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Memorandum

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1 Spin Valve related functions used in LEM

1.1 Skewed Lorentzian

The skewed Lorentzian asymmetry is defined as

$$A(t) = A_0 \frac{1}{N} \sum_{j=0}^{M} \frac{1}{1 + \left[\frac{B_j - B_{\text{ext}}}{\beta(1 \pm \Delta)}\right]^2} \cos(\gamma_\mu B_j t + \phi), \tag{1}$$

where the sign of $\pm\Delta$ is '+' for $B_j > B_{\text{ext}}$ and '−' for $B_j < B_{\text{ext}}$. The norm N is

$$N = \sum_{j=0}^{M} \frac{1}{1 + \left[\frac{B_j - B_{\text{ext}}}{\beta(1 \pm \Delta)}\right]^2}. \tag{2}$$

M is the number of field values which can be adjusted by the user (see file `spinValve_startup.xml` tag `number_of_fields`). The spacing between B_j's is different for $B_j < B_{\text{ext}}$ and $B_j > B_{\text{ext}}$, namely

$$\Delta B_\pm = B_j - B_{j+1} = R \cdot \beta(1 \pm \Delta), \tag{3}$$

where R is a user adjustable parameter, set to a default value of $R = 10$ (see file `spinValve_startup.xml` tag `range`).

According to the supplementary material of [1], the value $R = 7$ has been chosen, no information is given for M! These numbers need to be evaluated somehow. In order to be able for the user to tweak these parameters they were out-sourced into file called at the startup of the fit (for details see Sec.1.1.1).

To test this I generated a synthetic data set (`09001.root`) which can be used to check the needed number of M. R has been fixed to 10 (not 7, as in [1]) since the Lorentzian has quite extended wings. The synthetic data set follows the function

$$A(t) = A_0 \exp(-\lambda t) \cos(\gamma_\mu B_{\text{ext}} t + \varphi) \tag{4}$$

with $A_0 = 0.22$ per segement (in the following fit results 2 segments will be combined and hence A_0 reduced to 0.2), $\lambda = 0.5\,(1/\mu\text{sec}) \Rightarrow \beta = 5.87\,(\text{G})$, $B_{\text{ext}} = 200\,(\text{G})$.

M	Asymmetry	β (G)	Δ	B_{ext} (G)	χ^2
7	0.121(6)	2.25(3)	+0.01(1)	200.18(6)	6.703
37	0.191(1)	5.85(7)	−0.00(2)	200.10(9)	1.317
67	0.191(1)	5.86(7)	−0.00(2)	200.10(9)	1.317
97	0.191(1)	5.86(7)	−0.00(2)	200.10(9)	1.317

Table 1: Parameters obtained for the synthetic exponetially damped signal (`09001.root`).

M	Asymmetry	β (G)	Δ	B_{ext} (G)	χ^2
7	0.050(1)	20.6(2)	0.55(1)	191.5(2)	2.564
37	0.111(2)	12.4(3)	0.20(2)	194.7(3)	1.262
67	0.123(2)	17.1(7)	0.42(3)	196.5(3)	1.197
97	0.126(4)	19.0(1.0)	0.48(4)	197.0(5)	1.190
127	0.127(3)	19.8(9)	0.50(2)	197.1(4)	1.187
157	0.128(3)	20.1(1.0)	0.51(3)	197.2(4)	1.187
187	0.128(3)	20.5(8)	0.52(3)	197.3(4)	1.186
207	0.129(3)	20.5(1.0)	0.52(3)	197.4(4)	1.186

Table 2: Parameters obtained for 2012 run 4966.

From Tab.1 and 2 it is quite obvious that M needs to be adopted to the problem. The default settings will be: $M = 201$ and $R = 10$.

1.1.1 Skewed Lorentzian — how to call it from `musrfit`

The source code for the user function can be found under `<musfit-home>/src/external/libSpinValve`, where also this description is found. The file `spinValve_startup.xml` (see Appendix A.1) should be place in the directory where the analysis takes place. It holds the value for M (see tag `<number_of_fields>`) and R (see tag `<range>`).

To call the user function from the msr-file you need a in the `THEORY` block a line like

```
userFcn  libPSpinValve.so PSkewedLorentzian 4 2 3 map1
```

The parameters for this function are `PSkewedLorentzian <B_ext> <beta> <Delta> <phase>` where `<B_ext>` is the applied field, `<beta>` is the width β as given in Eq.(1), `<Delta>` is the skewness Δ, and `<phase>` is the detector phase.

In the directory `<musfit-home>/src/external/libSpinValve/test` some example files are given.

A Technical description for the skewed Lorentzian

A.1 The file `spinValve_startup.xml`

```
<?xml version="1.0" encoding="UTF-8"?>
<spin_valve_proximity xmlns="http://nemu.web.psi.ch/musrfit/libSpinValve">
  <comment>
    $Id$
    number_of_fields: number of sampling points in field around the Lorentzian peak
    range: range in which the sampling points are placed, given in units of \beta(1\pm\Delta)
  </comment>
  <skewed_lorentzian_parameters>
    <number_of_fields>251</number_of_fields>
    <range>10.0</range>
```

```
  </skewed_lorentzian_parameters>
</spin_valve_proximity>
```

A.2 msr-file example section for the skewed Lorentzian

```
SV1139, 0mV, FC T=24.99 K, E=15.85 keV, B=~194(G)/6.00(A), Tr/Sa=16.51/0.00 kV, RAL-RAR=-0.26 kV, SR=-10.00
##################################################################
FITPARAMETER
#       Nr. Name        Value     Step      Pos_Error Boundaries
         1 Asy          0.1284    -0.0034     0.0023      0       none
         2 Beta         20.47     -1.26       0.72
         3 Delta        0.516     -0.031      0.022
         4 Field        197.27    -0.44       0.34
         5 N0_L         963.74    -0.87       0.86
         6 Bkg_L        12.81     -0.15       0.15
         7 Phase_L      2.3       -1.3        1.3
         8 alpha_LR     1.1659    -0.0014     0.0014
         9 Bkg_R        16.74     -0.16       0.16
        10 Phase_R      177.1     -1.2        1.2

##################################################################
THEORY
asymmetry      1
userFcn  libPSpinValve.so PSkewedLorentzian 4 2 3 map1

##################################################################
```

A.3 Parameters used to generate `09001.root`

The file `09001.root` represents a `MusrRoot`-file with synthetic data. A detector system, consisting of 8 detectors has been assumed. The asymmetry follows Eq.(4). The used parameters are:

```
t0's               : 3519.0, 3420.0, 3520.0, 3621.0, 3417.0, 3518.0, 3422.0, 3423.0
N0's per bin       : 200.0, 200.0, 200.0, 200.0, 200.0, 200.0, 200.0, 200.0
Bkg's per bin      : 1.3, 1.5, 1.0, 1.3, 1.2, 1.1, 1.0, 1.4
A0's per segment   : 0.2201, 0.22, 0.2202, 0.2198, 0.22, 0.2199, 0.22, 0.2203
phases per segment : 5, 50, 95, 140, 185, 230, 275, 320
```

And the other parameters as given after Eq.(4).

References

[1] A.J. Drew, *et al.*, Nature Materials **8**, 109 (2009).