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Appendices

Appendix A
An error propagation

By using Van der Pauw technique, the resistivity and Hall coefficient is calculated from

$$\rho_{xx} = \frac{\pi d f}{(\ln 2)\, I} V_\rho \tag{A.1}$$

and

$$R_H = \frac{d}{BI} V_H \tag{A.2}$$

respectively, where $V\rho$ and V_H are average longitudinal and transverse voltage respectively, I is the current, B is the magnetic field, d is the sample thickness and f is a correction factor. By using the error propagation equation, the error in measured voltages related to the error in resistivity and Hall data by

$$\frac{\sigma^2_{\rho_{xx}}}{(\rho_{xx})^2} = \frac{\sigma^2_{V_\rho}}{(V_\rho)^2} \tag{A.3}$$

and

$$\frac{\sigma^2_{BR_H}}{(BR_H)^2} = \frac{\sigma^2_{V_H}}{(V_H)^2}, \tag{A.4}$$

where the Hall term is represented by BR_H because it will be used to convert to the conductivity tensor in the final stage. That is the percentage error of resistivity and Hall data are as same as the percentage error of measured voltages. Transforming the resistivity and Hall coefficient to conductivity tensor components σ_{xx} and σ_{xy}, the error that propagates from ρ_{xx} and R_H to σ_{xx} and σ_{xy} are calculated though the error propagation equation. The statistical uncertainties of σ_{xx} and σ_{xy} are written in variance form that related to the variances of ρ_{xx} and BR_H by

$$\sigma^2_{\sigma_{xx}} = \sigma^2_{\rho_{xx}} \left(\frac{\partial \sigma_{xx}}{\partial \rho_{xx}}\right)^2 + \sigma^2_{BR_H} \left(\frac{\partial \sigma_{xx}}{\partial (BR_H)}\right)^2 + 2\sigma^2_{\rho_{xx}, BR_H} \left(\frac{\partial \sigma_{xx}}{\partial \rho_{xx}}\right) \left(\frac{\partial \sigma_{xx}}{\partial (BR_H)}\right) \tag{A.5}$$

and

$$\sigma^2_{\sigma_{xy}} = \sigma^2_{\rho_{xx}} \left(\frac{\partial \sigma_{xy}}{\partial \rho_{xx}}\right)^2 + \sigma^2_{BR_H} \left(\frac{\partial \sigma_{xy}}{\partial (BR_H)}\right)^2 + 2\sigma^2_{\rho_{xx}, BR_H} \left(\frac{\partial \sigma_{xy}}{\partial \rho_{xx}}\right) \left(\frac{\partial \sigma_{xy}}{\partial (BR_H)}\right). \tag{A.6}$$

The ρ_{xx} and R_H are assumed to be independent then the covariance term, $\sigma^2_{\rho_{xx}, R_H}$, is neglected. The first derivative of each term in the brackets are given,

$$\frac{\partial \sigma_{xx}}{\partial \rho_{xx}} = \frac{(BR_H)^2 - \rho^2_{xx}}{\left(\rho^2_{xx} + (BR_H)^2\right)^2}, \tag{A.7}$$

$$\frac{\partial \sigma_{xx}}{\partial (R_H B)} = \frac{-2\rho_{xx}(BR_H)}{\left(\rho^2_{xx} + (BR_H)^2\right)^2}, \tag{A.8}$$

$$\frac{\partial \sigma_{xy}}{\partial \rho_{xx}} = \frac{\rho^2_{xx} - (BR_H)^2}{\left(\rho^2_{xx} + (BR_H)^2\right)^2}, \tag{A.9}$$

and

$$\frac{\partial \sigma_{xy}}{\partial (R_H B)} = \frac{-2\rho_{xx}(BR_H)}{\left(\rho^2_{xx} + (BR_H)^2\right)^2}. \tag{A.10}$$

By substitute Eqs. (A.7), (A.8), (A.9) and (A.10) into Eqs. (A.5) and (A.6), we obtain

$$\sigma^2_{\sigma_{xx}} = \sigma^2_{\rho_{xx}} \left(\frac{(BR_H)^2 - \rho^2_{xx}}{\left(\rho^2_{xx} + (BR_H)^2\right)^2}\right)^2 + \sigma^2_{BR_H} \left(\frac{2\rho_{xx}(BR_H)}{\left(\rho^2_{xx} + (BR_H)^2\right)^2}\right)^2 \tag{A.11}$$

and

$$\sigma^2_{\sigma_{xy}} = \sigma^2_{\rho_{xx}} \left(\frac{2\rho_{xx}(BR_H)}{\left(\rho^2_{xx} + (BR_H)^2\right)^2}\right)^2 + \sigma^2_{BR_H} \left(\frac{\rho^2_{xx} - (BR_H)^2}{\left(\rho^2_{xx} + (BR_H)^2\right)^2}\right)^2, \tag{A.12}$$

which can be expressed in the proportional form as

$$\frac{\sigma^2_{\sigma_{xx}}}{(\sigma_{xx})^2} = \frac{\sigma^2_{\rho_{xx}}}{(\rho_{xx})^2} \left(\frac{(BR_H)^2 - \rho^2_{xx}}{\rho^2_{xx} + (BR_H)^2}\right)^2 + \frac{\sigma^2_{BR_H}}{(BR_H)^2} \left(\frac{2(BR_H)^2}{\rho^2_{xx} + (BR_H)^2}\right)^2 \tag{A.13}$$

and

$$\frac{\sigma^2_{\sigma_{xy}}}{(\sigma_{xy})^2} = \frac{\sigma^2_{\rho_{xx}}}{(\rho_{xx})^2} \left(\frac{2\rho^2_{xx}}{\rho^2_{xx} + (BR_H)^2}\right)^2 + \frac{\sigma^2_{BR_H}}{(BR_H)^2} \left(\frac{\rho^2_{xx} - (BR_H)^2}{\rho^2_{xx} + (BR_H)^2}\right)^2. \tag{A.14}$$

Alternatively, the conductivity variances can be expressed in term of conductivity components as

$$\frac{\sigma^2_{\sigma_{xx}}}{(\sigma_{xx})^2} = \frac{\sigma^2_{\rho_{xx}}}{(\rho_{xx})^2}\left(\frac{\sigma^2_{xy}-\sigma^2_{xx}}{\sigma^2_{xx}+\sigma^2_{xy}}\right)^2 + \frac{\sigma^2_{BR_H}}{(BR_H)^2}\left(\frac{2\sigma^2_{xy}}{\sigma^2_{xx}+\sigma^2_{xy}}\right)^2 \tag{A.15}$$

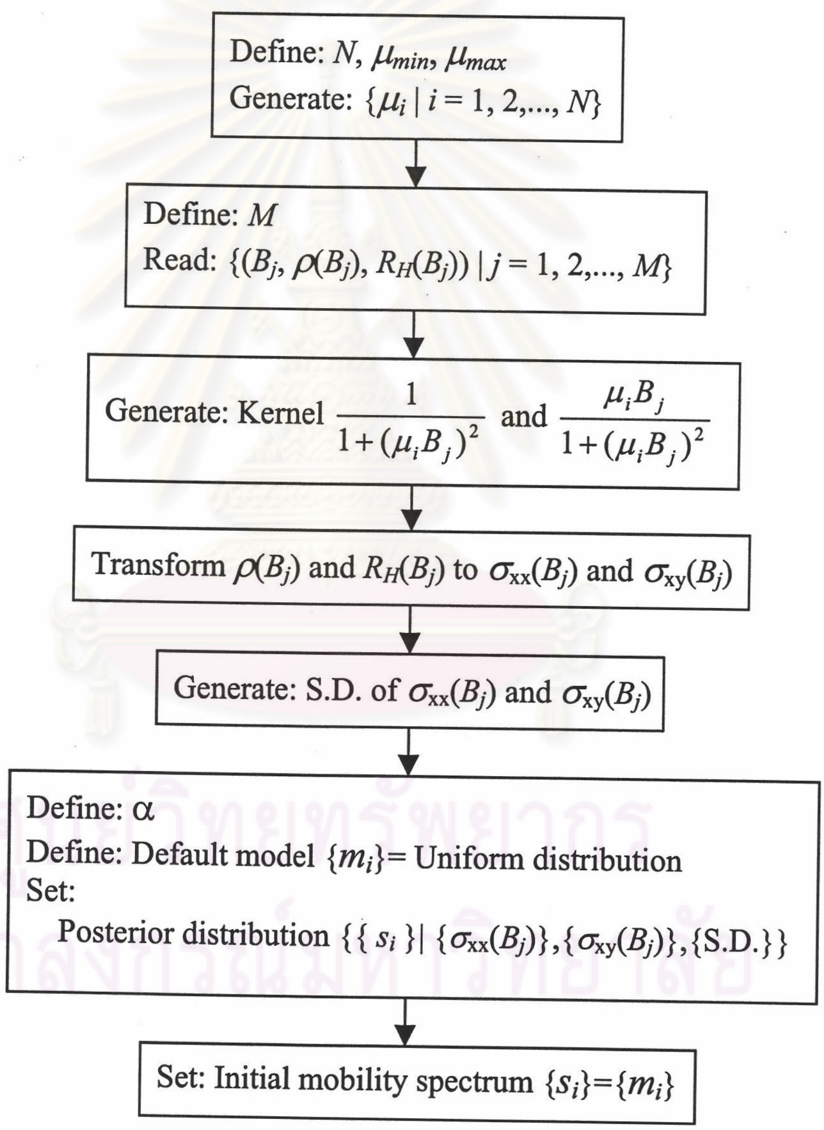
and

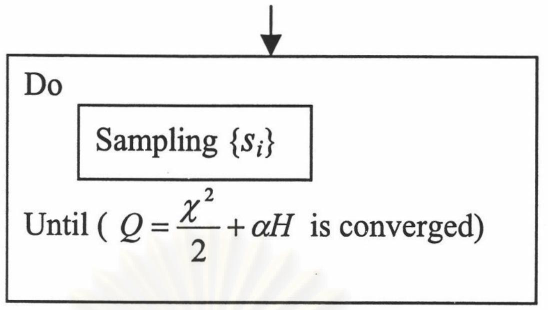
$$\frac{\sigma^2_{\sigma_{xy}}}{(\sigma_{xx})^2} = \frac{\sigma^2_{\rho_{xx}}}{(\rho_{xx})^2}\left(\frac{2\sigma^2_{xx}}{\sigma^2_{xx}+\sigma^2_{xy}}\right)^2 + \frac{\sigma^2_{BR_H}}{(BR_H)^2}\left(\frac{\sigma^2_{xy}-\sigma^2_{xx}}{\sigma^2_{xx}+\sigma^2_{xy}}\right)^2 \tag{A.16}$$

by using Eqs. (2.13) and (2.14).

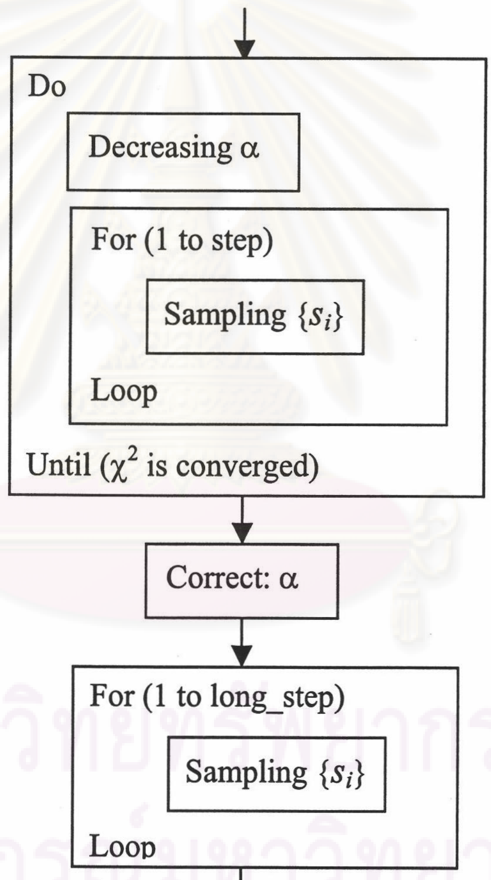
Appendix B
Programming Flowchart

Step 1)

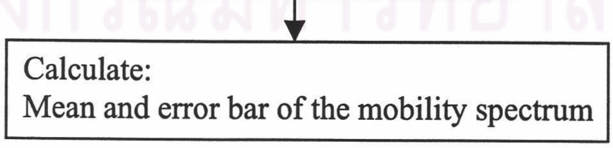



Do
Sampling $\{s_i\}$
Until ($Q = \frac{\chi^2}{2} + \alpha H$ is converged)

Step 2)


Do
Decreasing α
For (1 to step)
Sampling $\{s_i\}$
Loop
Until (χ^2 is converged)
Correct: α
For (1 to long_step)
Sampling $\{s_i\}$
Loop

Step 3)


Calculate:
Mean and error bar of the mobility spectrum

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