A I P S L E T T E R

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A newsletter for users of the NRAO
Astronomical Image Processing System

Written by a cast of *AIPS*

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Happy 41st birthday *AIPS* and FITS, COVID-19

The FITS format was devised in a meeting at the VLA site on March 27 and 28, 1979. Don Wells (then of NOAO) and Eric Greisen (still of NRAO) were the primary authors while Barry Clark and other NRAO staff members provided valuable suggestions. The FITS format, enhanced by later extensions, is still in wide spread use in astronomy and is the envy of other scientific fields. Then the FITS format colored the design of the *AIPS* internal formats. The *AIPS* project was begun officially on July 1, 1979 and has stood the test of time remarkably well.

Due to the outbreak of the COVID-19 pandemic, the NRAO went to "infectious disease operating status" on March 16, 2020. Telescope operations (other than ALMA) continued with a skeleton support staff. The rest of us were expected to work as best we could from home. On June 8 we began the first steps to return to the new normal. Primarily, this means that those employees who could not do their jobs properly from home have returned to work with numerous safety precautions. Those of us who can work from home will continue to do so indefinitely.

This status means that your editor does find times when he would like interesting things to do. If you find any problems with *AIPS* or have any suggestions for new or improved functions, please do not hesitate to e-mail me.

AIPSLetter publication

We have discontinued paper copies of the *AIPSLetter* entirely, at least for this issue. The *AIPSLetter* will be available in PostScript and pdf forms as always from the web site listed above. New issues will be announced in the NRAO eNews mailing and on the bananas and mnj list server.

Current and future releases

We have formal *AIPS* releases on an annual basis. While all architectures can do a full installation from the source files, Linux (32- and 64-bit), and MacIntosh OS/X (Intel) systems may install binary versions of recent releases. Binary versions for Solaris and MacIntosh (PPC) are available for the `31DEC17` release but not for later releases. The last, "frozen" release is called `31DEC19` while `31DEC20` remains under active development. You may fetch and install a copy of these versions at any time using *anonymous* `ftp` for source-only copies and `rsync` for binary copies. This *AIPSLetter* is intended to advise you of improvements to date in `31DEC20`. Having fetched `31DEC20`, you may update your installation whenever you want by running the so-called "Midnight Job" (MNJ) which copies and compiles the code selectively based on the changes and compilations we have done. The MNJ will also update sites that have done a binary installation. There is a guide to the install script and an *AIPS* Manager FAQ page on the *AIPS* web site.

The MNJ for binary versions of *AIPS* now uses solely the tool `rsync` as does the initial installation. For locally compiled ("text") installations, the Unix tool `cvs` running with anonymous ftp is used for the MNJ. Linux sites will almost certainly have `cvs` installed; but other sites may have to install it from the web. Secondary MNJs will still be possible using `ssh` or `rcp` or NFS as with previous releases. We have found that `cvs` works very well, although it has one quirk. If a site modifies a file locally, but in an *AIPS*-standard directory, `cvs` will detect the modification and attempt to reconcile the local version with the NRAO-supplied version. This usually produces a file that will not compile or run as intended. For local versions, use a copy of the task and its help file in a private disk area instead.

Improvements of interest in `31DEC20`

We expect to continue publishing the *AIPSLetter* approximately every six months, but the publication is now primarily electronic. There have been several significant changes in `31DEC20` in the last six months. Some of these were in the nature of bug fixes which were applied to `31DEC19` before and after it was frozen. If you are running `31DEC19`, be sure that it is up to date; pay attention to the patches and run a MNJ any time a patch relevant to you appears. There are six new tasks in `31DEC20`. They are `UVRMS` to compute statistics on a time series of selected averaged visibility data, `SPRMS` to plot the spectra of mean and standard deviation of selected visibility data, `MOD3D` to convert a set of facets' Clean Component files into a single "3-dimensional" `CC` table, `PDPLT` to plot polarization D-term spectra from multiple antennas and/or data sets, `DENAN` to report and remove NaNs from data sets, `MTARS` to compute rotation measure models for input to `TARS` (the test task for `FARS`), and `RMTFC` to plot the convolution of the complex rotation measure transfer function with various RM thickness models. Further enhancements to rotation-measure analysis and another task to print `SY` table data are on the near horizon.

`31DEC20` contains a change to the TV display program `XAS` that makes it incompatible with previous releases when characters are displayed. `31DEC14` contains a change to the "standard" random parameters in *uv* data and adds columns to the `SN` table. Note, however, that the random parameters written to FITS files have not been changed. Older releases of *AIPS* cannot handle the new *internal uv* format and might be confused by the `SN` table as well. `31DEC09` contains a significant change in the format of the antenna files, which will cause older releases to do wrong things to data touched by `31DEC09` and later releases. You are encouraged to use a relatively recent version of *AIPS*, whilst those with recent VLA data to reduce should get release `31DEC19` or, preferably, the latest release.

UV-data

`RLDLY`

A serious error was found that has been in the code since March 2015! If the visibility data were described with the "new" random parameters `ANTENNA1`, `ANTENNA2`, and `SUBARRAY` rather than the older compound `BASELINE`. then the only data used in the solution were those in which the reference antenna was the higher numbered. Thus reference antenna 1 would never have data. Since `RLDLY` can combine data from all baselines to the reference antenna, this bug caused it to omit anywhere from all to none of the desired data depending on the reference antenna number. `RLDLY` worked fine for any old format data sets, but, by now, they are no longer common.

UVFIX

The differential aberration correction requires the comparison of the apparent position of the source to the apparent position of a point 10 asec North. Since we treat the apparent position as fixed during the run (it actually isn't), we need to do this comparison only once at the same time that we compute the source apparent position. In `31DEC18` and previous, this was done but only for the first source (with the result used for all sources). In `31DEC19` and `31DEC20`, the comparison was recomputed every time a source changed which put a time change in the offset position but not the reference position. This made the correction a (false) function of time. Furthermore, when the input file was in B1950, the `EPOCH` variable did not stay at 2000 for this comparison. This could make the aberration correction a factor of 200 rather than 0.99992! All these issues have been corrected with the aberration correction now a function of source but not time (except for planets).

Calibration models

Some model images of the standard calibration sources with Clean Component tables are shipped with *AIPS*. Rick Perley has, however, a very large set of such models for more sources and with better frequency discrimination. Access to these, from Rick's web sites, has been added. Verb `CALDIR` will list them and `CALRD` will load them into your data catalog.

Models for known sources scale the source-table fluxes by the flux found within a central circle, ignoring Clean components outside. That circle was too small and has been increased a bit. New sources, suitable for calibration at low frequencies, were added to this algorithm (3C123, 3C196, 3C295, and 3C380).

Models at low frequency require making images over a rather wide field. In *AIPS* this is done with multiple overlapping facets. If one has all the facets and their "2-dimensional" `CC` tables, the modeling routines use the facet coordinates to compute a correct model for the data. Shipping a large number of facets is however prohibitive. Therefore a new task `MOD3D` was written. It does the conversion of the "2-D" tables into the "3-D" form needed by the modeling code and then writes a "3-dimensional" `CC` table. All *AIPS* use of these tables was modified to handle the multiple formats that now arise.

Miscellaneous

CLCOR got confused on `OPCODE = 'EOPS'` when the input `CT` table had multiple nearly identical entries. This arises when `FITLD` concatenates multiple data sets. A simple fix allows this identical groups case to work along with the more complex cases with non-identical groups.

The header for visibility data now keeps track of the application of calibration (`DOCAL`, `DOBAND`, and `DOPOL`). This information will be displayed by `IMHEADER` and is used to decide if warnings about a lack of polarization calibration are appropriate.

CLIP now reports the fraction of data flagged for each IF and polarization. The counts of flagged cross-hand polarizations were corrected.

EDITR and other interactive editing tasks were changed to allow the user to enter only those values needed rather than requiring the maximum number of values at all times.

BPEDT was given the option to set the initial plot ranges when starting up.

ELINT was given the options to color the symbols by source, to plot all the data (not just that time range used to in the fitting), and to control the plot range.

DENAN is a new task to replace NaNs (if any) in a data set with zeros.

EVAUV was corrected to take into account changes made to lower level Q routines last year.

UVHOL was given the option to fit the peak and the sidelobes on each side and then to display the fit values and their ratio.

PRTSY was changed to sort both new and old format `SY` tables correctly.

VLBI

APCAL now appends new solutions to a pre-existing `SN` table rather than replacing such tables. A new `PLOT OPCODE` is available to plot the model in `TRECVR` and `TAU0` with no model fitting.

DELZN was changed to pass its reference date to `CLCOR` in case the reference date of the data set is different.

Display and analysis

`XAS` and new tasks

The TV server program was changed to allow an intensity value when writing characters to the display. This enables the use of color in standard plot characters through a new subroutine (`G3CHAR`). The new task `PDPLT` uses this capability. It over-plots spectra of polarization D terms from multiple antennas and up to four different data sets. Color is used to distinguish antennas and data sets and a plot label shows the colors used for each antenna. `PDPLT` is being used to study the polarization characteristics of the VLA's receivers.

New task `UVRMS` averages selected visibility data in a sequence of time intervals. It then conducts a statistical analysis of the time sequence, printing mean, standard deviation, median, first and third quartiles, median absolute deviation, maximum, minimum, and more. In order to determine whether these statistics are valid, the task offers the option to plot a histogram of the data and to plot the values as a function of time. A companion task `SPRMS` has also been written. It does a similar average to that in `UVRMS` but keeps spectral channels and IFs separate. It then makes spectral plots of the mean and standard deviation.

`XGAUS` and friends

`XGAUS`, `ZEMAN`, `RMFIT`, `AGAUS` and `ZAMAN` received a variety of mostly minor improvements. In the edit window, which appears after the initial fitting of the models to the spectra, the type and extrema of any displayed image are shown in the header to the menu. That menu now includes an option to `RESET WINDOW` to change the image display to its maximum extent and the option `LABEL WEDGE?` to turn on/off intensity labeling of the step wedge. In model fitting, the initial guess is now limited to those components that were fit in the previous spectrum. This saves work constantly telling the task not to fit one or more components when that is appropriate. This is particularly important in `ZEMAN` when using the Gaussian model. Numerous other minor bugs and features were addressed. The new menu appearance was documented in revised versions of *AIPS* Memos 118 and 122.

Miscellaneous

KNTR and `PCNTR` now have the adverb `PVPLOT` to request a plot of a polarization vector within a box located in one of the corners. The length of this vector in Jy/beam appears in one of the plot label lines.

EXTLIST lists the contents of extension files in some detail. It was updated for changes in some plot tasks and to add tasks that were missing including the new plot tasks.

PLGET is a verb that will get the adverbs used to make a particular plot file. It was updated for missing and new tasks and changes in older ones.

CLPLT and `CAPLT` were corrected to work when there is only one sample. They now include the model when setting the default plot range.

TARPL was changed to plot the input files to `TARS` as well as the outut files.

MTARS is a new task similar to `MODIM` to compute models of polarization in a form suitable for input to `TARS`, the Faraday rotation measure synthesis test task.

RMTFC is a new task to convolve the (complex) rotation measure transfer function with various simple models of RM thickness.

General

Compilation procedures were changed to avoid an issue that prevented the compilation of `XAS` during installation.

fix_aips_elcap was renamed and `install.pl` changed since Mac users often thought that the fix applied only to the El Capitan (10.11) version of the operating system. It applies to all versions $\geq$ 10.11.

Help files were written for adverbs that lacked same. Further improvements to adverb help files are in progress.

CookBook updates were made for the new calibration models and new tasks as well as other changes described above.

Patch Distribution for `31DEC19`

Important bug fixes and selected improvements in `31DEC19` can be downloaded via the MNJ or from the Web beginning at: `http://www.aoc.nrao.edu/aips/patch.html`
Alternatively one can use *anonymous* `ftp` to the NRAO server `ftp.aoc.nrao.edu`. Documentation about patches to a release is placed on this site at `pub/software/aips/`*release-name* and the code is placed in suitable sub-directories below this. As bugs in `31DEC20` are found, they are simply corrected since `31DEC20` remains under development. Corrections and additions are made with a midnight job rather than with manual patches. Because of the many binary installations, we now actually patch the master version of `31DEC19`, meaning that a MNJ run on `31DEC19` after the patch will fetch the corrected code and/or binaries rather than failing. Also, installations of `31DEC19` after the patch date will contain the corrected code. The `31DEC19` release has had a number of patches:

1. `BPASS` had a bad call sequence causing aborts. *2020-01-22*
2. `FACSET` did not include all the flux of standard calibration source models. *2020-01-27*
3. `UVFIX` did not compute the aberration correction properly, especially when converting from B1950 to J2000. *2020-02-28*
4. `EVAUV` did not compute the DFT subtraction model correctly, aborting due to a call sequence error. *2020-03-02*
5. `RENUMBER` aborted if the catalog file required expansion. *2020-03-03*
6. `CLIP` over counted cross-hand flags when cross-hands are flagged because of parallel hands. *2020-03-25*
7. `CLPLT, CAPLT` died when trying to self-scale plots with only one point. *2020-04-07*
8. `VLBAUTIL`had an error when trying to use curl to fetch the EOP file. *2020-04-21*
9. `VLBARUN` had 2 errors when trying `DOPLOT=2` to make a very large number of plots. *2020-05-07*
10. `RLDLY` had an error when selecting data. *2020-06-10*
11. `PRTSY` sorted on the wrong column when `OPCODE` was set. *2020-06-12*
12. `CLCOR` got confused on `EOPS` when the `CT` table had multiple nearly identical entries. *2020-06-19*
13. `OMFIT` had 3 `FORMAT` statements that were improper when writing to character string variables. *2020-06-29*

Recent *AIPS* Memoranda

All *AIPS* Memoranda are available from the *AIPS* home page. *AIPS* Memo 117 was revised to describe changes to the Clean Components table, Memos 118 and 122 were revised to show new interactive options in the edit stage of operation.

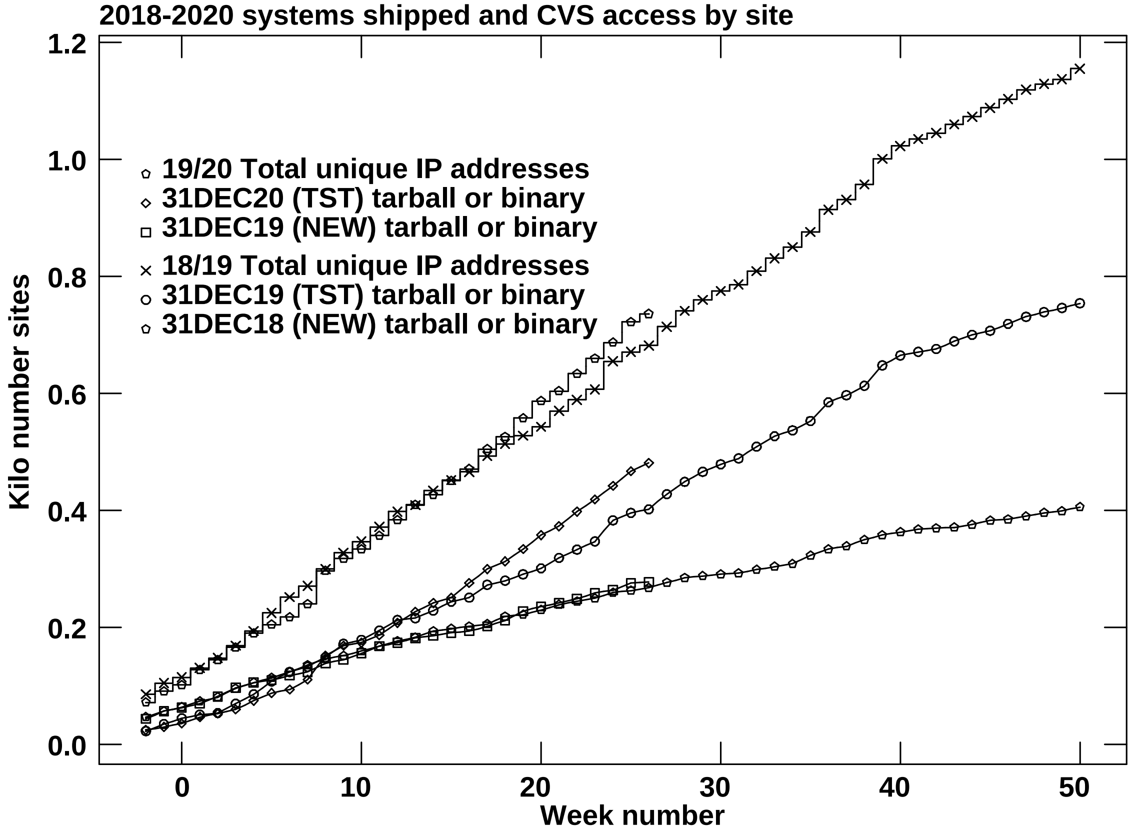
117 ***AIPS* FITS File Format**
Eric W. Greisen, NRAO
March 12, 2020 revision
AIPS has been writing images and *uv* data in FITS-format files for a very long time. While these files have been used widely in the community, there is a perception that a detailed document in still required. This memo is an attempt to meet that perception. *AIPS* FITS files for *uv* are conventions layered upon the standard FITS format to assist in the interchange of data recorded by interferometric telescopes, particularly by radio telescopes such as the EVLA and VLBA.

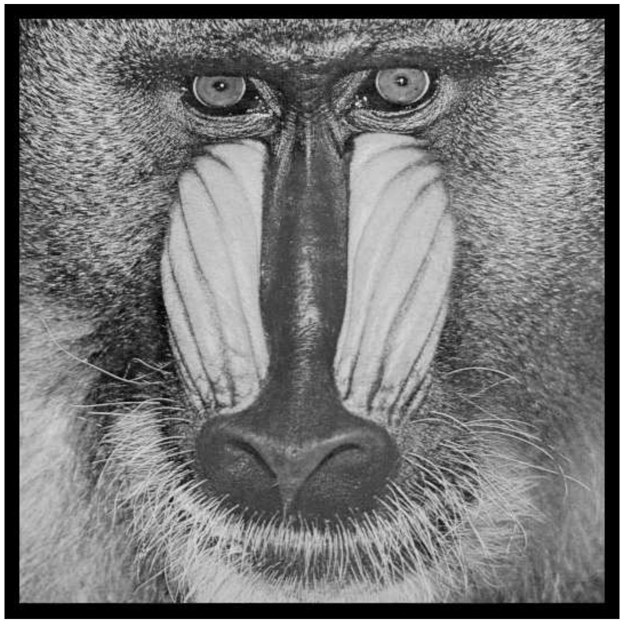
118 **Modeling Spectral Cubes in *AIPS***
Eric W. Greisen, NRAO
May 6, 2020 revision
AIPS has done Gaussian fitting along the x-axis of image cubes with task `XGAUS` since the 1980s. That task has recently been overhauled to be much easier to use and much more capable. In like fashion, new tasks `ZEMAN` and `RMFIT` have been developed. The former fits the standard leakage and scaling terms for Stokes V cubes, including a new option to do this for each of the Gaussians found by `XGAUS`. The latter fits polarization models to Stokes Q and U cubes, using the output of Faraday Rotation Measure Synthesis (*AIPS* task `FARS`) to assist with initial guesses. The models can contain multiple components each with a polarization flux, angle, rotation measure, and rotation measure "thickness." The present memo will describe the functions of these tasks in some detail with numerous graphical examples. A revision of this memo discusses changes made for the `31DEC15` release and two new tasks to plot spectra with model fits and a number of tasks which make visibility and image model files. The November 2017 revision includes new display options in `RMFIT`.

122 **Modeling Absorption-line Cubes in *AIPS***
Eric W. Greisen, NRAO
May 6, 2020 revision
AIPS does Gaussian fitting of spectral lines with recently-overhauled task `XGAUS` and can fit V polarization image cubes for Zeeman-splitting with the relatively new task `ZEMAN`. Both of these tasks are designed for emission spectra in which the noise is not a function of spectral channel. In absorption, however, the noise in optical depth becomes high when the optical depth is high. Therefore, new tasks `AGAUS` and `ZAMAN` have been written to provide similar functions but with mathematics suitable for absorption lines. This memo describes the new tasks in some detail and includes a description of a new, simplified modeling task `MODAB` which may also be useful. That task has shown that the results of these four tasks are biased by the presence of the Zeeman splitting and need modest correction if they are meant to describe the actual pre-splitting line widths and magnetic field.

AIPS Distribution

We are now able to log apparent MNJ accesses and downloads of the tar balls. We count these by unique IP address. Since some systems assign the same computer different IP addresses at different times, this will be a bit of an over-estimate of actual sites/computers. However, a single IP address is often used to provide *AIPS* to a number of computers, so these numbers are probably an under-estimate of the number of computers running current versions of *AIPS*. So far in 2020 more than 278 IP addresses have downloaded the frozen form of `31DEC19`, while more than 481 IP addresses have downloaded `31DEC20`. A total of 736 different IP addresses have appeared in one of our transaction log files. These numbers are noticeably higher than those of last year at this time.





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