fitting stage.

The best-fit model NH_3 lines are written to an output register if a non-zero output list is given, using the input data for headers. The low-tau model may also be saved (yes to "save the low-tau profiles"). To plot, use the "A" option in PLot, and list a data and a fit register to plot. If results were saved, these are printed below the plot.

When the option to save fit parameters is used, the results are written to the data and model spectrum (if saved), overwriting data in the first eight channels of each quadrant. Be sure to zero these channels for subsequent automatic fits if this option is turned on. The following results are stored in the first eight channels of each quadrant:

- $T_{\rm ex}$ excitation temperature
- $T_{\rm ex}$ error 1 sigma
- Velocity (km/s)

- Velocity RMS error
- FWHM (km/s)
- FWHM error (km/s)
- τ (dimensionless)
- τ error (dimensionless)

```
Make a model profile?  yes, to synthesize NH3 lines
Save fit parameters in spectra?  yes, to write fit results to data area
Save the low-tau profiles?  yes, to save the low-tau models
  Enter low-tau output list:    registers for low-tau models
Inject your own initial guesses?  yes, to provide manual guesses
  Enter new estimates:    ampl, vel, fwhm (0 = automatic)
Endpoints to skip, baseline channels:  N,B;  skips N end
          channels each quad. uses adjacent B chans for b.line

Enter NH3 input list:  register list to fit
Enter fit output list (0 for no save):  registers for model spectra (if
                                        saved)
```

PLOT

Plots spectra over a given channel range in various ways. Spectra may be plotted versus channel number or versus velocity, and may be either overlaid (several plots on the same xy-axis) or stacked. Overlaying an empty register is a convenient way of plotting a zero line.

If the velocity axis is chosen, all spectra in the plot list may be aligned in velocity by answering yes to "Register plots on same velocity axis?". Supply a minimum and maximum velocity to set the scale (or 0,0 to default to the full range of the first plot in the list). If you answer no to the registration option, the velocity axis of the first plot is assumed for all other plots in the list, and you are not prompted for a minimum and maximum velocity.

Data contained in two or more quadrants having the same velocity axis will appear overlaid if plotted versus velocity over all channels. To avoid traceback problems in crossing quadrant boundaries, be sure to zero the endpoints (ZERO). The traceback then results in a line through zero (sometimes desirable).

For autoscaled plots the selected channel range is used to determine the minimum and maximum amplitudes for scaling. In velocity plots with registration, reducing the the velocity range does not affect autoscaling.

Use plot type "Normal" for most plots. "Ammonia" plots assume that up to 3 J-levels of the ammonia line are contained in one register, and model-fit spectra in another (see NH3FIT). "Database" format provides for two overlaid spectra with the second one manually scaled (gives a blowup of the autoscaled plot to improve dynamic range).

The `D` format can be useful for switching easily between velocity and channel plots, and between auto and manual scaling. If only one register is plotted, `D` always gives an autoscaled velocity plot; switching to `N` will revert to your default selection.

To exit a plot before it is finished type ^Y. The current part of the plot will finish before returning to the command prompt.

```
Plot versus velocity?  yes for x-axis in velocity; else channels
  Register on same velocity axis?  yes, to align all in velocity
    Enter min,max velocity:      0,0 means plot full range.
Overlay or stack plots? o to overlay plots; s to plot in a stack
Automatic scaling?  no, to enter your own min, max
  Enter Ymin, Ymax:    enter min, max for Y-axis
Plot Vertical line?(n):  plot a vertical line on the x-axis
Interactive marking of xcoord?(n):  mark with mouse,
                                    or cursor and key
Enter plot type (n,a,d):  ''n'' should generally be used
Enter Plot channel range:  channel range for plotting and autoscale
Graphics device/type (? to see list, default /xdisp):
                           output device (/null to exit)
Enter plot list:    give the register list to plot
```

POSITION

Finds the sky positions of spectral features from data observed at three or more telescope pointings. A single position may be determined (no, to "Fit EACH channel in list?"), in which case the average intensity over a channel range is used for the fit, or each channel in a range may be fit individually and the results stored in a file for plotting with SPOTMAP.

The algorithm uses a least-squares fit to a two-dimensional Gaussian model of the beam; the assumption is that each feature is a point source. A minimum of three different sky positions is required to determine the amplitude, and the x and y positions, of the spectral features.

When a single position is requested, the amplitude and centre position of the best-fit Gaussian is printed, along with the sigma value for the beamsize in x and y. These parameters may be used to compare the fit to the data using XYPLOT (plot channel intensity versus RA or DEC) and overlaying curve 2. This works best for data taken on RA and DEC lines, and fit to a single channel.

When fitting to each channel in a range, an amplitude cutoff is required to avoid positioning noisy data; the uncertainty in the derived sky position is mainly a function of the signal to noise ratio. A rough rule of thumb on the positional accuracy is: the rms error is about the FWHM beamsize divided by the signal/noise ratio (e.g. $\sim 1\%$ FWHM for S/N = 100). The uncertainty also depends on how well the observations cover the source position. Although POSITION will attempt to find a position even if the observations are nowhere near the source, the results will not be very accurate. Four or five measurements at $\sim 1/2$ beam separation surrounding the source gives the best result.

A comparison between the observed locations and the sky position can be made quickly by plotting the input data registers versus RA and DEC in XYPLOT, and overlaying the fit sky position (curve 4).

```
Fit EACH channel in list?  yes, to make a SPOTMAP file
```

```
   Amplitude cutoff    don't fit data below cutoff
   List of channels to fit:    fit all channels in list
   File name for positions:    File for spotmap (.POS)
Channel range to average:  single position for this channel range
Enter POS register list:  list of registers to use in fit
Enter FWHM beamwidth:  enter beamwidth in arcmin
```

PRint

Prints out and/or clears the log file any time.

```
Do you want to start log afresh?  Yes, to clear the log (if your answer
                                  is ''no'', the log file is spooled to
                                  the printer)
```

Quotient

Forms quotients from signal and reference spectra. In the general case one reference is used for a list of signal spectra. Provision is also made for forming quotients from a list of signals and a list of references of the same length.

The algorithm used is: $Q = T_{\rm ref}S/R - T_{\rm sig}$ where $T_{\rm ref}$ and $T_{\rm sig}$ are the system temperatures measured for the signal and reference, and Q, S and R are quotient, signal and reference spectra. The dialogue requests a list of quotients; this is actually the list of signal spectra, which are then overwritten by the quotients. The headers are unchanged except for the spectrum type, which becomes `q`.

Quotients formed in spectra (loaded as type `Q`) are slightly different from the ones formed by Quotient. In spectra the algorithm is $Q = T_{\rm ref}S/R - T_{\rm ref}$.

```
Enter QUOTIENT list:  actually SIGNAL list; it becomes QUOTs
Enter REFERENCE (single, or list):  REF register, or list same size as
                                    above.
```

RVel

Switches between topocentric, geocentric, barycentric, LSR (kinematic) and LSR (dynamic) reference frames (the LSR-K frame being the one commonly used). The reference frame and the Doppler shift computed and used by spc to rescale the frequency axis is recorded for each register and is reported by the INfo command. The velocity scales are computed using the radio convention, $v_{\rm radio} = c(1 - \nu/\nu_0)$, where ν_0 is the rest frequency of the spectral line of interest.

```
Enter reference frame, TOPO, GEO, BARY, LSRK, or LSRD [LSRK]:
                                  Enter the required frame.
Enter RVEL list:  list of registers to frequency shift.
```

The reference frame and Doppler shift are recorded in output SDF files and recovered again when they are read.

SCale

Applies a scaling factor to each quadrant separately. This differs from the constant factor applied in CAlibrate in that different factors can be applied to different quadrants, and the factors applied are not stored in the header. It is useful to adjust for errors in the $T_{\rm cal}$ used, and to apply general amplitude corrections.

```
Enter scale factors for each quadrant:
                              give one number for each quadrant.
Enter SCALE list:  register list to scale.
```

SHift

Shifts channels from an input register (B) onto channels in the output list (A), and adds them together according to: $A_i = |b_{\rm f}|A_i + b_{\rm f}B_{\rm s}$ where $b_{\rm f}$ (blend factor) is a constant, $|b_{\rm f}|$ is its absolute value, i is the channel number, and s is the shifted channel number. Shifting can be done from one register to another or within the same register.

SHift is useful for adding, subtracting or averaging quadrants together. For example, dual-polarization data can be combined by shifting channels 513-1024 into 1-512 with $b_{\rm f} = 1$ (adding) or $b_{\rm f} = 0.5$ (averaging) within the same register. SHift can also be used to zero portions of a spectrum by setting $b_{\rm f} = -1$ and shifting a channel range onto itself within the same register.

SHift does not automatically write headers when shifting data to a new register, in contrast to COpy. However, header data can also be shifted (except for names) by shifting data in the channel range 8197-8260. Remember that shifted data is *blended* with existing data, so a true copy only results when shifting into an empty register with $b_{\rm f} = 1$.

```
Enter blend factor:  factor for blending channels together
Channel ranges to shift:  give ranges of channels to be shifted
Start channels:  new start channels for each shift range

Enter list B:    Register list to shift FROM
Enter list A:    Register list to shift    TO
```

SMooth

Smooths spectra by Hanning, Boxcar or Binning algorithms. Quadrants can be smoothed differently by answering no to “smooth all quads?”. Smoothed spectra cannot be unsmoothed.

The Boxcar algorithm replaces each channel with the average of the original channels over the box size, beginning with the start channel. The Binning algorithm replaces all channels in the bin with the average of the original channels over the bin size, beginning with the start channel and incrementing by the bin size. The velocity centroid of Binned data may vary with the start channel.

```
Smooth all quadrants?  no, to select particular quadrants
   Enter quadrants to smooth:    give list of quadrants
Enter smooth type: (H, BO, BI):  type, (size and start channel for BO,
                                 BI)
Enter smooth list:  list of registers to smooth
```

SOlve

Solves for linear polarization and Stokes parameters from a set of observations made at different feed angles. SOlve includes options to self-calibrate and to remove an instrumental term.

At least three different position angles (*posn* = *feed* + *parallactic*) are required as input. The data must be organized as a stack of registers with identical properties except for changing position angles. If two linear polarizations were observed in two quadrants, the second quad must be shifted so that it occupies the same channel range as the first (use FIXpol).

The available options are: SOlve (yes, to do the Stokes solution), "Selfcal", which scales all spectra in the list to give the same integrated flux over a selected channel range (use an unpolarized feature), and "Correct" which removes an instrumental term. The "cutoff" value is used to determine which channels should be shown in the printout and appear in the plots.

The algorithm uses a least squares solution to the function: $A = I_{\mathrm{u}}/2 + I_{\mathrm{p}}\cos^2(p_{\mathrm{ao}} - p_{\mathrm{a}})$ where A is the measured channel amplitude, I_{u} is the unpolarized intensity, I_{p} is the linearly polarized intensity, p_{ao} is the position angle of the observation, and p_{a} is the polarization position angle. The following quantities are written to six output registers as spectra, in this order (tagged by *type* for STatistics and PLot):

- `SI`: total intensity, $I = I_{\mathrm{u}} + I_{\mathrm{p}}$
- `SQ`: Stokes Q, $Q = I_{\mathrm{p}}\cos(2p_{\mathrm{a}})$
- `SU`: Stokes U, $U = I_{\mathrm{p}}\sin(2p_{\mathrm{a}})$
- `SP`: polarized intensity, $I_{\mathrm{p}} = (Q^2 + U^2)^(1/2)$
- `%P`: Percent polarization, $\%P = 100I_{\mathrm{p}}/I$
- `PA`: polarization angle, $p_{\mathrm{a}} = 0.5\tan^{-1}(U/Q)$

The quality of the data and the fit can be checked using XYplot with curve 1 overlaid. To do this, write down I_{u}, I_{p} and p_{a} for a polarized channel from the printout, and plot the amplitude of the channel against position angle (register location 5014) using the fit results as input parameters for the curve.

```
Solve, Selfcal, Correct options:  y y y, for all three options
   channel range of unpolarized feature:  unpolarized feature to
   selfcal on channel range to self-calibrate only this range is
   self-calibrated
   %Pol, position angle, feed:     instrument polarization (correct
                                   opt.)
```

```
Enter cutoff:    amplitude cutoff for polarization solution
Print Stokes spectra?:  yes, to print polarization results on screen
   All channels above cutoff ok?    yes, otherwise choose a range
      Enter channel range      channel range to print
      More printout?      yes, for more printout
Quadrants to search:  quadrants to search for points with values
more than ''cutoff''

Enter STOKES input list:  list the registers to use in solution
Enter output list:  need 6 registers to hold output spectra
```

SPotmap

Plots the x, y positions and spectrum derived using the multiple-channel fit option in POsition. It requires a `.POS` file as input.

SPotmap was adapted from another program, and it has a slightly different interactive format from other modules in spc. In order to ascend from various levels in SPotmap (e.g. from plotting to source selection) you type a dash "-".

By default, SPotmap chooses an x, y box size which is square on the sky and contains all spots. By entering your own minimum and maximum for x and y in (arcseconds) you can zoom in on specific regions of interest.

```
Enter file name (.POS):  give a filename (.POS understood)
List sources in file?  yes, gives listing of names and numbers
Enter source name or number: select by number or name (dash to exit)
Graphics device/type (? to see list, default /xdisp): device type
                             (/null to exit)
Distinguish points?  yes, plots a different character each vel.
Enter box to plot:  X,Y min.and max. (<CR> accepts default)
```

STatistics

Calculates the maximum, minimum, mean and rms amplitude over a range of channels. STatistics also gives the type of spectrum plotted, the channel number with the maximum amplitude, T_{sys} and integration time for quadrant 1.

STatistics provides statistical quantities for analysis, and also a quick way to check the spectrum type and to find the peak channel number. The spectrum types shown in STatistics (and PLot) are:

- `S` signal
- `R` reference
- `Q` quotient
- `a` average
- `q` made with Quotient
- `SI` Stokes I

- `SQ` Stokes Q
- `SU` Stokes U
- `SP` Polarized flux density
- `%P` percent polarization
- `PA` polarization angle
- `FT` NH_3 fit
- `LT` low-tau NH_3 fit
- `MT` model NH_3
- `FG` GFit fit
- `MG` Gaussian model
- `AM` XFm ampl.
- `PH` XFm phase
- `L+` positive lags (FFT)
- `L-` negative lags

```
Enter STAT list:  register list for statistics
Enter channel range:  channel range for calculations
```

Vcor

Corrects for several velocity errors due to early bugs in spectra's Doppler tracking routine. The three recognized errors are:

- A half-day time error present until 1984/07/31.
- A 1-channel error present from 1987/07/20 to 1987/09/15.
- A time-dependent error present from 1987/07/20 to 1987/09/12.

Vcor calculates the error present and corrects the spectra, either by performing a channel shift or by changing the velocity in the header. Vcor checks the observing date to determine which velocity correction (if any) is required, and applies it to the data. Vcor does not flag spectra that have been corrected, so be careful not to apply the correction more than once. Load warns of a velocity error for data with observation dates within the ranges listed above; this warning should be ignored for `SAV` files which were corrected before being written.

```
Correct Header (h) or Shift spectra (s)?  type ``h'' to fix header
                                          velocity type ``s'' to shift
Enter VCOR list:  register list to apply corrections to.
```

WRITE

Writes the contents of SPC registers to a disk file (`name.SDF`) for storage and retrieval of reduced data. Each WRITE to an existing file *appends* to that file. To load spectra back into SPC from a `SDF` file, use the record number in which the spectrum was written - not the sequence number of the original `SPC` file. A listing of the available record numbers can be obtained with DIRECTORY.

The `SDF` files are FITS binary tables files which conform to the single-dish FITS (SDFITS) convention.

```
Enter WRITE list:                 The list of registers to save
Enter filename (.SDF):            output filename (.SDF understood)
```

(W. allows NO input; the same register number is appended to the same file!)

XFM

Does a Fourier transform (FFT) on the input register list. If the transform involves real data, an amplitude and a positive lag register are required. For complex data, both amplitude and phase registers, and positive and negative lag spectra are required (4 registers).

XFM may be used to transform spectra back into the lag domain for editing simple correlator problems (reverse transform). It can also be used to generate spectra by transforming synthesized lag spectra (forward transform) for experiments, testing or convolution purposes. For a complex forward transform, the output may be either in the form of amplitude and phase or sin and cos.

XFM takes its header information from the input register list and transforms each quadrant separately; you may choose which quadrants to transform. Note that the *input* registers may be either amplitudes or lags depending on which transform direction is chosen. Be careful here; the dialogue requests AMP and LAG lists in the same order regardless of which direction was chosen. Transformed spectra are tagged type `AM`, `PH`, `L+` or `L-` depending on the kind of transform done.

The length of a transformed spectrum is equal to the number of channels in the quadrant transformed. It is possible to double the number of channels in a spectrum by extending the lag range with zeros, doubling the number of channels for that spectrum (edit the appropriate header items) and transforming back. This is sometimes useful for comparison of data taken with different channel resolutions. A spectrum extended in this way only provides finer sampling of the original spectrum - not improved frequency resolution.

```
Enter Reverse or Forward:  R (amp to lags) or F (lag to amp)
Enter Complex or Real:  C, for both amplitude and phase
   Amp/Pha to Sin/Cos?    yes, to get Sin and Cos (forward)
Enter list of quadrants to transform:  can select specific quadrants
Enter AMPLITUDE list:  registers containing channel amplitude
   PHASE list:    regs containing phase (complex)
Enter POSITIVE lag list  registers for positive lags
   NEGATIVE lag list    regs for negative lags (complex)

(X. does nothing.)
```

XYPLOT

Plots up to 10 y-axes against any x-axis chosen from the data and header array for a list of registers. For example: $T_{\rm sys}$ of all quadrants versus zenith angle; RA versus DEC; LST versus Register number; amplitude of channels 256 and 768 versus register number, etc. might be useful to plot.

In addition, up to 10 curves may be overlaid on the plots for comparison with the data. There are currently four types available:

- Plots the expected flux density of a linearly polarized source as a function of feed angle. Its input parameters are the unpolarized and polarized flux, and the position angle (from SOLVE).
- Plots a slice through a Gaussian profile in RA or DEC given the amplitude, centre coordinate and sigma of the Gaussian. This can be used to check the results of POSITION.
- Plots $T_{\rm sys}$ versus cosec(Z). It requires $T_{\rm rcv}$ and $T_{\rm sky}$ derived by the atmospheric opacity option in CALIBRATE as inputs.
- Plots (x, y) positions on any plot. It is handy for checking sky positions against observed positions (e.g. POSITION results).

If more than one y-axis is requested, the various quantities plotted are distinguished by a different plot character. If only one y-axis is requested, points plotted may be distinguished on the basis of register number (i.e. all plotted characters are different); sequence number, source name or sky position.

```
Overlay curve?  yes, to plot a curve
   How many?    number curves to plot (10 max)
   Curve type (1,2,3 or 4):    enter type of curve
   Enter curve parameters:    prompts for each curve

Enter X axis and Y axes: give X axis, and list of Y axes (10 max)
Distinguish sources?  yes, to distinguish points
   Distinguish by (r,se,so,p):    key to distinguish on
Enter XY list:    give the register list to plot
Graphics device/type (? to see list, default /xdisp):
                               select plot device(/null to exit)
Automatic scaling ok?  no, to manually set scales on X and Y
   Enter new min,max:    enter X and Y min, max.
```

ZERO

Zeros the edges of spectra for each quadrant. High values often result due to division by small numbers at the edges when forming quotients. The number of channels to zero is specified for each quadrant, and this number is zeroed at both ends of the spectrum.

```
Enter number of edge channels to zero:  give a number for each quadrant
Enter ZERO list;  list of registers to zero.
```

Part IV

SPC header items

The following is a list of header information contained in the SPC registers. These items can be examined with STATISTICS or EDIT, and plotted with XYPLOT. They are located just after the 8196 spectral channels in each register; the locations are listed below. A list of header locations can also be obtained on-line with the EDIT command.

Item	Location	Description	Units
1	8197	Sequence number in original SPC file	integer
2	8198	Feed angle (platform + RAB - 90)	deg
3	8199	Q1: Velocity, centre channel	km/s
4	8200	Q1: Velocity increment	km/s
5	8201	Q1: Integration time	s
6	8202	Q1: System temperature	K
7	8203	Local sidereal time (LST)	h
8	8204	Zenith angle	deg
9	8205	Parallactic angle	deg
10	8206	Declination or galactic latitude	deg
11	8207	Right ascension or galactic longitude	h or deg
12	8208	Q1: Number channels	integer
13	8209	RAB's K-band polarimeter position angle	deg
14	8210	Q1: System temperature of Reference	K
15	8211	Focus platform position angle	deg
16	8212	Observation date	YYYYMMDD
17	8213	Telescope identification number	integer
18	8214	Position angle (parallactic + feed)	deg
19	8215	Gain (from CALIBRATE command)	real
20	8216	Signal, Reference or Quotient	integer
21	8217	Number of quadrants	integer
22-25	8218-8221	Q1-Q4: Number channels	integer
26-29	8222-8225	Q1-Q4: System temperature	K
30-33	8226-8229	Q1-Q4: Bandwidth	MHz
34-37	8230-8233	Q1-Q4: Integration time	s
38-41	8234-8237	Q1-Q4: Velocity (channel 1)	km/s
42-45	8238-8241	Q1-Q4: Velocity step	km/s
46-49	8242-8245	Q1-Q4: Temperature of Cal	K
50	8246	Focus position	mm
51	8247	Q1: Frequency, channel 1	MHz
52	8248	Q1: Frequency increment	MHz
53	8249	Equatorial (24) or galactic (360)	h or deg
54-57	8250-8253	Q1-Q4: Frequency, centre channel	MHz
58	8254	Stokes number of first quadrant	integer
59	8255	UTC	sec
60	8256	SPC register number	integer
61	8257	Reference frame code	integer

62	8258	Doppler shift applied	real
63-64	8259-8260	reserved	(blank)