

AMSSpin - A LabVIEW Program for the Kappabridge KLY-4S and KLY-3S

Introduction

AMSSpin is a graphical-based program for acquiring anisotropy of magnetic susceptibility (AMS) data with the Kappabridge KLY-4S or KLY-3S. The principal advantages of the program are the real time display of susceptibility data acquired during a spin and the display of bestfit 2D and 3D models to the data (and the resulting residuals). These data allow the user to evaluate instrument drift and the signal to noise ratio and to identify errors resulting from misorientation or poor centering of the sample. Eigenvectors for the current sample can be plotted together with previously measured data (in a variety of coordinate systems) to allow evaluation of within site consistency. The processing of data differs from that of the SUFAR program supplied with the instrument, both in terms of analyzing data from a single spin as well as in the determination of the six independent elements of the bestfit tensor (see Gee et al., 2007). Finally, we have designed a cubic sample holder for core samples that allows more reproducible positioning of the sample in three orthogonal orientations.

While AMSSpin provides a user friendly environment for acquiring AMS data, the program does not have all the functionality of the SUFAR program provided with the Kappabridge. In particular, susceptibility variations with temperature and with applied field are not implemented although different applied fields can be used (obviously with the KLY-4S only) for AMS measurements. Also note that the amount of error checking with AMSSpin is more limited than for the SUFAR program. While the program should report errors (e.g. due to belt tension, optical sensor failure) these features have not been tested. The output of the program differs from that of the SUFAR program as well. The standard output is principally the six independent elements of the tensor (in geographic coordinates) and an error estimate since statistical parameters and eigenparameters in other coordinate systems are easily calculated. A variety of other more voluminous output formats are available although these generate several files per sample and are probably not desirable for normal use. The LabVIEW source code is suitable for a variety of platforms but at present the program is available only for the Macintosh.

Installation

Installing the program requires the following:

- AMSSpin program
- Calibration file(s) - see below
- Macintosh running OSX. The program has been tested on a few different types of G4s (a universal binary suitable for the Intel-based Macs will be released shortly)
- Keyspan USB to serial adaptor and driver. I recommend the latest (2.4) driver, which is available from <http://www.keyspan.com/downloads>
- Labview 8.2.1 Run-time library for OSX (available at no cost from National Instruments). From <http://www.ni.com> select "Drivers and Updates" under "Product Support". In the search boxes, select:

- Product Line: LabVIEW
- Software: LabVIEW Run-time Engine
- Software Version: 8.2.1
- Operating System: Mac OS X
- VISA Run-time library 4.1 for OSX (available at no cost from National Instruments). From <http://www.ni.com> select "Drivers and Updates" under "Product Support". In the search boxes, select:
 - Product Line: VISA
 - Software: VISA Run-time Engine
 - Software Version: 4.1
 - Operating System: Mac OS X

Install the Labview and VISA Run-time libraries and the Keyspan driver. You will then need to restart your computer for LabVIEW to properly recognize the serial ports on your computer.

The AMSSpin program requires one (for KLY-3S) or two (for KLY-4S) files to be located in the same folder as the program. These files contain the information on the default calibration data and the calibration values for various fields used for the KLY-4S. These files are read in at startup and are modified by user calibrations. The names of the files are hardwired in the program (SUFAR.SAV and CALKLY4S.SAV) and have the same structure as the files provided with the Kappabridge and modified by the SUFAR program.

The CALKLY4S.SAV file has the following format:

```

USER CALIBRATION : 300 A/m 06-24-2006 16:11:48
 0      2.0 148.67412 149.12283 U
 1      4.0  74.33706  74.56142 U
 2      6.0  49.55804  49.70761 U
 3      8.0  37.16853  37.28071 U
 4     10.0  29.73482  29.82457 U
 9     20.0  14.86741  14.91228 U
14     30.0   9.91161   9.94152 U
19     39.5   7.52780   7.55052 U
24     49.5   6.00703   6.02516 U
29     59.8   4.97238   4.98739 U
34     69.2   4.29694   4.30991 U
39     79.4   3.74494   3.75624 U
44     89.3   3.32977   3.33982 U
49     98.9   3.00655   3.01563 U
74    148.6   2.00100   2.00704 U
100   200.1   1.48600   1.49048 U
125   250.2   1.18844   1.19203 U
150   300.0   0.99116   0.99415 U
175   350.2   0.84908   0.85164 U
200   400.1   0.74318   0.74543 U

```

226 452.3 0.65741 0.65940 U

where the columns are: potentiometer setting, actual field (A/m), bulk gain, anisotropy gain. This file will be available only for Kappabridge KLY-4S units.

The SUFAR.SAV file includes a number of default values and has the following format:

1	COM	
.1400	ETALB	
.9911608	GAINB	
.02715	ETALA	
.9941522	GAINA	
-21.57594	DELTA	
-5.051529E-06	HOLDER	
0	HOLDERC	
0	HOLDERS	
10.00	ACT VOL	
2	factory set	

Prior to using the program you will need to convert your existing files to Macintosh files (using BBEdit or a comparable text editor) if you want to preserve the nice formatting. The values (ETALB = maximum; ETALA = minimum) for the standard provided with your instrument will be different than those above. The gain values are for a default field of 300 A/m. This field value is set during startup (for the KLY-4S) or factory set (for the KLY-3S). The gain values in this file will be modified only if the user calibrates with a field of 300 A/m. For other field settings, the gain values are used internally in the program but the SUFAR.SAV file is unchanged. The anisotropy values for the sample holder (HOLDERC, HOLDERS), com port, and factory set gain value (2) are not used in the AMSSpin program.

CAUTION: You must calibrate the instrument using the AMSSpin program prior to use as the phase lag (delta) will differ from that with the SUFAR program. There is apparently a bug in the SUFAR program that results in an additional phase shift of 5.625° (one notch). This generates no problems with the data from the SUFAR program since the same phase shift is applied to the standard and unknowns.

Startup

When AMSSpin is started (by double clicking), the graphical interface will appear but the program will not yet be running. This is to allow a few variables (including the serial port, output mode) to be set. Once selected these values will remain in effect until the program is restarted, i.e. if you want to change the type of output you'll need to restart the program. The upper left hand portion of the interface will look like



Select the serial port:

This is perhaps the least intuitive aspect of the program. Although LabVIEW is platform independent, it is primarily used on Windows machines and there are a few items that do not port well to the Mac. The serial ports are listed as VISA resources with the prefix ASRL* (VISA includes other types of I/O such as GPIB) and it is not obvious which of the choices in the pulldown menu is the correct one. The simplest way to sort this out is to start the program once without the Keyspan device plugged in. Examine the numbers of the ports available (which will include internal modem, Bluetooth etc.). Quit the program, insert the Keyspan device and then restart the program. Now if you examine the list of available VISA resources the new one will be the one you need to select.

Select data acquisition or simulation:

If you want to try out the program without actually collecting data, position the hand selector over the toggle switch and set to "Simulate KLY4S". Using some test files (see below) you will be able to explore the program operation without actually having the Kappabridge connected. To collect data, simply leave the toggle set to the default position of "KLY4S Attached".

Select the output type:

"Tensor"

The default output type is "Tensor", which provides a minimal amount of data as a single output line with the following:
 sample, k_{11} , k_{22} , k_{33} , k_{12} , k_{23} , k_{13} , sigma, bulk, crossover, phase, field (A/m), volume (cc), sample holder, date, time, user

where the six independent elements of the tensor and sigma are *trace normalized*. The bulk susceptibility is in SI units, assuming the volume given. The crossover value is the misfit (in SI units) of the three spins of

data after adjusting each spin by the bestfit offset to minimize the misfits at crossovers. The phase lag and applied field values are also recorded and the date and time of the measurement.

"Raw"

In addition to the tensor output above, this format generates a separate file (*sample.raw* for each sample) with the measured spin data and the bulk measurement as an $n \times 4$ tab-delimited file. For range 1, n is 8 revolutions $*64 + 12$ or 520 with fewer spins for higher ranges (5 revolutions on range 4). The bulk data are padded by zeros, as are any spins at higher ranges if multiple ranges are used during the measurement of the three spins. These "raw" data are not the raw two-byte integers from the instrument, but rather are scaled to SI values (zero mean for each spin and baseline corrected for the bulk data) so that range, phase angle and calibration data need not be stored.

"All"

In addition to the tensor and raw data output above, this format generates two additional files (*sample.2D* and *sample.3D*) for each sample. The *sample.2D* file contains 64 rows and $3*(nrevolution + 3)$ columns. The first n revolution columns for each spin are the data used for stacking. The following three columns are the mean and standard deviation of these n revolutions and the bestfit 2D model. All 2D data are in SI units and correspond to the 2D data displayed during data acquisition. The *sample.3D* file is 64×9 , with the mean data, bestfit 3D model, and residuals for each of the three measurement positions. The mean data, bestfit 3D model and residuals are trace normalized values and correspond to the 3D model and residuals displayed after data acquisition is complete.

Select the interpolation type:

This selects the method used to resample the data from multiple spins at 64 evenly spaced intervals (starting at 0°). All three methods give very similar sigma values for the final tensor.

"Linear"

"Spline" - Default (cubic spline interpolation)

"Phase" - Apply phase shift in frequency domain.

Starting and stopping the program:

When the parameters above are selected, press on the open white arrow (top left of figure above) to start the program (the arrow becomes black when the program is running).

CAUTION: To stop the program, please use the red stop button (which gracefully closes the serial port) rather than the red stop sign next to the run arrow.

Modes of Operation

AMSSpin functions primarily as keystroke driven program, i.e. most interactions with the program will be initiated with a keystroke. Nearly all the displays on the front panel are indicators (which display data but cannot be changed by the user). The only exceptions are the selectors for the type of display, coordinate system and search width which are all located above the equal area plot.

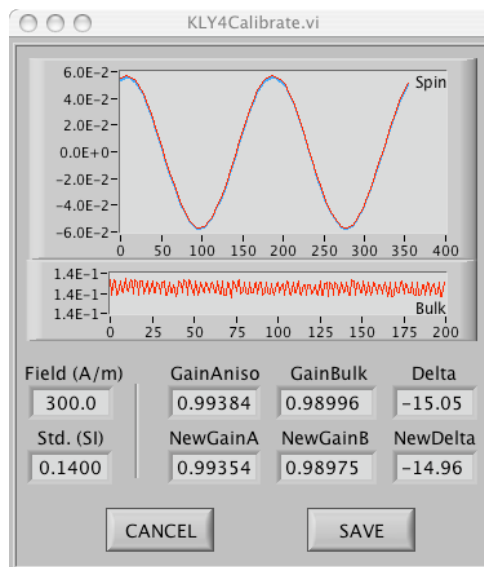
There are three modes of operation: Menu Mode, Measurement Mode, and Data Mode. A light blue bar indicates which mode is currently active.

Menu Mode:

"b" Set Field - Displays dialog allowing user to select applied field (2-450 A/m). The corresponding gain values for this field replace the current gain settings. Available only with KLY-4S.

"c" Calibrate - Calibrate using the current field setting. This command brings up a modal window (shown below) that will display the bulk and spin data used for calibration as well as previous values. Valid calibration data must be within 25% of the stored values.

CAUTION: Load the standard in position 1 before selecting calibrate.



"f" Filename - Select tensor output file. You will be prompted for whether this is an existing or new file. Note that existing data need only have the sample, 6 tensor elements in the order above as the first seven values in each record (additional data in the record are ignored).

"h" Save/Discard Sample Holder - After a successful measurement has been completed you may save the sample holder value for use in subsequent measurements. This selection is a toggle, as indicated by the "Save SH" indicator below ("NEW" indicates that a sample holder will need to be measured for the subsequent sample; "OLD" indicates that the stored scalar sample holder value will be subtracted from all subsequent measurements). If an "OLD" sample holder value has been stored, "h" will discard this holder value and set the "Save SH" to "NEW". Conversely, if "Save SH" is currently "NEW" and a valid sample holder measurement is available (as indicated by the blue SH boolean) then this sample holder value will be stored and "Save SH" will be set to "OLD". A valid sample holder value must be between -1.5×10^{-5} and 0 (SI).

SaveSH	Holder	SH	1	2	3	B	Field (A/m)
NEW	0.00E+0	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	300.0
gainaniso	gainbulk	delta (deg)		vol (cc)			
0.99415	0.99116	-21.58		10.00			

"n" New Sample - Brings up a dialog box to allow entry of new sample name and switch to measurement mode.

"o" Orientation File - Load an orientation file. The orientation information for the sample may be specified in one of two formats (AzDip, LabAz). Both files have the same format: sample, azimuth, plunge, bedding strike, bedding dip (where the convention is the dip is to the right of strike). The azimuth and plunge for the sample orientation in space are either:

AzDip convention: azimuth and dip of the sample +z axis

LabAz convention: azimuth and dip of the sample +x axis

See the figure illustrating the spin positions below for an illustration of the AzDip (black arrow in direction of drill, corresponding to the +x3 or +z axis) and LabAz (red arrow, corresponding to the +x1 or +x axis) conventions. The sample orientation data are matched to the current sample name according to the following rules. If an exact match (case insensitive) is found in the orientation file, these data are used. If no exact match is found, the final character of the sample name is stripped off and a match is sought. If this returns no match then the sample is regarded as unoriented and all coordinate systems are equivalent. After

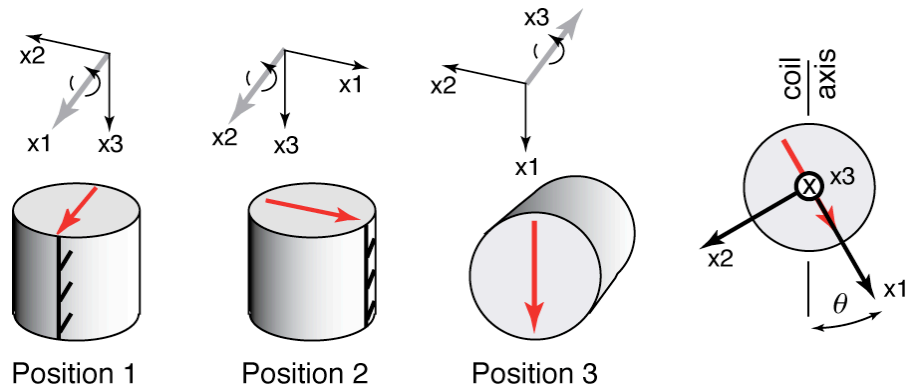
the file is loaded, you will be prompted for whether to use the file as a prompt file. This obviates the need for typing the sample names but can only be used if all specimens have a unique match in the orientation file.

"r" Repeat Sample - Change to measurement mode using the previous sample name.

"u" User - Brings up a dialog box to allow entry of user name, which is appended to the output record.

Measurement Mode:

A complete measurement consists of a sample holder bulk measurement (or a valid saved sample holder value), three spins in the three positions shown below, and a bulk measurement in position 3. A prompt string above the plots for the spin data shows what the upcoming measurement will be.



CAUTION: Several other combinations of 90° rotations will yield internally consistent (but incorrect) tensors.

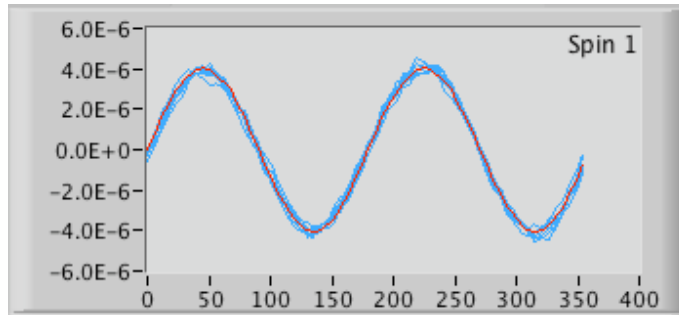
"m" Menu - Return to the menu mode. Note that already acquired data will remain displayed until the menu mode is exited (by either "n" or "r").

"p" Previous - Clears the last measured position (a keystroke is necessary to initiate the next measurement). This keystroke can be used to back up to any previous measurement (excluding the sample holder if a stored value is being used).

"s" Start Over - Clear all data for this sample and start over with first measurement (either sample holder or spin 1).

"any" Next Measurement - Any other keystroke than "m", "p", "r", or "s" while in measurement mode causes the next measurement to be taken.

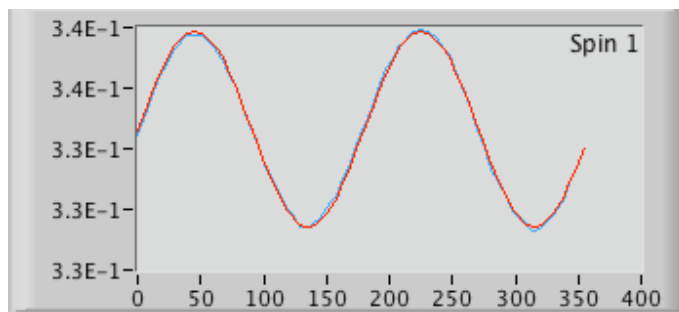
For each measurement, the raw data will be displayed as they are being acquired. Following completion of a spin, the raw data are processed (see Gee et al., 2007) and the n revolutions of data (light blue) and the bestfit 2D model (red) to these data are displayed (see below).



When all measurements are completed, the program switches to Data Mode for final processing and display.

Data Mode:

Upon completion of all three spins and the bulk measurement, the 2D spin data and model will be replaced by the final scaled data (blue; means of the n revolutions in each position) and 3D model (red).



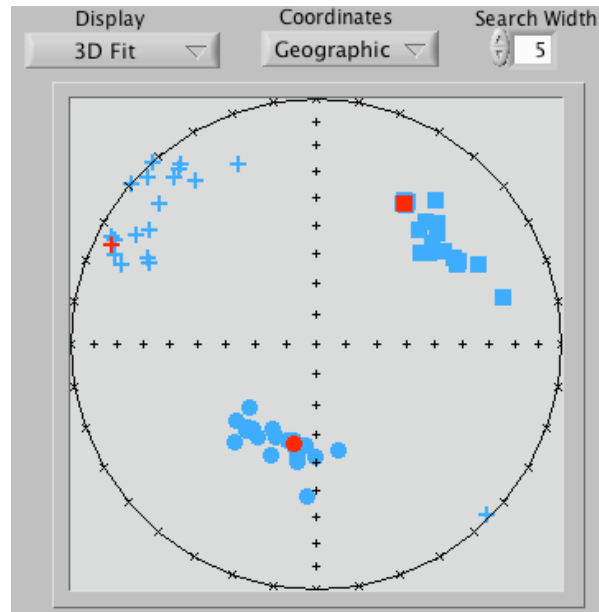
The accompanying statistical information (using linear perturbation analysis as described in Gee et al., 2007) and eigenvectors associated with the

max	int	min	sigma	Bulk (SI)		
0.33854	0.33150	0.32996	8.11E-5	4.180E-4		
F	F12	F23	E12	E23	E13	
2542.07	3762.25	180.37	0.8	3.7	0.7	
L	F	Pprime	T	CrossOrig	CrossFix	
1.021	1.005	1.028	-0.637	2.03E-6	2.26E-10	
coord.	Dec	Inc	Dec	Inc	Dec	Inc
samp	112.3	41.7	286.0	48.2	19.5	3.2
geog	31.5	32.5	296.0	8.5	193.1	56.1
strat	211.7	24.1	307.0	11.6	60.6	62.9

principal eigenvalues are tabulated in sample, geographic and bedding (stratigraphic) corrected coordinates. The critical values (at the 95% confidence level) for the F tests also remain the same. The susceptibility tensor is statistically isotropic if $F < 3.4817$ and is statistically oblate if $F_{12} <$

4.2565 or statistically prolate if $F_{23} < 4.2565$. The semi-angles of the error ellipses for the eigenvectors are E_{12} , E_{23} , E_{13} .

Finally, the principal directions for the current sample (red) and previously measured specimens with the same "Search Width" initial characters the same as the current sample are shown in light blue. Squares, plus symbols and circles denote the eigenvectors associated with the maximum, intermediate and minimum eigenvalues, respectively. The Display, Coordinates, and Search Width selectors may be used to review earlier steps in the data processing or to view the principal directions from a different selection of samples or in different coordinate systems.



"d" Discard Data - Discard data and return to the Menu Mode.

"m" Modify - Modify the sample name. Changes in the sample name will update the plots accordingly.

"r" Remeasure - Remeasure a particular position. You will be prompted for the position to remeasure (the data for this position will be cleared but a keystroke will be needed to initiate the measurement). The resulting data will be reprocessed after completion of this measurement.

"s" Save Data - Data in the selected output format(s) are written to the output file(s) and these data are also added to the array of previous results in memory (for subsequent plotting).

CAUTION: If position 3 has been incorrectly measured you will need to remeasure both position 3 and the bulk measurement.