Imports

In [13]:
```
import numpy as np
from numpy import loadtxt
import matplotlib.pyplot as plt
from scipy.optimize import curve_fit
import glob
from numpy import diff
import pandas as pn
import math
import scipy.constants as sc
import pickle
import copy
from scipy import interpolate
from matplotlib import rcParams, cycler, cm, rc
plotall = True
overview_plot = True
from pylab import meshgrid,cm,imshow,contour,clabel,colorbar,axis,title,show,pcolor
import pandas as pd
from matplotlib.lines import Line2D
import scipy as scipy
```

Selects the appropiate data and gives it a file path. Also prints the path and the amount of files in its folder

In [15]:
```
# --- Selecting data from AHE Folder ---
folder_AHE = r"C:\Users\pblah\Data\Navy Beach\FM112 Flake\AHE"
subpath_AHE = folder_AHE + "\*.txt"
print(subpath_AHE)
pathlist_AHE = glob.glob(subpath_AHE)
F = int(len(folder_AHE)) ##this is used for calculating the number of characters in
print(len(pathlist_AHE))

# ---Selecting data from MR folder ---
folder_MR = r"C:\Users\pblah\Data\Navy Beach\FM112 Flake\MR"
subpath_MR = folder_MR + "\*.txt"
print(subpath_MR)
pathlist_MR = glob.glob(subpath_MR)
F = int(len(folder_MR)) ##this is used for calculating the number of characters in
print(len(pathlist_MR))

print(pathlist_MR)
```

```
C:\Users\pblah\Data\Navy Beach\FM112 Flake\AHE\*.txt
0
C:\Users\pblah\Data\Navy Beach\FM112 Flake\MR\*.txt
0
[]
```

Finds the Temperatures used via the filename and makes them into an array

In [17]:
```
# --- Finding Temperature Array for data in certain folder ---
```

```
Temperature_list = []
for i,path in enumerate(pathlist_AHE[0::]):
    file = path[F::]
    T_index_max = file.find('K.')
    string_tmp = file[T_index_max-5:T_index_max]
    T_index_min = string_tmp.find('_')
    Temperature = string_tmp[T_index_min+1::]
    Temperature=float(Temperature)
    Temperature_list = np.append(Temperature_list,Temperature)
print(Temperature_list)

print(type(Temperature_list))
```

```
[  1.5  20.1  39.9  59.9  79.8  89.8  99.9 109.9 120.  124.8 127.  130.
 140.  159.9]
<class 'numpy.ndarray'>
```

Closest Element Function

In [18]:
```
def closest_element(array,value):
    element = min(array, key=lambda x:abs(x-value))
    closest_element = np.where(array == element)[0][0]
    return closest_element
```

Closest Element Index Function

In [19]:
```
def closest_element_index(array,value):
    array1 = np.sort(array)
    closest_element = min(array1, key=lambda x:abs(x-value))
    closest_element_index = np.where(array1 == closest_element)[0][0]
    closest_index_range = array1[closest_element_index-1 : closest_element_index+1]
    mylist = []
    for i in closest_index_range:
        closest_index_actual = np.where(array == i)[0]
        mylist = np.sort(np.append(mylist,closest_index_actual))
    return mylist
```

Anti-Symmetriser

Anomalous Hall Resitivity

Extracts B and Resistance. Converts to resitivity (formula depends on VdP or Hall).

Splits data into 4 branches, maps it to a common x-axis. Anti-Symmetrises them.

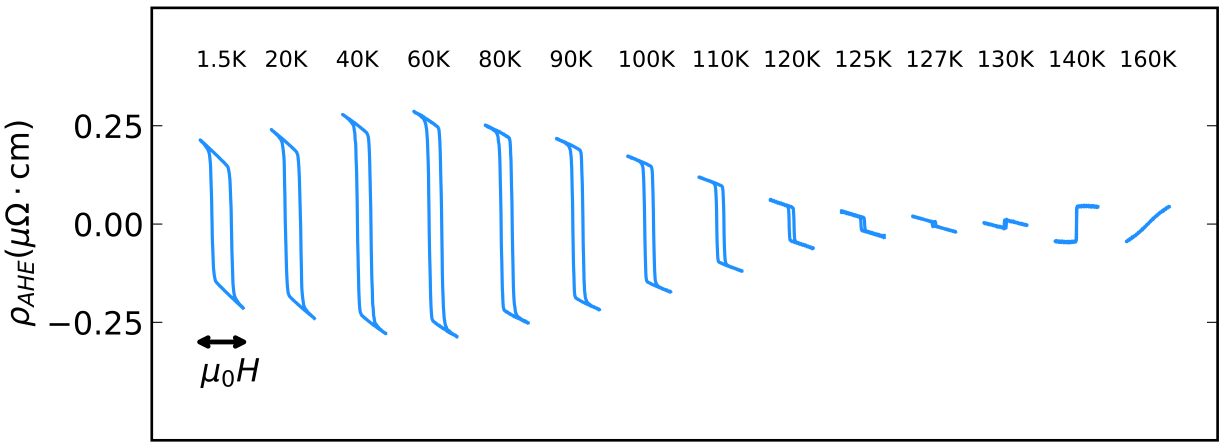
In [13]:
```
#cm = plt.get_cmap('winter', 18) # colour map

#Temperature labels for legend
Temperature_labels = Temperature_list.astype(str)

#Setting Size of figure 1
```

```
fig, ax = plt.subplots(figsize=(36, 12), dpi = 500)


offset = 0

for i,path in enumerate(pathlist_AHE[0::]): #Looping over AHE data from folder

    data = np.loadtxt(path, skiprows=2) #Extracting data from txt file in form of l

    B_raw = data[:,1]
    R_xx_raw = data[:,2]
    Theta_xx_raw = data[:,3]
    R_xy_raw = data[:,4]
    Theta_xy_raw = data[:,5]

    Rxx_raw = R_xx_raw*np.cos(Theta_xx_raw*sc.pi/180)  # Working out the resistance
    Rxy_raw = R_xy_raw*np.cos(Theta_xy_raw*sc.pi/180)


    B_max = np.max(B_raw)  #The maximum B field in the dataset

    Delta_B = 0.005 # in Tesla
    pts = int(B_max / Delta_B+1) #These points are used later to create my simulate

    index_max = np.where(B_raw>=B_max)[0] #The datapoints where the B field is at a
    index_min = np.where(B_raw<=-B_max)[0] #The datapoints where the B field is at

    MAX = index_max[int(len(index_max))-1] #Takes the last one of these points that
    MIN = index_min[0] #Just picks the first value of these few points that are at


    #---Not sure this if/else condition is needed now, if I do the sweeps as +10 to

    if index_min[0] > index_max[0]: # This if/else condition determines what to do
        B_new = np.linspace(-B_max, B_max,pts)
        B = B_raw[MIN:MAX]
        R_xx = R_xx_raw[MIN:MAX]
        Theta_xx = Theta_xx_raw[MIN:MAX]
        R_xy = R_xy_raw[MIN:MAX]
        Theta_xy = Theta_xy_raw[MIN:MAX]

    else:
        B_new = np.linspace(B_max, -B_max,pts)
        B = B_raw[MAX:MIN]
        R_xx = R_xx_raw[MAX:MIN]
        Theta_xx = Theta_xx_raw[MAX:MIN]
        R_xy = R_xy_raw[MAX:MIN]
        Theta_xy = Theta_xy_raw[MAX:MIN]


    Rxx = R_xx*np.cos(Theta_xx * np.pi /180) #Works out the resistances over the ra
    Rxy = R_xy*np.cos(Theta_xy * np.pi /180)

    Rxy_raw = Rxy_raw *1E6* 2E-6/1.5E-6 * 5.5E-9*1E2 # Anomalous Hall resitivity
```

```
IZero=np.where(B_raw==0)[0] #The index list of values you get at B=0. The [0] i

Imax=np.where(B_raw==np.max(B_raw))[0][0] #The (index of) the first value of th

Imin=np.where(B_raw==np.min(B_raw))[0][0] #The (index of) the first point of wh

FZ=IZero[0] #The datapoint when you go through B=0 for the first time
SZ=IZero[-1] #The datapoint when you go through B=0 for the second time


Rxy_1 = Rxy_raw[Imax:FZ+1] #The first branch of the sweep. You do +1 due to the
B_1 = B_raw[Imax:FZ+1] #The x-axis of this first branch

Rxy_2 = Rxy_raw[FZ:Imin+1] #The second branch of the sweep
B_2 = B_raw[FZ:Imin+1] #The x-axis of this second branch

Rxy_3 = Rxy_raw[Imin:SZ] #The third branch of the sweep
B_3 = B_raw[Imin:SZ] #The x-axis of this third branch

Rxy_4 = Rxy_raw[SZ::] #The fourth branch of the sweep
B_4 = B_raw[SZ::] #The x-axis of this fourth branch

TM=np.where(B_raw[Imax:FZ+1]==np.max(B_raw[Imax:FZ+1]))[0] #At the beginning, (
B_int = B_raw[TM[-1]:FZ+1] #This gives the positive x-axis of the sweep (10 to



f_1 = interpolate.interp1d(B_1, Rxy_1) #This creates a linear interpolation (ak
Rxy_1_int = f_1(B_int) #This maps this line to the x-axis which will be common

f_3 = interpolate.interp1d(B_3, Rxy_3) #This creates a linear interpolation (ak
Rxy_3_int = f_3(-B_int[::-1]) #This begins the mapping of this line to the x-ax
Rxy_3_int = Rxy_3_int[::-1] #You then reverse the order again, so you go from -

f_2 = interpolate.interp1d(B_2, Rxy_2) #This creates a linear interpolation (ak
Rxy_2_int = f_2(-B_int[::-1]) #This begins the mapping of this line to the x-ax
Rxy_2_int = Rxy_2_int[::-1] #You then reverse the order again, so you go from -

f_4 = interpolate.interp1d(B_4, Rxy_4) #This creates a linear interpolation (ak
Rxy_4_int = f_4(B_int) #This maps this line to the x-axis which will be common


#Anti-Symmetrising the data using the four interpolated branches

Asym_NH_pos = (Rxy_1_int - Rxy_3_int)/2 #NH means Normal Hall, pos means the po
Asym_AHE_pos = (Rxy_4_int - Rxy_2_int)/2 #This gives the difference between the

Asym_NH_neg = -Asym_NH_pos #Because anti-symmetrising the data converts the 4 b
Asym_AHE_neg = -Asym_AHE_pos

#---Combining the 4 antisymmetrised branches into one full curve---

full_curve = np.append(Asym_NH_pos,Asym_AHE_neg[::-1])
full_curve1 = np.append(full_curve,Asym_NH_neg)
full_curve2 = np.append(full_curve1,Asym_AHE_pos[::-1])
full_B = np.append(B_int,-B_int[::-1])
```

```
full_B1 = np.append(full_B,-B_int)
full_B2 = np.append(full_B1,B_int[::-1])


if i ==0 or i==1 or i==2 or i==3:

    minus2T_range = closest_element_index(full_B2, -1.5)
    plus2T_range = closest_element_index(full_B2, 1.5)


    #print(minus2T_range)
    #print(plus2T_range)

    minus2T_1 = int(minus2T_range[0])
    minus2T_2 = int(minus2T_range[2])
    plus2T_1 = int(plus2T_range[0])
    plus2T_2 = int(plus2T_range[2])

    #print(plus2T_1,minus2T_1)
    #print(plus2T_2,minus2T_2)



#Plotting it with colour convention and saving the data to a pandas Dataframe


    #print(full_B2[plus2T_1:minus2T_1])
    #plt.plot(full_B2[plus2T_1:minus2T_1] + offset, full_curve2[plus2T_1:minus2
    #plt.plot(full_B2[minus2T_2:plus2T_2] + offset, full_curve2[minus2T_2:plus2

    full_B_df = np.concatenate((full_B2[plus2T_1:minus2T_1],full_B2[minus2T_2:p
    full_curve_df = np.concatenate((full_curve2[plus2T_1:minus2T_1],full_curve2

    #plt.plot(full_B_df + offset, full_curve_df, ms=1,alpha=1,color = 'dodgerbl
    plt.plot(full_B_df + offset, full_curve_df, ms=1,alpha=1,color = 'dodgerblu

    pd.DataFrame({'B':full_B_df,'AHE':full_curve_df}).to_csv(r'C:\Users\pblah\D
    pd.DataFrame({'B':full_B_df + offset,'AHE':full_curve_df}).to_csv(r'C:\User


else:
    #plt.plot(full_B2+ offset, full_curve2, ms=1,alpha=1,color = 'dodgerblue',
    plt.plot(full_B2+ offset, full_curve2, ms=1,alpha=1,color = 'dodgerblue', l
    pd.DataFrame({'B':full_B_df + offset,'AHE':full_curve_df}).to_csv(r'C:\User
    #pd.DataFrame({'Temperature':Temperature_labels1,'Coercive_Field':coercive_


offset = offset + 5 #This offset is to allow all the loops to be plotted on one

rho_xy_atzeroB = full_curve2[IZero][0] #Value of AHE where B=0

#print('rho_xy_atzeroB',rho_xy_atzeroB)
```

```
################### Annotations ####################################

    ### B Arrow Annotations ###
plt.annotate("",xy=(-2, -0.3), xycoords='data', xytext=(2, -0.3), textcoords='data'
plt.annotate("$\mu_0 H$",xy = (-1.5,-0.4),fontsize=60, weight = 'bold')

    ### Temperature annotations ###
plt.annotate(str(Temperature_list[0]) + "K",xy = (-1.8,0.4),fontsize=42)
plt.annotate(str(round(Temperature_list[1])) + "K",xy = (3,0.4),fontsize=42)
plt.annotate(str(round(Temperature_list[2])) + "K",xy = (8,0.4),fontsize=42)
plt.annotate(str(round(Temperature_list[3])) + "K",xy = (13,0.4),fontsize=42)
plt.annotate(str(round(Temperature_list[4])) + "K",xy = (18,0.4),fontsize=42)
plt.annotate(str(round(Temperature_list[5])) + "K",xy = (23,0.4),fontsize=42)
plt.annotate(str(round(Temperature_list[6])) + "K",xy = (27.8,0.4),fontsize=42)
plt.annotate(str(round(Temperature_list[7])) + "K",xy = (33,0.4),fontsize=42)
plt.annotate(str(round(Temperature_list[8])) + "K",xy = (38,0.4),fontsize=42)
plt.annotate(str(round(Temperature_list[9])) + "K",xy = (43,0.4),fontsize=42)
plt.annotate(str(round(Temperature_list[10])) + "K",xy = (48,0.4),fontsize=42)
plt.annotate(str(round(Temperature_list[11])) + "K",xy = (53,0.4),fontsize=42)
plt.annotate(str(round(Temperature_list[12])) + "K",xy = (58,0.4),fontsize=42)
plt.annotate(str(round(Temperature_list[13])) + "K",xy = (63,0.4),fontsize=42)

# Borders#

ax.spines["top"].set_linewidth(5)
ax.spines["bottom"].set_linewidth(5)
ax.spines["right"].set_linewidth(5)
ax.spines["left"].set_linewidth(5)
ax.spines["left"].set_bounds(-0.55,0.55)
ax.spines["right"].set_bounds(-0.55,0.55)
ax.spines["top"].set_position(['data',0.55])
ax.spines["bottom"].set_position(['data',-0.55])


#Axis Limits#

plt.ylim(-0.45,0.45)


######## Labels, ticks and saving ##############

#plt.title("FM112 Flake AHE",fontsize=30)
#ax.legend(Temperature_list,ncol=2,fontsize=15,loc =1)
#plt.legend(Temperature_labels)
#plt.xlabel(r'$\mu _0 H_\perp$(T)',fontsize=30)
plt.ylabel(r'$\rho_{AHE}(\mu\Omega\cdot$cm)',fontsize=60, labelpad = 20)
ax.tick_params(axis='y', which='major', labelsize=80, length = 20, width = 2, direc
plt.xticks([])
plt.yticks(fontsize = 60)
#plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM112 Flake\Figures\FM112_Flake_AHE_C
#plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM112 Flake\Figures\FM112_Flake_AHE_C
plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM112 Flake\Figures\FM112_Flake_AHE_Cu
plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM112 Flake\Figures\FM112_Flake_AHE_Cu
plt.show()
```


1.5K
20K
40K
60K
80K
90K
100K
110K
120K
125K
127K
130K
140K
160K
0.25
0.00
−0.25
$\rho_{AHE}(\mu\Omega \cdot \mathrm{cm})$
$\mu_0 H$