

## Appendix B

### Magnetic Field Calculations

The calculation of the magnetic field of the magnetic-bottle spectrometer in Mathematica is given on the following pages.

### ■ Magnetic Field for Permanent Magnet with Magnetization, M, Using the Magnetic Scalar Potential

```

Phi1[r_, theta_, z_, r1_, theta1_, b_] =  $\frac{M}{4 \pi}$ 
  (  $\frac{1}{\sqrt{r1^2 + r^2 - 2 r r1 \cos[\theta - \theta1] + (z)^2}}$  -  $\frac{1}{\sqrt{r1^2 + r^2 - 2 r r1 \cos[\theta - \theta1] + (z + b)^2}}$  );
Phi2[r_, theta_, z_, r1_, b_] = Simplify[Integrate[Phi1[r, theta, z, r1, theta1, b], {theta1, 0, 2 Pi}]];
Phi[r_, theta_, z_, R_, b_] := NIntegrate[r1*Phi2[r, theta, z, r1, b], {r1, 0, R}];
Delta = .0001 (*cm*);
HR[r_, theta_, z_, R_, b_] := -1*(Phi[r + Delta/2, theta, z, R, b] - Phi[r - Delta/2, theta, z, R, b]) / Delta
HZ[r_, theta_, z_, R_, b_] := -1*(Phi[r, theta, z + Delta/2, R, b] - Phi[r, theta, z - Delta/2, R, b]) / Delta
BR[r_, theta_, z_, R_, b_] := mu*HR[r, theta, z, R, b];
BZ[r_, theta_, z_, R_, b_] := mu*HZ[r, theta, z, R, b];
mu = 4 Pi*10^-1 (*Gauss cm/Amp*);
b = 5.08 (*cm- 2 in thickness*);
R = 1.27 (*cm - 1 in diameter*);
M = 8000 (*magnetization*);

```

### ■ Magnetic field of a loop with current J and radius a at any pt. (r,z). (equations from Landau and Lifshitz)

```

BLoopR[r_, z_, z1_, a_, J_] = J * (mu / (2 Pi)) * ((z - z1) / r) / Sqrt[(a + r)^2 + (z - z1)^2] *
  (-EllipticK[4 a r / ((a + r)^2 + (z - z1)^2)] + (a^2 + r^2 + (z - z1)^2) *
  EllipticE[4 a r / ((a + r)^2 + (z - z1)^2)] / ((a - r)^2 + (z - z1)^2));
BLoopZ[r_, z_, z1_, a_, J_] = J * (mu / (2 * Pi)) / Sqrt[(a + r)^2 + (z - z1)^2]
  (EllipticK[4 a r / ((a + r)^2 + (z - z1)^2)] + (a^2 - r^2 - (z - z1)^2) *
  EllipticE[4 a r / ((a + r)^2 + (z - z1)^2)] / ((a - r)^2 + (z - z1)^2));
a = 2.05 (*radius of coil in cm*);
J = .9(*current in coil in Amps*);
x1 = 5 (*distance of solenoid from origin in cm*);
L = 30 (*length of solenoid in cm*);
x2 = L + x1;
mu = 4 Pi*10^-1(*Gauss cm/Amp*);
BSolenoidZ[r_, z_, a_, J_] = Sum[BLoopZ[r, z, i/9, a, J], {i, 18, 288}];
BSolenoidR[r_, z_, a_, J_] = Sum[BLoopR[r, z, i/9, a, J], {i, 18, 288}];
BtotR[r_, z_] := BSolenoidR[r, z, a, J] + BR[r, 0, z, R, b];

```

```
BtotZ[r_, z_] := BSolenoidZ[r, z, a, J] + BZ[r, 0, z, R, b];
```

### ■ Calculation of the adiabatic parameter

```
Δ = .0001 (*cm*);
m = .511 10^6 (* mass of e in eV *);
En = 1 (* Energy of e in eV *);
c = 3 10^10 (*cm/s*);
v = Sqrt[2 En / m] * c;
me = 9.11 10^-31 (*kg*);
e = 1.6 10^-19 (*coul*);
K = 2 10^4 * Pi me v / e;

χ1[r_, z_] := -K * (BtotZ[r, z + Δ / 2] - BtotZ[r, z - Δ / 2]) / (Δ BtotZ[r, z]^2)
```