In [23]:
```
import numpy as np
print(np.version.version)
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
import os
import matplotlib.ticker as ticker
from matplotlib.ticker import ScalarFormatter
from matplotlib.ticker import (MultipleLocator, AutoMinorLocator)
from numpy.polynomial import Polynomial
import matplotlib.cm as cm
import matplotlib as mpl
import numpy.ma as ma
```

```
1.24.3
```

In [3]:
```
%run NNO_Functions_FM301.ipynb
```

In [4]:
```
"---Folder Paths---"


folder_Hall_Bar_6_IVs = r"C:\Users\pblah\Data\Navy Beach\FM301\Hall Bar 6\IVs"
pathlist_Hall_Bar_6_IVs = folderpath(folder_Hall_Bar_6_IVs)

folder_Hall_Bar_6_IVs_warmup_longsweep = r"C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Warmup\Raw Data\Data"
pathlist_Hall_Bar_6_IVs_warmup_longsweep = folderpath(folder_Hall_Bar_6_IVs_warmup_longsweep)

folder_Hall_Bar_6_IVs_warmup_longsweep_offsetted = r"C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Warmup\Offsetted"
pathlist_Hall_Bar_6_IVs_warmup_longsweep_offsetted = folderpath_csv(folder_Hall_Bar_6_IVs_warmup_longsweep_offsetted)

folder_Hall_Bar_6_IVs_ramp_cooldown = r"C:\Users\pblah\Data\Navy Beach\FM301\Hall Bar 6\IVs\With Ramp\Cooldown"
pathlist_Hall_Bar_6_IVs_ramp_cooldown = folderpath(folder_Hall_Bar_6_IVs_ramp_cooldown)

folder_Hall_Bar_6_IVs_ramp_warmup = r"C:\Users\pblah\Data\Navy Beach\FM301\Hall Bar 6\IVs\With Ramp\Warmup"
pathlist_Hall_Bar_6_IVs_ramp_warmup = folderpath(folder_Hall_Bar_6_IVs_ramp_warmup)

folder_Hall_Bar_6_IVs_moredatapoints_warmup = r"C:\Users\pblah\Data\Navy Beach\FM301\Hall Bar 6\IVs\With More Datapoints\Warmup"
pathlist_Hall_Bar_6_IVs_moredatapoints_warmup = folderpath(folder_Hall_Bar_6_IVs_moredatapoints_warmup)

folder_Hall_Bar_6_IVs_moredatapoints_cooldown = r"C:\Users\pblah\Data\Navy Beach\FM301\Hall Bar 6\IVs\With More Datapoints\Cooldown"
```

```
pathlist_Hall_Bar_6_IVs_moredatapoints_cooldown = folderpath(folder_Hall_Bar_6_IVs_moredatapoints_cooldown)

folder_Hall_Bar_6_IV_testing  = r"C:\Users\pblah\Data\Navy Beach\FM301\Hall Bar 6\IVs\Testing"
pathlist_Hall_Bar_6_IV_testing = folderpath(folder_Hall_Bar_6_IV_testing)

folder_Hall_Bar_6_IVs_longsweep = r"C:\Users\pblah\Data\Navy Beach\FM301\Hall Bar 6\IVs\Long Sweep Cooldown"
pathlist_Hall_Bar_6_IVs_longsweep = folderpath(folder_Hall_Bar_6_IVs_longsweep)

folder_Hall_Bar_6_IVs_longsweep_normalised_data = r"C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation"
pathlist_Hall_Bar_6_IVs_longsweep_normalised_data = folderpath_csv(folder_Hall_Bar_6_IVs_longsweep_normalised_data)


folder_Hall_Bar_6_IVs_longsweep_symmetrised_data = r"C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Symmetrised"
pathlist_Hall_Bar_6_IVs_longsweep_symmetrised_data = folderpath_csv(folder_Hall_Bar_6_IVs_longsweep_symmetrised_data)

folder_Hall_Bar_6_IVs_longsweep_cut_and_fitted =  r"C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Cut and Fitted"
pathlist_Hall_Bar_6_IVs_longsweep_cut_and_fitted = folderpath_csv(folder_Hall_Bar_6_IVs_longsweep_cut_and_fitted)

folder_Hall_Bar_6_IVs_longsweep_warmup_cut_and_fitted =  r"C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Warmup\Cut and Fitted"
pathlist_Hall_Bar_6_IVs_longsweep_warmup_cut_and_fitted = folderpath_csv(folder_Hall_Bar_6_IVs_longsweep_warmup_cut_and_fitted)

folder_Hall_Bar_6_IVs_longsweep_warmup_symmetrised_data = r"C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Warmup\Symmetrised"
pathlist_Hall_Bar_6_IVs_longsweep_warmup_symmetrised_data = folderpath_csv(folder_Hall_Bar_6_IVs_longsweep_warmup_symmetrised_data)

folder_Hall_Bar_6_IVs_RT_cooldown = r"C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\R vs T"
pathlist_Hall_Bar_6_IVs_RT_cooldown = folderpath_csv(folder_Hall_Bar_6_IVs_RT_cooldown)

folder_Hall_Bar_6_IVs_RT_warmup = r"C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Warmup\R vs T"
pathlist_Hall_Bar_6_IVs_RT_warmup = folderpath_csv(folder_Hall_Bar_6_IVs_RT_warmup)

folder_Hall_Bar_6_IVs_combining_pandas = r"C:\Users\pblah\Data\Navy Beach\FM301\Data\Resitivity Combined Pandas"
pathlist_Hall_Bar_6_IVs_combining_pandas = folderpath_csv(folder_Hall_Bar_6_IVs_combining_pandas)




#print(pathlist_Hall_Bar_6_IVs)
#print(len(pathlist_Hall_Bar_6_IVs_warmup_longsweep))
#print(pathlist_Hall_Bar_6_IVs_ramp_cooldown)
#print(pathlist_Hall_Bar_6_IVs_ramp_warmup)
#print(pathlist_Hall_Bar_6_IVs_moredatapoints_warmup)
#print(folder_Hall_Bar_6_IVs_moredatapoints_warmup)
#print(len(pathlist_Hall_Bar_6_IVs_moredatapoints_warmup))
#print(len(pathlist_Hall_Bar_6_IVs_longsweep))
#print(pathlist_Hall_Bar_6_IVs_longsweep_normalised_data)
#print(len(pathlist_Hall_Bar_6_IVs_longsweep_data))
#print(len(pathlist_Hall_Bar_6_IVs_longsweep_symmetrised_data))
#print(pathlist_Hall_Bar_6_IVs_longsweep_symmetrised_data)
#print(pathlist_Hall_Bar_6_IVs_longsweep_cut_and_fitted)
#print(len(pathlist_Hall_Bar_6_IVs_warmup_longsweep_offsetted))
#print(pathlist_Hall_Bar_6_IVs_longsweep_warmup_cut_and_fitted)
```

```
#print(pathlist_Hall_Bar_6_IVs_longsweep_warmup_symmetrised_data)
#print(pathlist_Hall_Bar_6_IVs_RT_cooldown)
#print(pathlist_Hall_Bar_6_IVs_RT_warmup)
print(pathlist_Hall_Bar_6_IVs_combining_pandas)
```

```
['C:\\Users\\pblah\\Data\\Navy Beach\\FM301\\Data\\Resitivity Combined Pandas\\FM301 Hall Bar 6 Resitivity vs T cooldown.csv', 'C:\\Users\\pblah\\Data\\Navy Beach\\FM301\\Data
\\Resitivity Combined Pandas\\FM301 Hall Bar 6 Resitivity vs T warmup.csv']
```

Temperature Lists

In [5]:
```
def findtemperature(array):
    F = int(len(array))
    Temperature_list = []
    for i,path in enumerate(array):
        file = path[F::]
        T_index_max = file.find('K.')
        string_tmp = file[T_index_max-6: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)
        Temperature_list = np.round(Temperature_list)
    return Temperature_list
```

Closest Element Function

In [6]:
```
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 Range Function##

In [7]:
```
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
```

IVs

Long Sweep

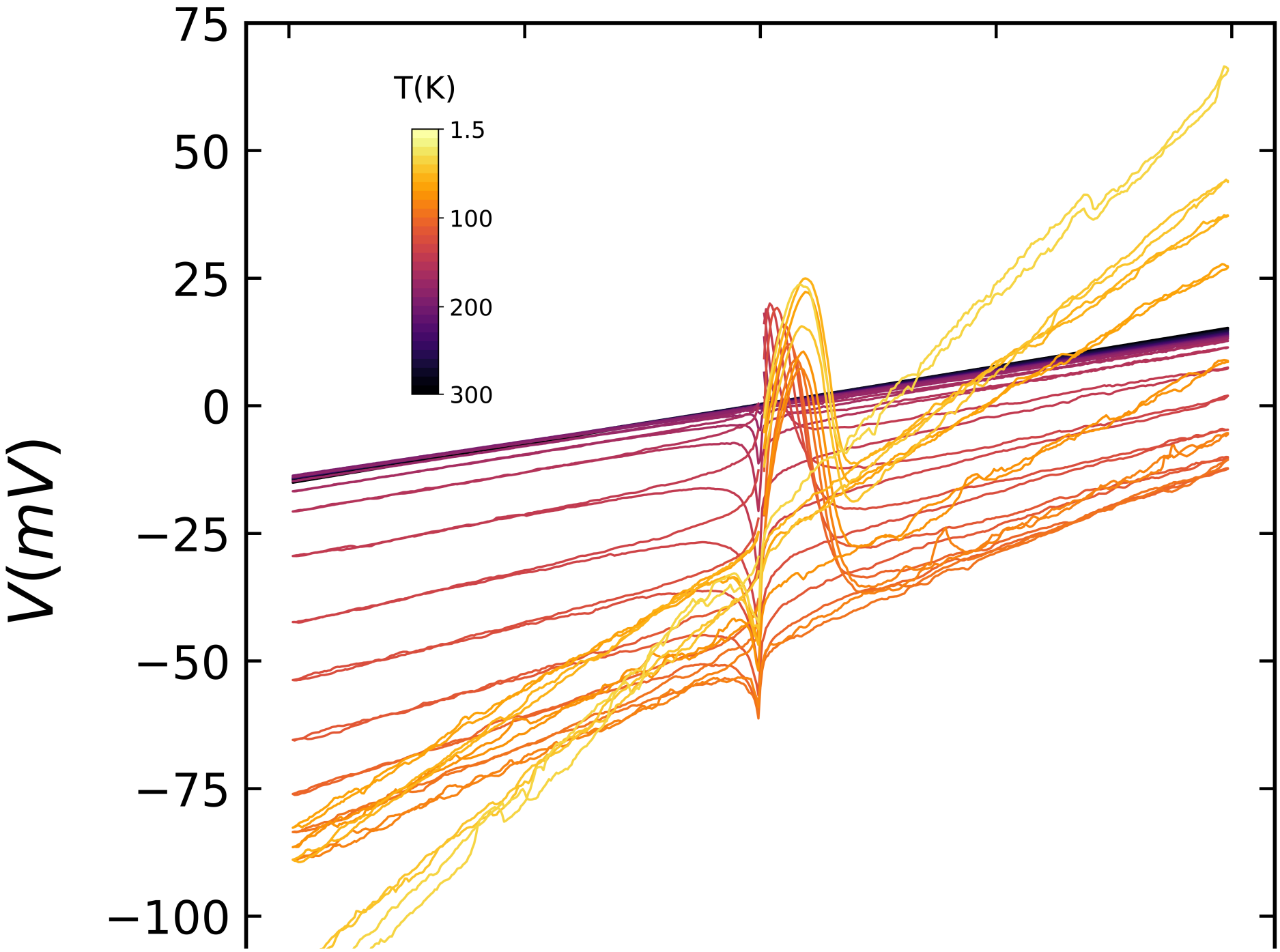
Cooldown

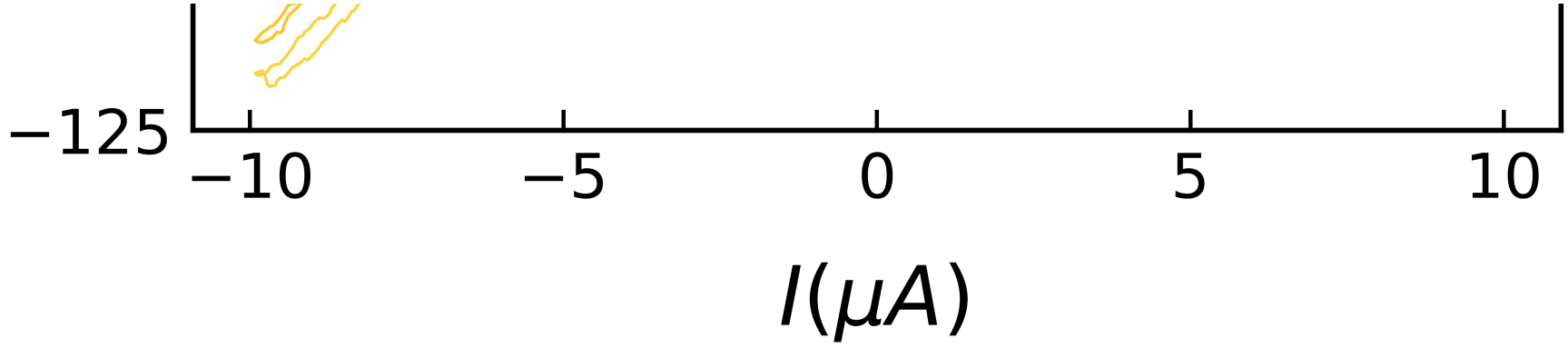
Checking the IVs

Plotting raw IVs

In [8]:
```
fig, ax = plt.subplots(figsize=(12, 12), dpi = 500)
temperature_list = findtemperature(pathlist_Hall_Bar_6_IVs_longsweep)
cm = plt.get_cmap('inferno', 30)


for i,data in enumerate(pathlist_Hall_Bar_6_IVs_longsweep):

    dataextracted = dataextractorIVs(data)
    current = dataextracted[0]
    V_Keithley = dataextracted[1]
    RLKin = dataextracted[1]
    ax.set_ylim(-125,75)
    ax.plot(current*1E6,V_Keithley*1E3 ,label = temperature_list[i], color=cm(i/len(temperature_list)-0.1))







norm = mpl.colors.Normalize(vmin=1.5, vmax=300)
sm = plt.cm.ScalarMappable(cmap=cm,norm = norm)
cax = fig.add_axes([0.25, 0.6, 0.02, 0.20])
tick_list = np.arange(temperature_list.min(),temperature_list.max(),80)
tick_list1 = [300,200,100,1.5]
cbar = plt.colorbar(sm, cax=cax, shrink = 0.01, orientation='vertical')
cbar.set_ticks(tick_list1[::-1])
cbar.set_ticklabels(list(map(str, tick_list1)))
cbar.ax.tick_params(labelsize=15)
cbar.ax.set_title('T(K)', fontsize = 20, pad = 20)


ax.set_xlabel("$I (\mu A)$ ",fontsize=40,labelpad = 25)
ax.set_ylabel(r'$V(mV)$',fontsize=40,labelpad = 25)

ax.tick_params(axis = 'x', which='major', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, top = True)
ax.tick_params(axis = 'y', which='major', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, right = True)
ax.tick_params(axis = 'y', which='minor', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, right = True)


ax.spines["top"].set_linewidth(2.5)
```

```
ax.spines["bottom"].set_linewidth(2.5)
ax.spines["right"].set_linewidth(2.5)
ax.spines["left"].set_linewidth(2.5)




plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM301\Figures\FM301_Hall_Bar_6_IVs_Longsweep_Raw.pdf",bbox_inches = "tight", format = "pdf")
plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM301\Figures\FM301_Hall_Bar_6_IVs_Longsweep_Raw.png",bbox_inches = "tight")
plt.show()


#plt.legend(labels = temperature_list)
#plt.xlim(0.75E-5,1E-5)
#plt.ylim(0.01,0.017)
#ax.xaxis.offsetText.set_fontsize(24)
```


T(K)
1.5
100
200
300
75
50
25
0
−25
−50
−75
−100
V(mV)

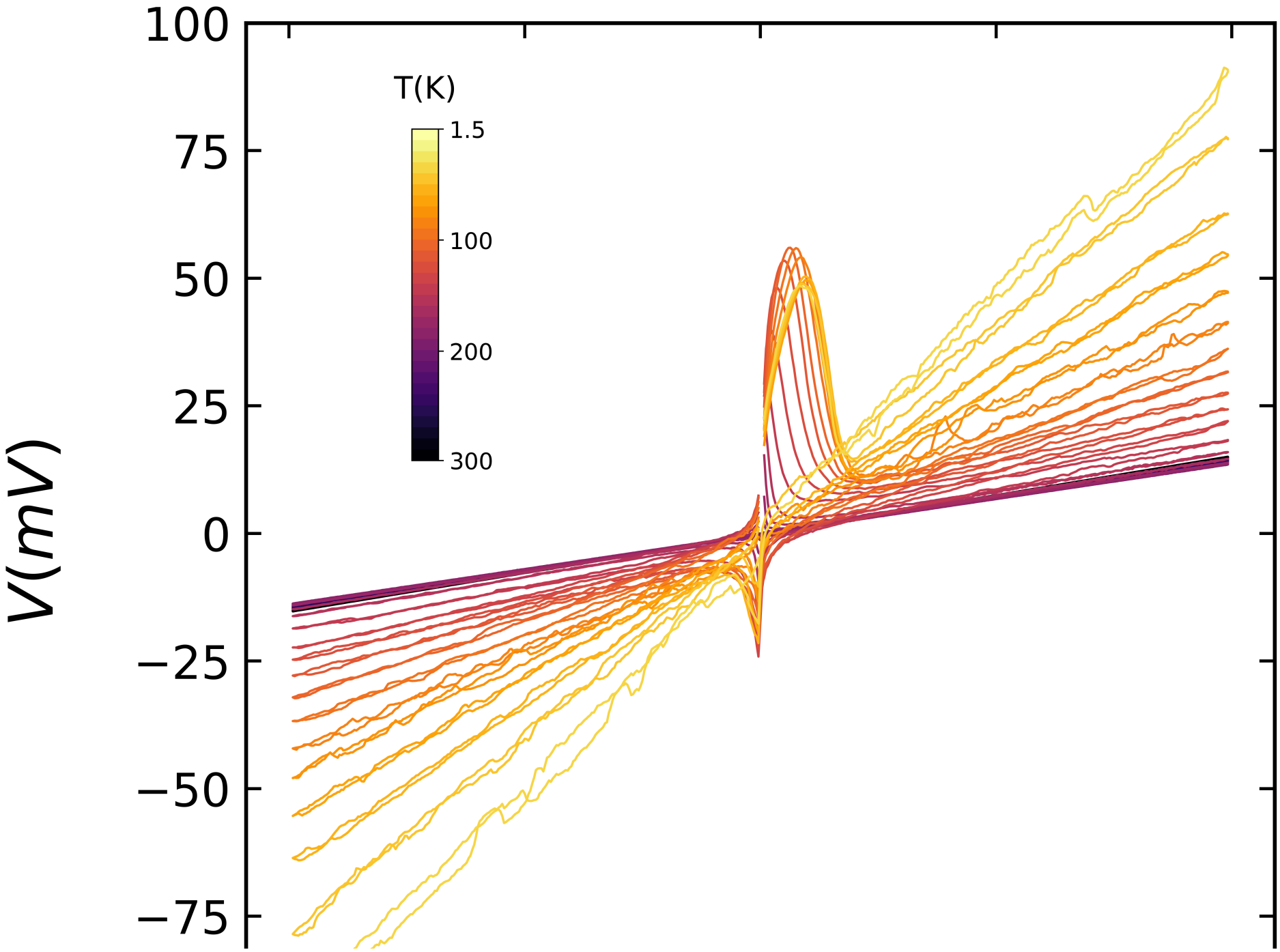


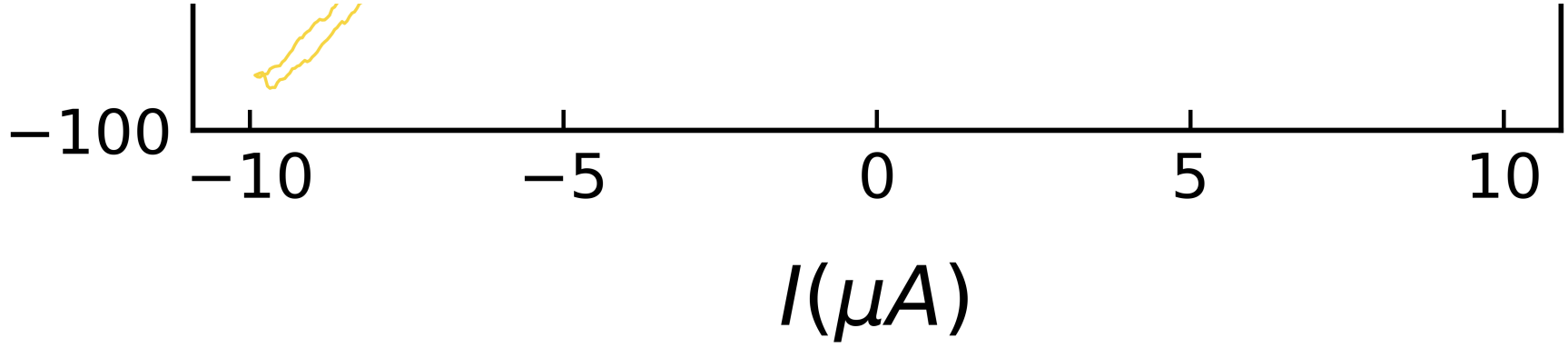
Offsetting

In [9]:
```
fig, ax = plt.subplots(figsize=(12, 12), dpi = 500)
cm = plt.get_cmap('inferno', 30)

temperature_list = findtemperature(pathlist_Hall_Bar_6_IVs_longsweep)


for i,path in enumerate(pathlist_Hall_Bar_6_IVs_longsweep):

    dataextracted = dataextractorIVs(path)
    current = dataextracted[0]
    V_Keithley = dataextracted[1]
    RLKin = dataextracted[1]

    plus10uA = int(closest_element_index(current,10E-6)[0])
    minus10uA = int(closest_element_index(current,-9.89E-6)[0])


    V_Keithley_endpoints = [V_Keithley[plus10uA],V_Keithley[minus10uA]]
    current_endpoints = [current[plus10uA],current[minus10uA]]
    line_y = interpolate.interp1d(current_endpoints, V_Keithley_endpoints)
    V_Keithley_int_line = line_y(current)
    offset = V_Keithley_int_line[0]
    V_Keithley_norm = V_Keithley - offset

    ax.set_ylim(-100,100)
    ax.plot(current*1E6,V_Keithley_norm*1E3,label = temperature_list[i],color=cm(i/len(temperature_list)-0.1))

    df = pd.DataFrame({'current':current,'V_Keithley':V_Keithley_norm})
    df.to_csv(r'C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ ' + str(i) + " " + 'FM301 Hall Bar 6 Normalised IVs' + " " + str(temperature_list[i]) + "



norm = mpl.colors.Normalize(vmin=1.5, vmax=300)
sm = plt.cm.ScalarMappable(cmap=cm,norm = norm)
cax = fig.add_axes([0.25, 0.55, 0.02, 0.25])
```

```
tick_list = np.arange(temperature_list.min(),temperature_list.max(),80)
tick_list1 = [300,200,100,1.5]
cbar = plt.colorbar(sm, cax=cax, shrink = 0.01, orientation='vertical')
cbar.set_ticks(tick_list1[::-1])
cbar.set_ticklabels(list(map(str, tick_list1)))
cbar.ax.tick_params(labelsize=15)
cbar.ax.set_title('T(K)', fontsize = 20, pad = 20)


ax.set_xlabel("$I (\mu A)$ ",fontsize=40,labelpad = 25)
ax.set_ylabel(r'$V(mV)$',fontsize=40,labelpad = 25)

ax.tick_params(axis = 'x', which='major', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, top = True)
ax.tick_params(axis = 'y', which='major', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, right = True)
ax.tick_params(axis = 'y', which='minor', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, right = True)


ax.spines["top"].set_linewidth(2.5)
ax.spines["bottom"].set_linewidth(2.5)
ax.spines["right"].set_linewidth(2.5)
ax.spines["left"].set_linewidth(2.5)









plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM301\Figures\FM301_Hall_Bar_6_IVs_Longsweep_Offset_Fixed.pdf",bbox_inches = "tight", format = "pdf")
plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM301\Figures\FM301_Hall_Bar_6_IVs_Longsweep_Offset_Fixed.png",bbox_inches = "tight")
plt.show()

#print("i",i)
#print("data",data)
#plt.scatter(current[plus10uA],V_Keithley[plus10uA])
#plt.scatter(current[minus10uA],V_Keithley[minus10uA])
#print('V_Keithley plus10uA',V_Keithley[plus10uA])
#print('V_Keithley minus10uA',V_Keithley[minus10uA])
#plt.plot(current,V_Keithley_int_line)
#plt.scatter(current,V_Keithley,s=1, color = 'red')
#plt.plot(current,V_Keithley_int_line,color = 'blue')

#ax.xaxis.offsetText.set_fontsize(24)

#plt.legend(labels = temperature_list)
```

```
#plt.xlim(0.75E-5,1E-5)
#plt.ylim(0.01,0.017)
```


100
75
50
25
0
−25
−50
−75
V(mV)
T(K)
1.5
100
200
300



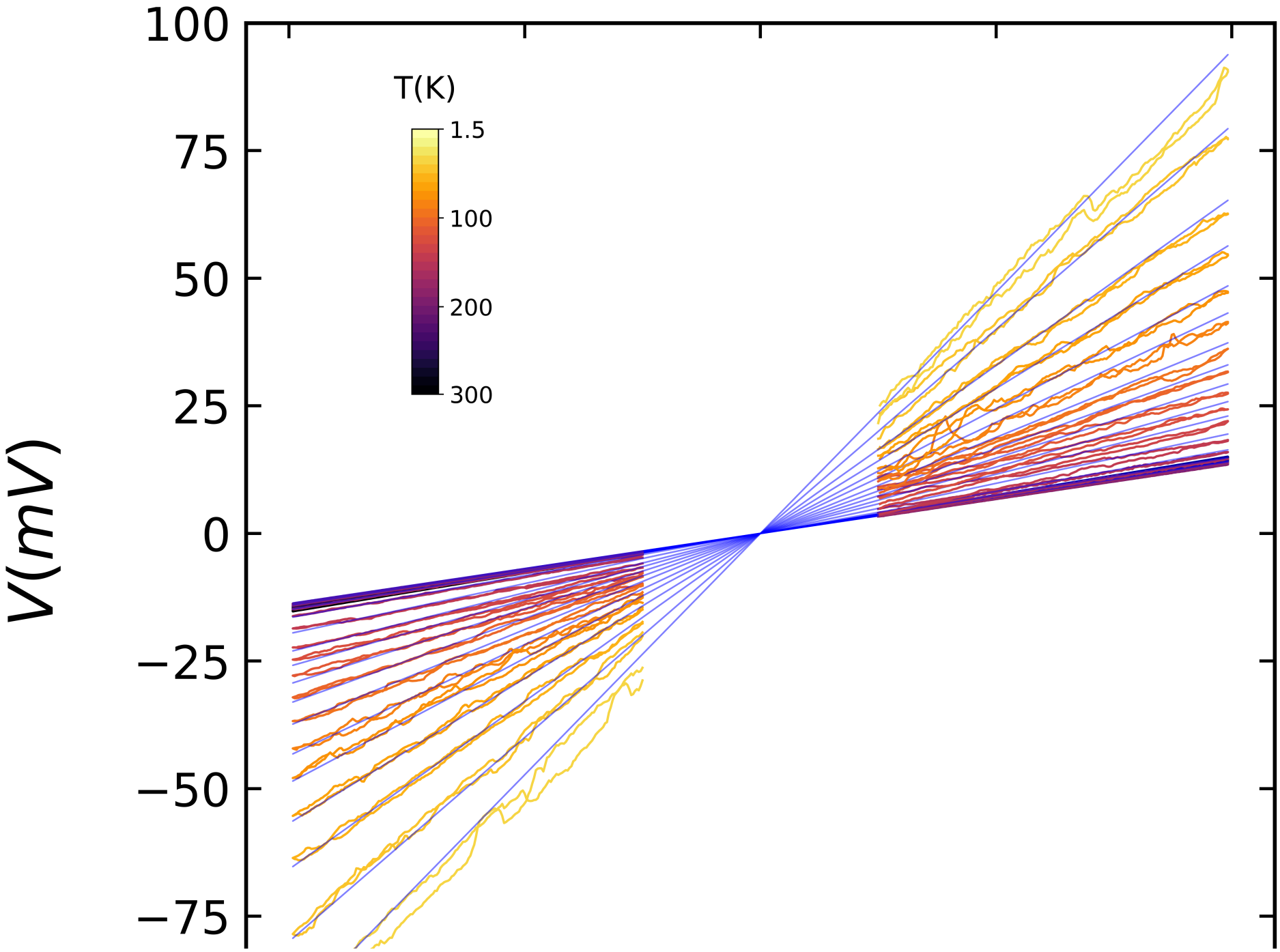
Cut and Fitting (With help from Graham)

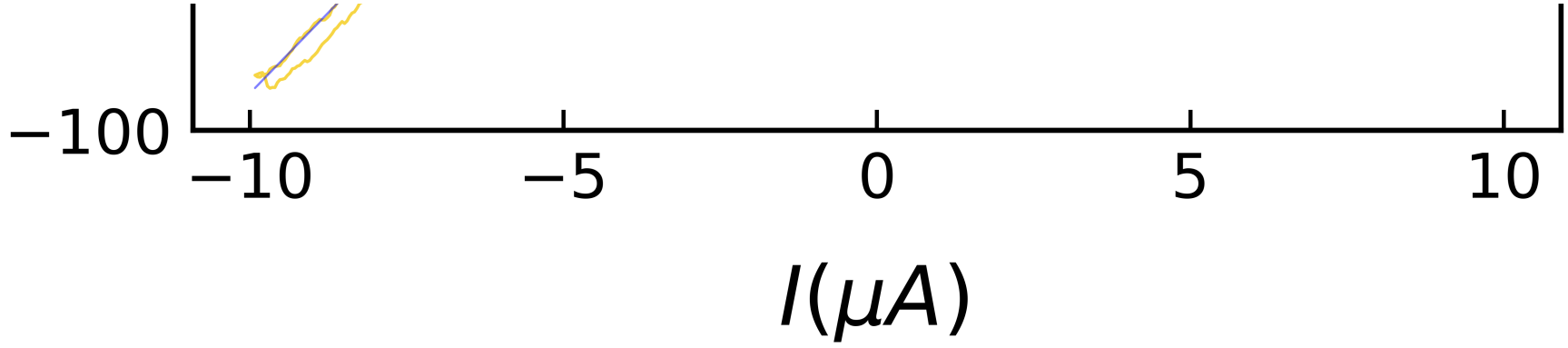
In [10]:
```
folder = folder_Hall_Bar_6_IVs_longsweep_normalised_data
temperature_list = findtemperature(pathlist_Hall_Bar_6_IVs_longsweep)

fig, ax = plt.subplots(figsize=(12, 12), dpi = 500)
cm = plt.get_cmap('inferno', 30)



for i,path in enumerate(pathlist_Hall_Bar_6_IVs_longsweep_normalised_data):

    print(path)

    data = np.loadtxt(path,delimiter = ",",skiprows = 1,usecols = (1,2),unpack = True)
    current = data[0]*1E6
    V_Keithley = data[1]*1E3

    threshold = 2.5
    current_masked = ma.masked_array(current, mask = np.logical_and(current<threshold,current>-threshold) )

    ax.set_ylim(-100,100)
    ax.plot(current_masked,V_Keithley,color=cm(i/len(temperature_list)-0.1))
    R=np.polyfit(current,V_Keithley, 1)[0]
    print(R)
    #R[i]=np.polyfit(current,V_Keithley, 1)[0]
    #print(R[i])
    ax.plot(current,current*R,color= "blue",linewidth=1, alpha = 0.5)


    df = pd.DataFrame({'current':current,'V_Keithley':V_Keithley,'Line Fit':current*R})
    df.to_csv(r'C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Cut and Fitted\ '  + str(i) + " " + 'FM301 Hall Bar 6 Cut and Fitted IVs' + " " + str(temperature_list[i]) + "K"


ax.set_xlabel("$I (\mu A)$ ",fontsize=40,labelpad = 25)
ax.set_ylabel(r'$V(mV)$',fontsize=40,labelpad = 25)
```

```
ax.tick_params(axis = 'x', which='major', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, top = True)
ax.tick_params(axis = 'y', which='major', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, right = True)
ax.tick_params(axis = 'y', which='minor', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, right = True)


ax.spines["top"].set_linewidth(2.5)
ax.spines["bottom"].set_linewidth(2.5)
ax.spines["right"].set_linewidth(2.5)
ax.spines["left"].set_linewidth(2.5)


norm = mpl.colors.Normalize(vmin=1.5, vmax=300)
sm = plt.cm.ScalarMappable(cmap=cm,norm = norm)
cax = fig.add_axes([0.25, 0.6, 0.02, 0.2])
tick_list = np.arange(temperature_list.min(),temperature_list.max(),80)
tick_list1 = [300,200,100,1.5]
cbar = plt.colorbar(sm, cax=cax, shrink = 0.01, orientation='vertical')
cbar.set_ticks(tick_list1[::-1])
cbar.set_ticklabels(list(map(str, tick_list1)))
cbar.ax.tick_params(labelsize=15)
cbar.ax.set_title('T(K)', fontsize = 20, pad = 20)

plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM301\Figures\FM301_Hall_Bar_6_Cut_IVs_with_Line.pdf",bbox_inches = "tight", format = "pdf")
plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM301\Figures\FM301_Hall_Bar_6_Cut_IVs_with_Line.png",bbox_inches = "tight")
plt.show()
```

C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 0 FM301 Hall Bar 6 Normalised IVs 298.0K.csv
1.525450748425785
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 1 FM301 Hall Bar 6 Normalised IVs 291.0K.csv
1.5158901000985023
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 2 FM301 Hall Bar 6 Normalised IVs 281.0K.csv
1.5076238733941791
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 3 FM301 Hall Bar 6 Normalised IVs 271.0K.csv
1.4953951311429747
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 4 FM301 Hall Bar 6 Normalised IVs 261.0K.csv
1.4854649245845915
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 5 FM301 Hall Bar 6 Normalised IVs 251.0K.csv
1.474892027122107
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 6 FM301 Hall Bar 6 Normalised IVs 241.0K.csv
1.4623927196704267
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 7 FM301 Hall Bar 6 Normalised IVs 232.0K.csv
1.4556749622785294
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 8 FM301 Hall Bar 6 Normalised IVs 221.0K.csv
1.442181621117627
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 9 FM301 Hall Bar 6 Normalised IVs 212.0K.csv
1.4268866348940648
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 10 FM301 Hall Bar 6 Normalised IVs 202.0K.csv
1.4155606211961544
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 11 FM301 Hall Bar 6 Normalised IVs 192.0K.csv
1.403221225549317
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 12 FM301 Hall Bar 6 Normalised IVs 183.0K.csv
1.391533232369048
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 13 FM301 Hall Bar 6 Normalised IVs 173.0K.csv
1.3776044209801657
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 14 FM301 Hall Bar 6 Normalised IVs 163.0K.csv
1.3736482474739526
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 15 FM301 Hall Bar 6 Normalised IVs 153.0K.csv
1.3778748525850641
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 16 FM301 Hall Bar 6 Normalised IVs 143.0K.csv
1.411925714566692
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 17 FM301 Hall Bar 6 Normalised IVs 133.0K.csv
1.4953986192873254
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 18 FM301 Hall Bar 6 Normalised IVs 123.0K.csv
1.651100611802784
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 19 FM301 Hall Bar 6 Normalised IVs 113.0K.csv
1.9635797655034009
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 20 FM301 Hall Bar 6 Normalised IVs 102.0K.csv
2.3196996207261984
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 21 FM301 Hall Bar 6 Normalised IVs 92.0K.csv
2.6043219809920846
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 22 FM301 Hall Bar 6 Normalised IVs 82.0K.csv
2.952585134593337
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 23 FM301 Hall Bar 6 Normalised IVs 72.0K.csv
3.33025802336661
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 24 FM301 Hall Bar 6 Normalised IVs 62.0K.csv
3.7655375417893073
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 25 FM301 Hall Bar 6 Normalised IVs 52.0K.csv
4.354136751788713
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 26 FM301 Hall Bar 6 Normalised IVs 42.0K.csv
4.8903139820962345

```
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 27 FM301 Hall Bar 6 Normalised IVs 31.0K.csv
5.680018861457535
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 28 FM301 Hall Bar 6 Normalised IVs 21.0K.csv
6.580081740196745
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 29 FM301 Hall Bar 6 Normalised IVs 11.0K.csv
7.995758636506014
C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Initial Normalisation\ 30 FM301 Hall Bar 6 Normalised IVs 5.0K.csv
9.456930293678289
```


100
75
50
25
0
−25
−50
−75
V(mV)
T(K)
1.5
100
200
300



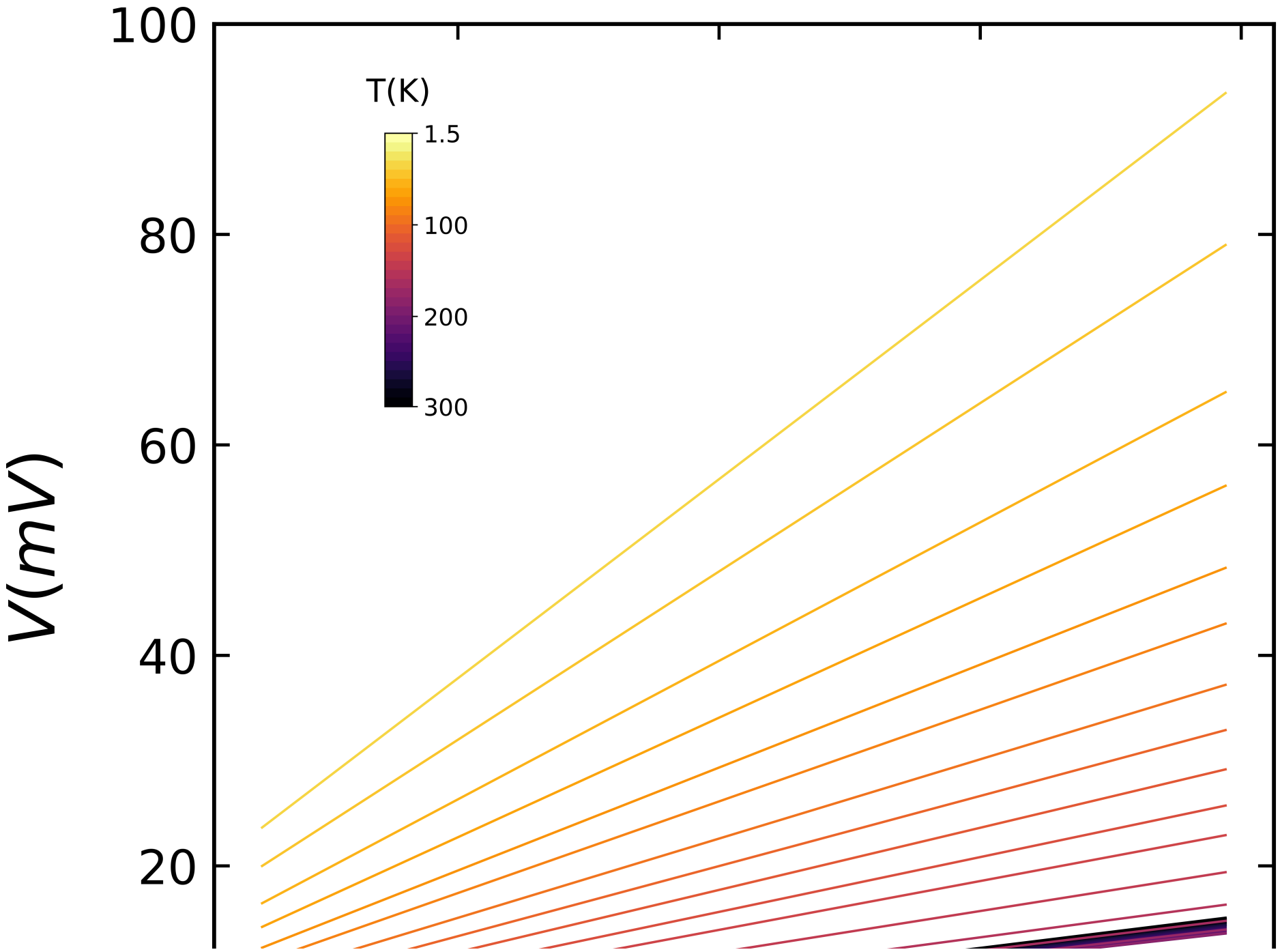
Symmetrising

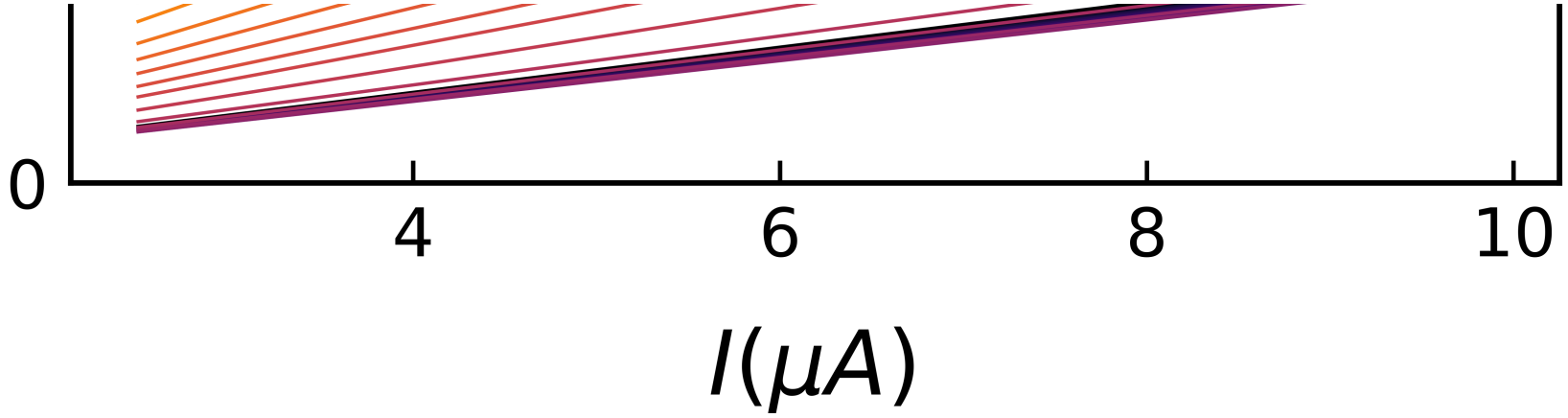
In [11]:
```
fig, ax = plt.subplots(figsize=(12, 12), dpi = 500)
temperature_list = findtemperature(pathlist_Hall_Bar_6_IVs_longsweep)
cm = plt.get_cmap('inferno', 30)

for i,path in enumerate(pathlist_Hall_Bar_6_IVs_longsweep_cut_and_fitted):


    data = np.loadtxt(path,delimiter = ",",skiprows = 1,usecols = (1,2,3),unpack = True)
    current = data[0]
    V_Keithley = data[1]
    Line_Fit = data[2]




    plus2uA = closest_element_index(current,2.5)
    plus10uA = closest_element_index(current,10)
    minus2uA = closest_element_index(current,-2.5)
    minus10uA = closest_element_index(current,-9.89)



    b1_start = current[int(plus2uA[0])]
    b1_end = current[int(plus10uA[0])]
    b2_start = current[int(plus10uA[0])]
    b2_end = current[int(plus2uA[1])]
    b3_start = current[int(minus2uA[0])]
    b3_end = current[int(minus10uA[0])]
    b4_start = current[int(minus10uA[0])]
    b4_end = current[int(minus2uA[0])]
    b1_start_index = np.where(current == b1_start)[0][0]
    b1_end_index = np.where(current == b1_end)[0][0]
    b2_start_index = np.where(current == b2_start)[0][0]
    b2_end_index = np.where(current == b2_end)[0][0]
    b3_start_index = np.where(current == b3_start)[0][0]
```

```
    b3_end_index = np.where(current == b3_end)[0][0]
    b4_start_index = np.where(current == b4_start)[0][0]
    b4_end_index = np.where(current == b4_end)[0][1]


    branch1_x = current[b1_start_index:b1_end_index]
    branch2_x = current[b2_start_index:b2_end_index]
    branch3_x = current[b3_start_index:b3_end_index]
    branch4_x = current[b4_start_index:b4_end_index+1]


    branch1_y = Line_Fit[b1_start_index:b1_end_index]
    branch2_y = Line_Fit[b2_start_index:b2_end_index]
    branch3_y = Line_Fit[b3_start_index:b3_end_index]
    branch4_y = Line_Fit[b4_start_index:b4_end_index+1]



    f_1 = interpolate.interp1d(branch1_x, branch1_y,fill_value="extrapolate")
    V_Keithley_1_int = f_1(branch1_x)

    f_2 = interpolate.interp1d(branch2_x, branch2_y,fill_value="extrapolate")
    V_Keithley_2_int = f_2(branch1_x[::-1])
    V_Keithley_2_int = V_Keithley_2_int[::-1]


    f_3 = interpolate.interp1d(branch3_x, branch3_y,fill_value="extrapolate")
    V_Keithley_3_int = f_3(branch1_x[::-1])
    V_Keithley_3_int = V_Keithley_3_int[::-1]


    f_4 = interpolate.interp1d(branch4_x, branch4_y,fill_value="extrapolate")
    V_Keithley_4_int = f_4(branch1_x)

    Sym_1_3 = (V_Keithley_1_int + V_Keithley_3_int)/2
    Sym_2_4 = (V_Keithley_2_int + V_Keithley_4_int)/2

    Sym_1_2 = (V_Keithley_1_int + V_Keithley_2_int)/2



    Sym_both = (Sym_1_3 + Sym_2_4)/2

    ax.set_ylim(0,100)

    ax.plot(branch1_x,Sym_both,color=cm(i/len(temperature_list)-0.1))


    df = pd.DataFrame({'current':branch1_x,'V_Keithley':Sym_1_2})
    df.to_csv(r'C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Symmetrised\ ' + str(i) + " " + 'FM301 Hall Bar 6 Symmetrised IVs' + " " + str(temperature_list[i]) + "K" + '.cs

ax.set_xlabel("$I (\mu A)$ ",fontsize=40,labelpad = 25)
ax.set_ylabel(r'$V(mV)$',fontsize=40,labelpad = 25)
```

```
ax.tick_params(axis = 'x', which='major', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, top = True)
ax.tick_params(axis = 'y', which='major', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, right = True)
ax.tick_params(axis = 'y', which='minor', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, right = True)


ax.spines["top"].set_linewidth(2.5)
ax.spines["bottom"].set_linewidth(2.5)
ax.spines["right"].set_linewidth(2.5)
ax.spines["left"].set_linewidth(2.5)


norm = mpl.colors.Normalize(vmin=1.5, vmax=300)
sm = plt.cm.ScalarMappable(cmap=cm,norm = norm)
cax = fig.add_axes([0.25, 0.6, 0.02, 0.2])
tick_list = np.arange(temperature_list.min(),temperature_list.max(),80)
tick_list1 = [300,200,100,1.5]
cbar = plt.colorbar(sm, cax=cax, shrink = 0.01, orientation='vertical')
cbar.set_ticks(tick_list1[::-1])
cbar.set_ticklabels(list(map(str, tick_list1)))
cbar.ax.tick_params(labelsize=15)
cbar.ax.set_title('T(K)', fontsize = 20, pad = 20)


plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM301\Figures\FM301_Hall_Bar_6_Symmetrised_IVs.pdf",bbox_inches = "tight", format = "pdf")
plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM301\Figures\FM301_Hall_Bar_6_Symmetrised_IVs.png",bbox_inches = "tight")
plt.show()



# print(current)
# print(V_Keithley)


# print("i",i)
# print("path",path)
# print(plus2uA)
# print(plus10uA)
# print(minus2uA)
# print(minus10uA)

# print('b1_start',b1_start,b1_start_index)
# print('b1_end',b1_end,b1_end_index)
# print('b2_start',b2_start,b2_start_index)
# print('b2_end',b2_end,b2_end_index)
# print('b3_start',b3_start,b3_start_index)
# print('b3_end',b3_end,b3_end_index)
# print('b4_start',b4_start,b4_start_index)
# print('b4_end',b4_end,b4_end_index)

# print('branch1_x',len(branch1_x),branch1_x)
# print('branch2_x',len(branch2_x),branch2_x)
# print('branch3_x',len(branch3_x),branch3_x)
# print('branch4_x',len(branch4_x),branch4_x)
```

```
# print('V_Keithley_1_int',V_Keithley_1_int)
# print('V_Keithley_2_int',V_Keithley_2_int)
# print('V_Keithley_3_int',V_Keithley_3_int)
# print('V_Keithley_4_int',V_Keithley_4_int)


# plt.scatter(current,V_Keithley, s = 1)
#ax.xaxis.offsetText.set_fontsize(24)
#plt.legend(labels = temperature_list)
```

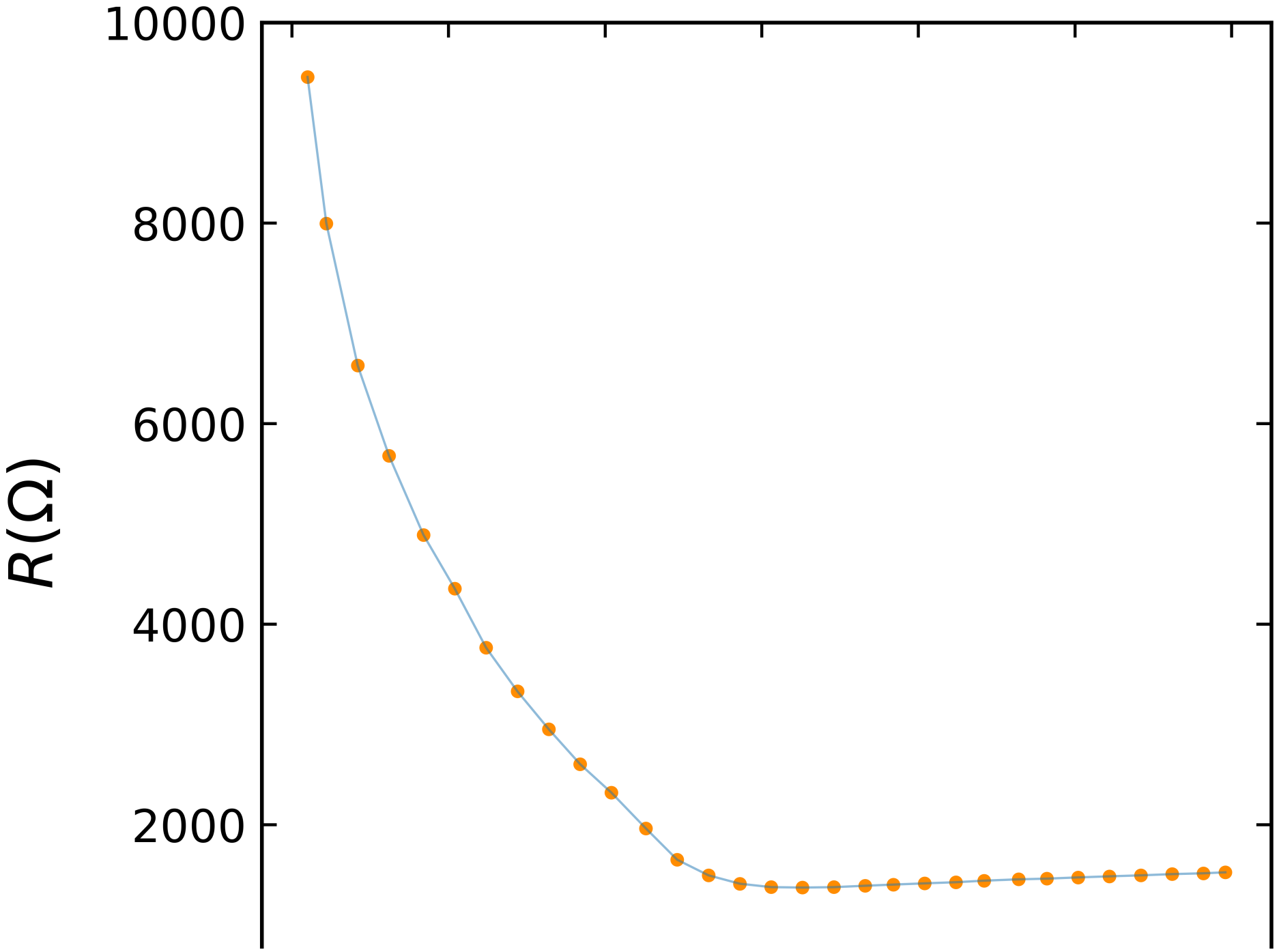

100
80
60
40
20
V(mV)
T(K)
1.5
100
200
300

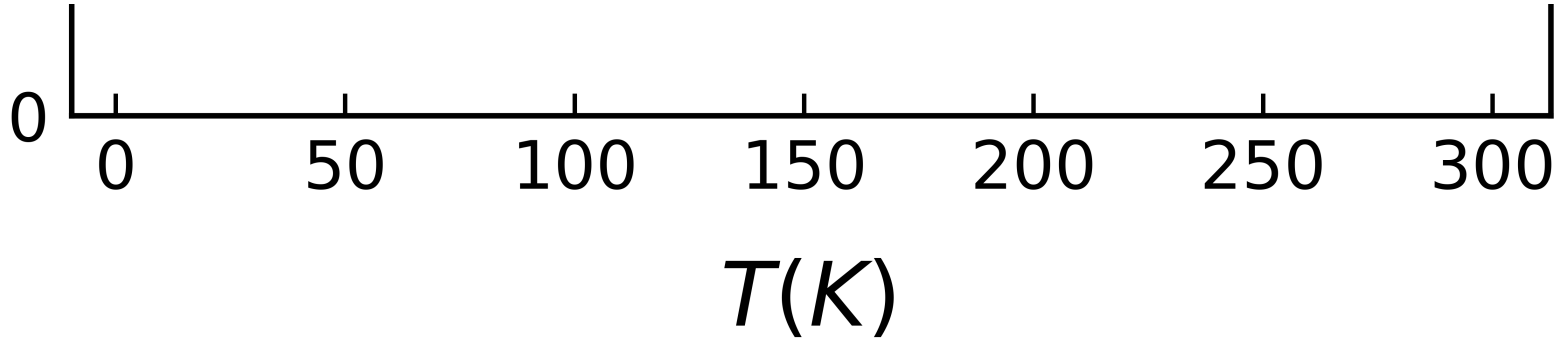


R vs T

In [12]:
```
fig, ax = plt.subplots(figsize=(12, 12), dpi = 500)
temperature_list = findtemperature(pathlist_Hall_Bar_6_IVs_longsweep)

values_at_10uA = []


for i,path in enumerate(pathlist_Hall_Bar_6_IVs_longsweep_symmetrised_data):


    data = np.loadtxt(path,delimiter = ",",skiprows = 1,usecols = (1,2),unpack = True)
    current = data[0]
    V_Keithley = data[1]

    dV_dI_crude_10uA = (V_Keithley[-1]/current[-1])
    values_at_10uA = np.append(values_at_10uA,dV_dI_crude_10uA)

ax.set_ylim(0,10000)
ax.scatter(temperature_list,values_at_10uA*1E3, color = "darkorange", alpha = 1, linewidth = 3 )
ax.plot(temperature_list,values_at_10uA*1E3, alpha = 0.5)


ax.set_xlabel("$T(K)$ ",fontsize=40,labelpad = 25)
ax.set_ylabel(r'$R(\Omega)$',fontsize=40,labelpad = 25)

ax.tick_params(axis = 'x', which='major', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, top = True)
ax.tick_params(axis = 'y', which='major', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, right = True)
ax.tick_params(axis = 'y', which='minor', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, right = True)


ax.spines["top"].set_linewidth(2.5)
ax.spines["bottom"].set_linewidth(2.5)
ax.spines["right"].set_linewidth(2.5)
```

```
ax.spines["left"].set_linewidth(2.5)

plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM301\Figures\FM301_Hall_Bar_6_IVs_Cooldown_dV_d_vs_T.pdf", bbox_inches = "tight", format = "pdf")
plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM301\Figures\FM301_Hall_Bar_6_IVs_Cooldown_dV_dI_vs_T.png", bbox_inches = "tight")
plt.show()

plt.show()
```

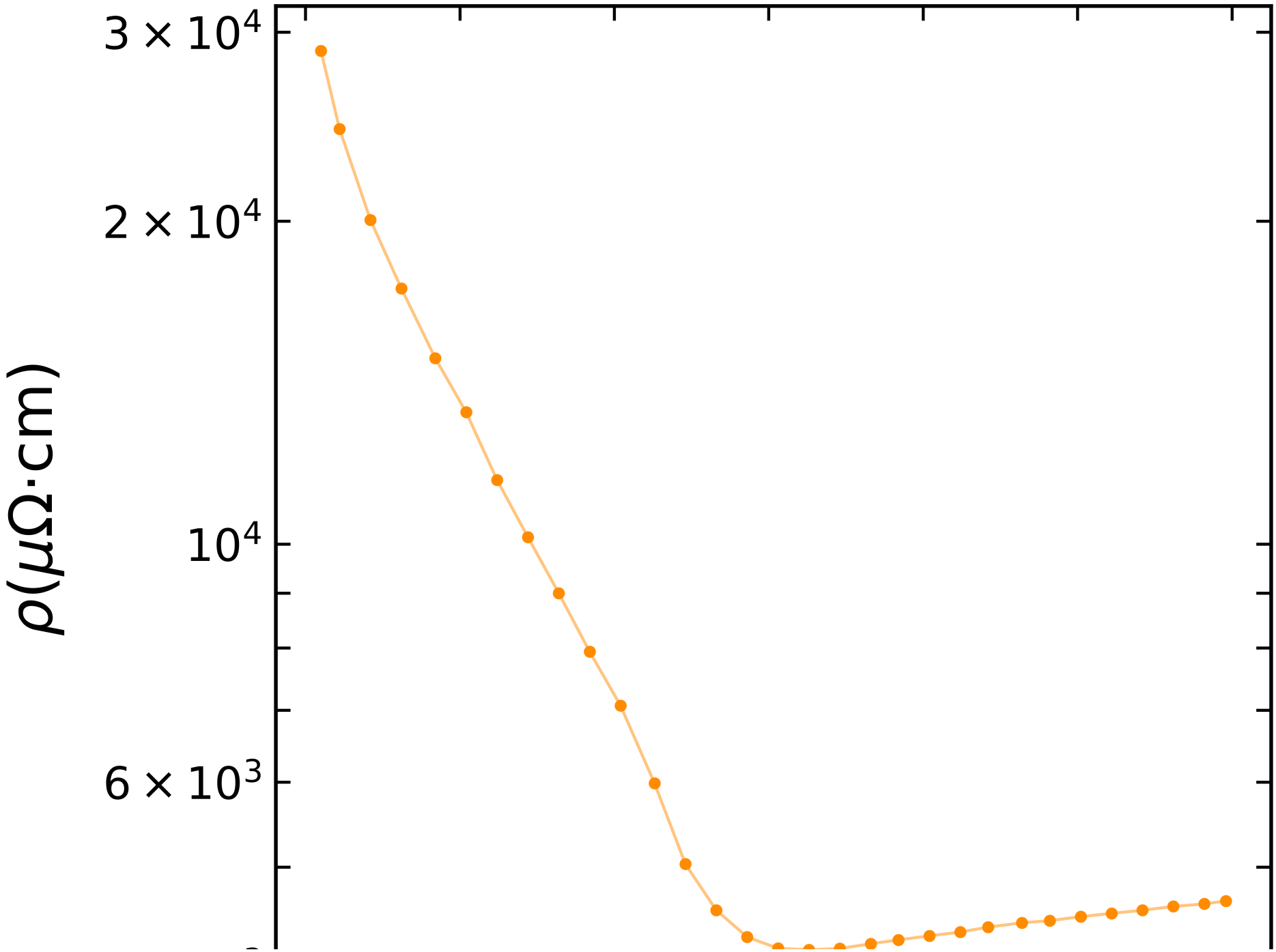

10000
8000
6000
4000
2000
R(Ω)

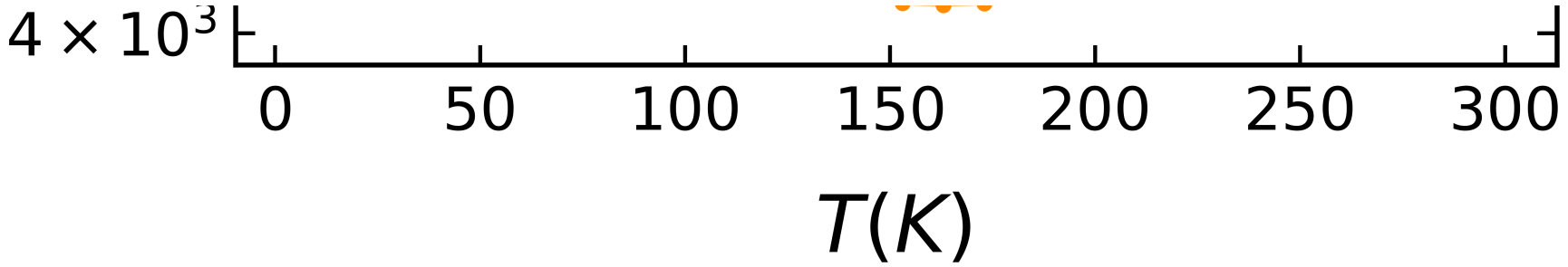


Resitivity

In [27]:
```
fig, ax = plt.subplots(figsize=(12, 12), dpi = 500)

#ax.set_ylim(0,30000)
ax.scatter(temperature_list, values_at_10uA*1E3 *(30.48E-9*10/10)*1E2*1E6, color = 'darkorange', s=50)
ax.plot(temperature_list,values_at_10uA*1E3 *(30.48E-9*10/10)*1E2*1E6, color = 'darkorange', lw = 2, alpha = 0.5)



ax.set_ylabel(r'$\rho$($\mu$$\Omega$·cm)',fontsize=40,labelpad = 25)
ax.set_xlabel("$T(K)$ ",fontsize=40,labelpad = 25)


ax.tick_params(axis = 'x', which='major', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, top = True)
ax.tick_params(axis = 'y', which='major', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, right = True)
ax.tick_params(axis = 'y', which='minor', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, right = True)

plt.yscale("log")
ax.get_yaxis().set_major_formatter(ticker.LogFormatterSciNotation(base=10))


ax.spines["top"].set_linewidth(2.5)
ax.spines["bottom"].set_linewidth(2.5)
ax.spines["right"].set_linewidth(2.5)
ax.spines["left"].set_linewidth(2.5)

df = pd.DataFrame({'temperature_list':temperature_list,'values_at_10uA':values_at_10uA*1E3 *(30.48E-9*10/10)*1E2*1E6})
df.to_csv(r'C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\R vs T\FM301 Hall Bar 6 Resitivity vs T cooldown.csv')
df.to_csv(r'C:\Users\pblah\Data\Navy Beach\FM301\Data\Resitivity Combined Pandas\FM301 Hall Bar 6 Resitivity vs T cooldown.csv')

plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM301\Figures\FM301_Hall_Bar_6_IVs_Cooldown_Resitivity_vs_T_Cooldown.pdf", bbox_inches = "tight", format = "pdf")
plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM301\Figures\FM301_Hall_Bar_6_IVs_Cooldown_Resitivity_vs_T_Cooldown.png", bbox_inches = "tight")
plt.show()
```

```
#### For Log Plot #########
#plt.yscale("log")
#ax.get_yaxis().set_major_formatter(matplotlib.ticker.LogFormatterSciNotation(base=10))
#ax.get_yaxis().set_minor_formatter(matplotlib.ticker.LogFormatterSciNotation(base=10, minor_thresholds = (10,0.1)))
#locmin = matplotlib.ticker.LogLocator(base=10.0, subs=(1,2,3,4,5,6))
#ax.yaxis.set_minor_locator(locmin)
#ax.yaxis.set_minor_formatter(matplotlib.ticker.LogFormatterSciNotation(base=10))
#ax.tick_params(axis='y', which='major', labelsize=30, direction = 'in')
#ax.tick_params(axis='y', which='minor', labelsize=20, width = 1, length = 10, direction = 'in')
#plt.ylim(1E3,1E5)
###################################
```


3×10^4
2×10^4
10^4
6×10^3
$\rho(\mu\Omega \cdot \mathrm{cm})$

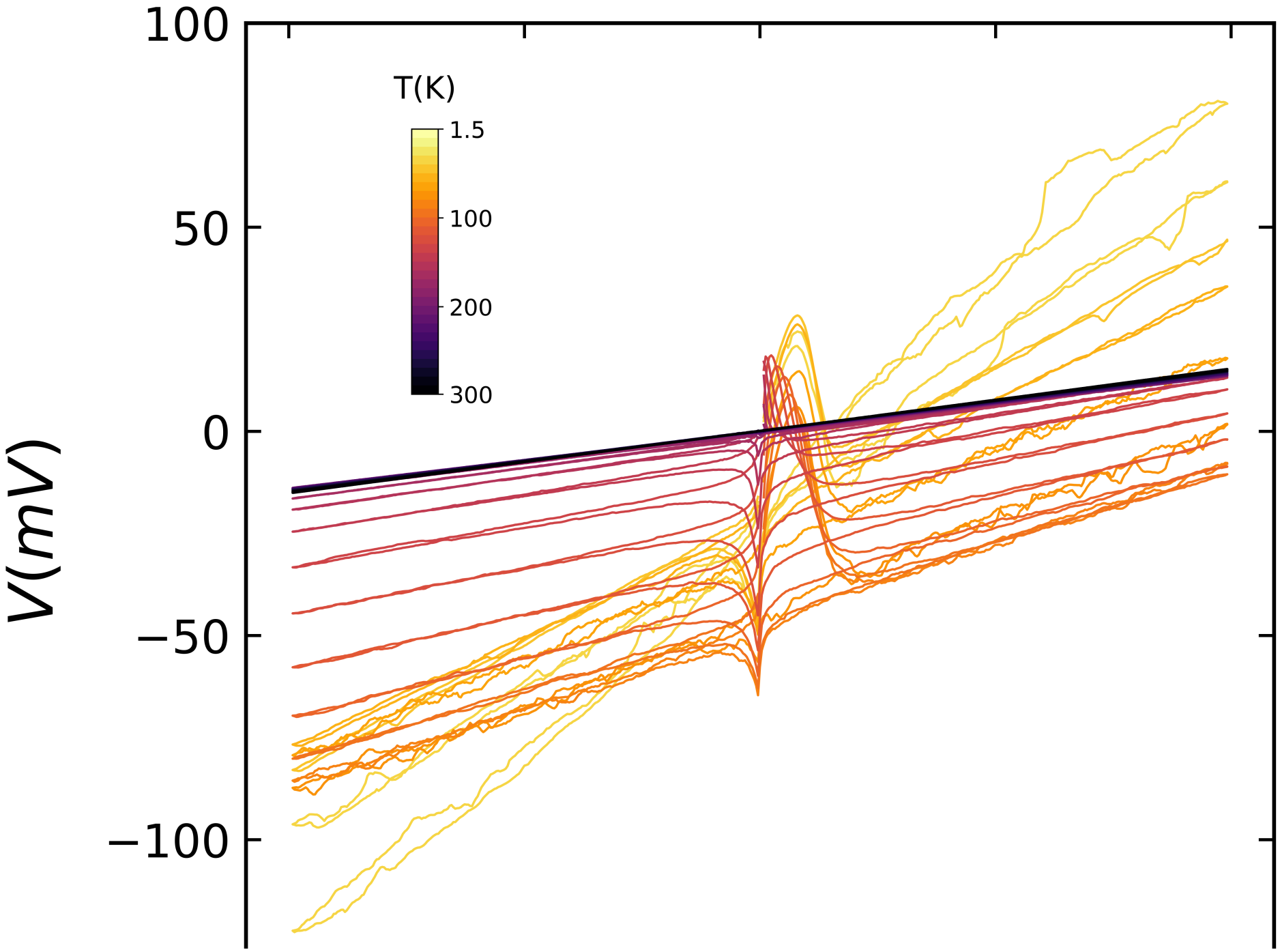


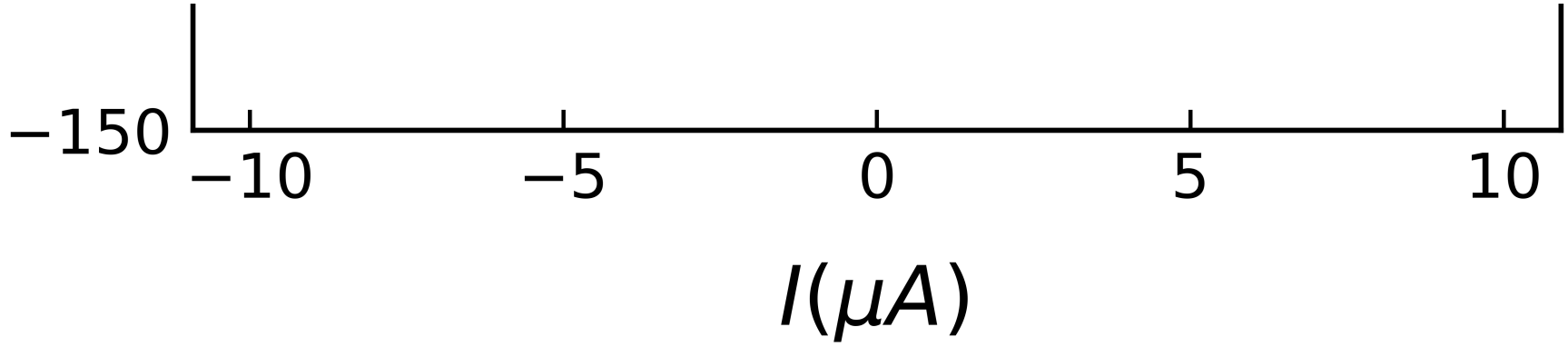
Warmup

Plotting raw IVs

In [14]:
```
fig, ax = plt.subplots(figsize=(12, 12), dpi = 500)
temperature_list_warmup = findtemperature(pathlist_Hall_Bar_6_IVs_warmup_longsweep)
cm = plt.get_cmap('inferno_r', 30)
cm1 = plt.get_cmap('inferno', 30)


for i,data in enumerate(pathlist_Hall_Bar_6_IVs_warmup_longsweep):

    dataextracted = dataextractorIVs(data)
    current = dataextracted[0]
    V_Keithley = dataextracted[1]
    RLKin = dataextracted[1]


    ax.plot(current*1E6,V_Keithley*1E3 ,label = temperature_list_warmup[i], color=cm(i/len(temperature_list)+0.1))

ax.set_ylim(-150,100)

ax.set_xlabel("$I (\mu A)$ ",fontsize=40,labelpad = 25)
ax.set_ylabel(r'$V(mV)$',fontsize=40,labelpad = 25)

ax.tick_params(axis = 'x', which='major', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, top = True)
ax.tick_params(axis = 'y', which='major', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, right = True)
ax.tick_params(axis = 'y', which='minor', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, right = True)


ax.spines["top"].set_linewidth(2.5)
ax.spines["bottom"].set_linewidth(2.5)
ax.spines["right"].set_linewidth(2.5)
ax.spines["left"].set_linewidth(2.5)


norm = mpl.colors.Normalize(vmin=1.5, vmax=300)
sm = plt.cm.ScalarMappable(cmap=cm1,norm = norm)
```

```
cax = fig.add_axes([0.25, 0.6, 0.02, 0.20])
#tick_list = np.arange(temperature_list.min(),temperature_list.max(),80)
tick_list1 = [300,200,100,1.5]
cbar = plt.colorbar(sm, cax=cax, shrink = 0.01, orientation='vertical')
cbar.set_ticks(tick_list1[::-1])
cbar.set_ticklabels(list(map(str, tick_list1)))
cbar.ax.tick_params(labelsize=15)
cbar.ax.set_title('T(K)', fontsize = 20, pad = 20)

plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM301\Figures\FM301_Hall_Bar_6_IVs_Warmup_Longsweep_Raw.pdf",bbox_inches = "tight", format = "pdf")
plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM301\Figures\FM301_Hall_Bar_6_IVs_Warmup_Longsweep_Raw.png",bbox_inches = "tight")
plt.show()


#plt.legend(labels = temperature_list)
#plt.xlim(0.75E-5,1E-5)
#plt.ylim(0.01,0.017)
#ax.xaxis.offsetText.set_fontsize(24)
```

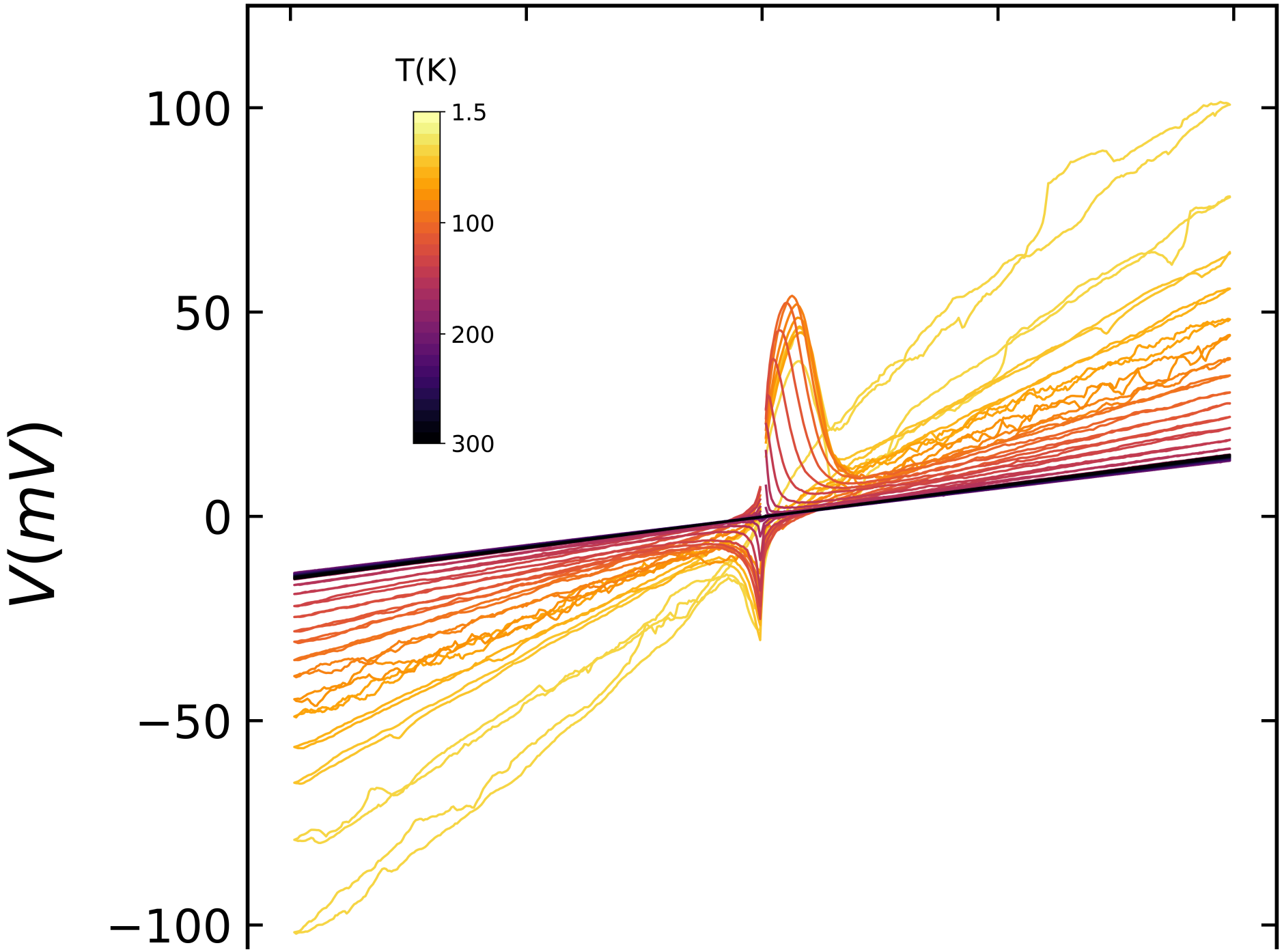

100
50
0
−50
−100
V(mV)
T(K)
1.5
100
200
300

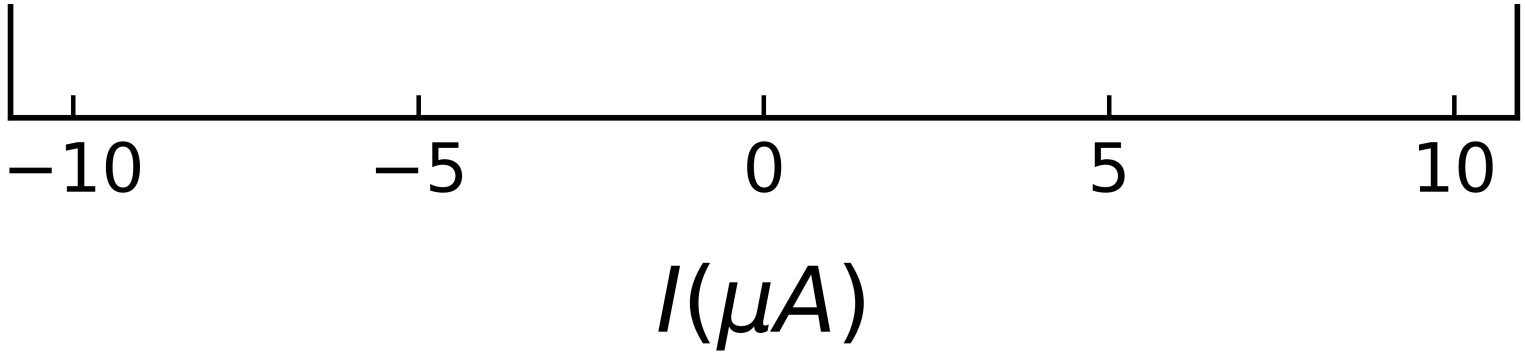


Offsetting

In [15]:
```
fig, ax = plt.subplots(figsize=(12, 12), dpi = 500)
cm = plt.get_cmap('inferno_r', 30)
cm1 = plt.get_cmap('inferno', 30)

temperature_list_warmup = findtemperature(pathlist_Hall_Bar_6_IVs_warmup_longsweep)


for i,path in enumerate(pathlist_Hall_Bar_6_IVs_warmup_longsweep):


    dataextracted = dataextractorIVs(path)
    current = dataextracted[0]
    V_Keithley = dataextracted[1]
    RLKin = dataextracted[1]

    plus10uA = int(closest_element_index(current,10E-6)[0])
    minus10uA = int(closest_element_index(current,-9.86E-6)[0])


    V_Keithley_endpoints = [V_Keithley[plus10uA],V_Keithley[minus10uA]]
    current_endpoints = [current[plus10uA],current[minus10uA]]

    line_y = interpolate.interp1d(current_endpoints, V_Keithley_endpoints, fill_value = "extrapolate")
    V_Keithley_int_line = line_y(current)
    offset = V_Keithley_int_line[0]
    V_Keithley_norm = V_Keithley - offset


    plt.plot(current*1E6,V_Keithley_norm*1E3,label = temperature_list_warmup[i],color=cm(i/len(temperature_list)+0.1))

    df = pd.DataFrame({'current':current,'V_Keithley':V_Keithley_norm})
    df.to_csv(r'C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Warmup\Offsetted\ '  + str(i) + '_' + str(i) + " " + 'FM301 Hall Bar 6 Warmup Offset IVs' + " " + str(temperatur


ax.set_ylim(-125,125)
```

```
ax.set_xlabel("$I (\mu A)$ ",fontsize=40,labelpad = 25)
ax.set_ylabel(r'$V(mV)$',fontsize=40,labelpad = 25)

ax.tick_params(axis = 'x', which='major', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, top = True)
ax.tick_params(axis = 'y', which='major', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, right = True)
ax.tick_params(axis = 'y', which='minor', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, right = True)


ax.spines["top"].set_linewidth(2.5)
ax.spines["bottom"].set_linewidth(2.5)
ax.spines["right"].set_linewidth(2.5)
ax.spines["left"].set_linewidth(2.5)


norm = mpl.colors.Normalize(vmin=1.5, vmax=300)
sm = plt.cm.ScalarMappable(cmap=cm1,norm = norm)
cax = fig.add_axes([0.25, 0.55, 0.02, 0.25])
#tick_list = np.arange(temperature_list.min(),temperature_list.max(),80)
tick_list1 = [300,200,100,1.5]
cbar = plt.colorbar(sm, cax=cax, shrink = 0.01, orientation='vertical')
cbar.set_ticks(tick_list1[::-1])
cbar.set_ticklabels(list(map(str, tick_list1)))
cbar.ax.tick_params(labelsize=15)
cbar.ax.set_title('T(K)', fontsize = 20, pad = 20)

plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM301\Figures\FM301_Hall_Bar_6_IVs_Warmup_Longsweep_Offset_Fixed.pdf",bbox_inches = "tight", format = "pdf")
plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM301\Figures\FM301_Hall_Bar_6_IVs_Warmup_Longsweep_Offset_Fixed.png",bbox_inches = "tight")
plt.show()

#print("i",i)
#print("data",data)
#plt.scatter(current[plus10uA],V_Keithley[plus10uA])
#plt.scatter(current[minus10uA],V_Keithley[minus10uA])
#print('V_Keithley plus10uA',V_Keithley[plus10uA])
#print('V_Keithley minus10uA',V_Keithley[minus10uA])
#plt.plot(current,V_Keithley_int_line)
#plt.scatter(current,V_Keithley,s=1, color = 'red')
#plt.plot(current,V_Keithley_int_line,color = 'blue')

#ax.xaxis.offsetText.set_fontsize(24)

#plt.legend(labels = temperature_list)

#plt.xlim(0.75E-5,1E-5)
#plt.ylim(0.01,0.017)
```

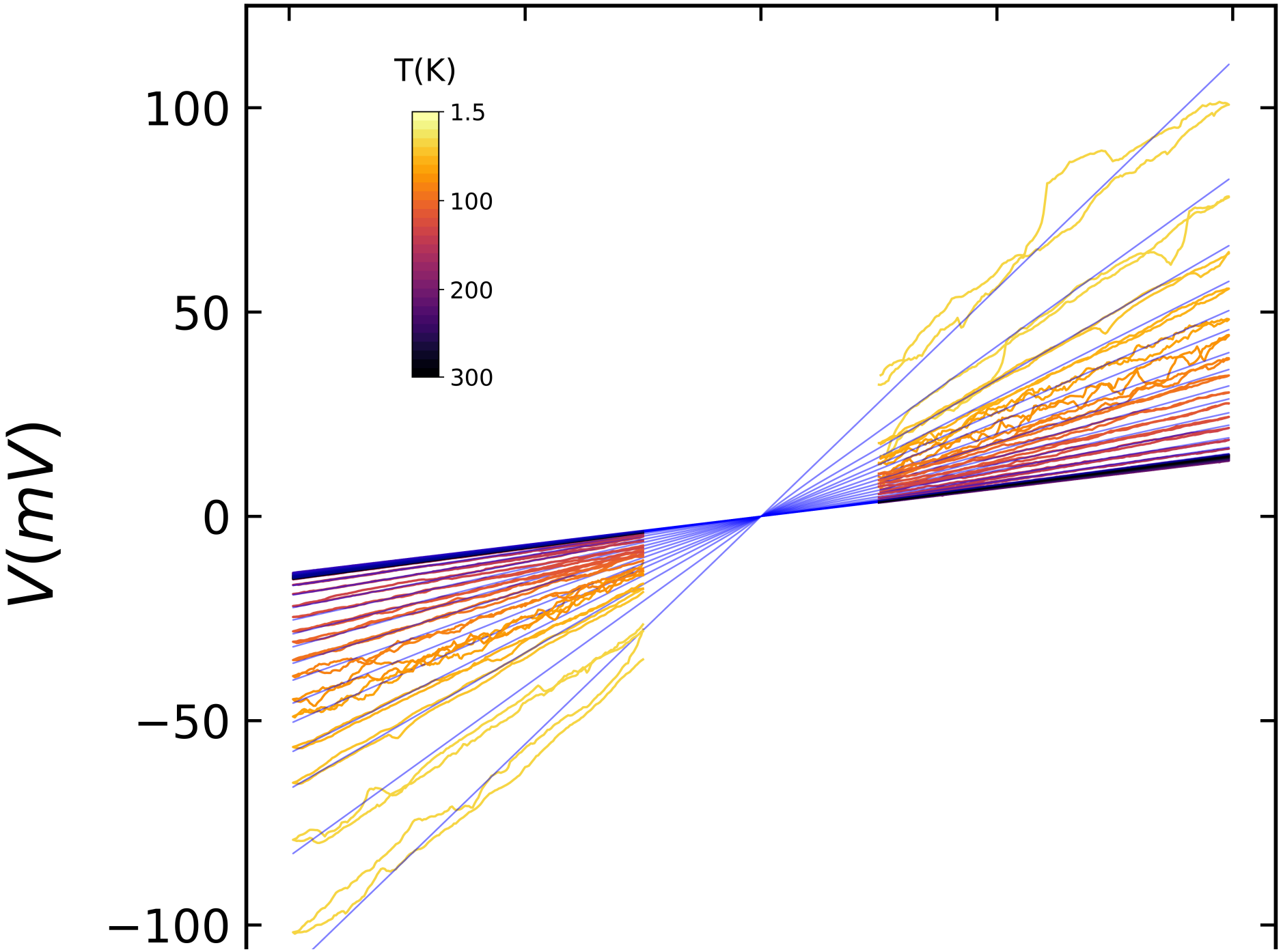

T(K)
1.5
100
200
300
100
50
0
−50
−100
V(mV)

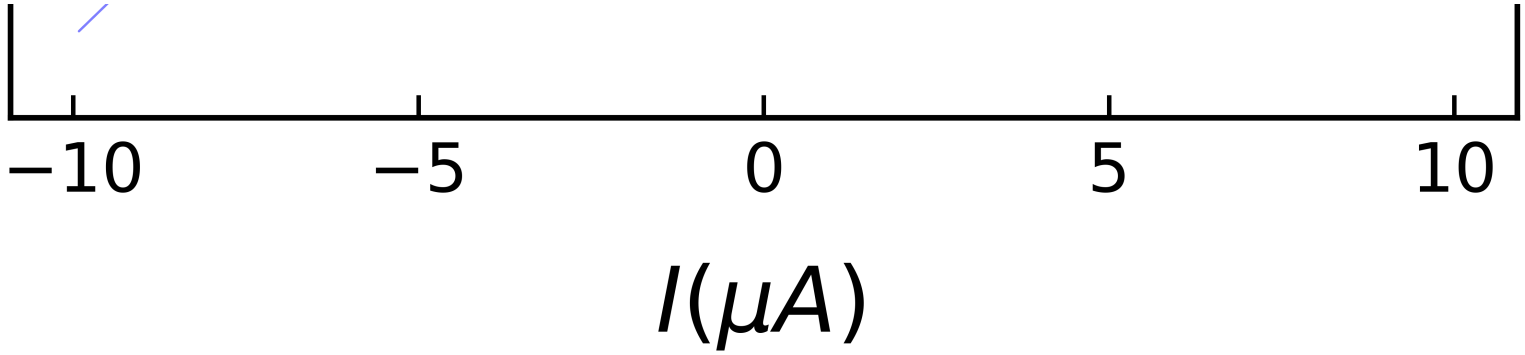


Cut and Fitting (With help from Graham)

In [16]:
```
folder = folder_Hall_Bar_6_IVs_longsweep_normalised_data
temperature_list_warmup = findtemperature(pathlist_Hall_Bar_6_IVs_warmup_longsweep)

#print(temperature_list_warmup)

fig, ax = plt.subplots(figsize=(12, 12), dpi = 500)
cm = plt.get_cmap('inferno_r', 30)
cm1 = plt.get_cmap('inferno', 30)



for i,path in enumerate(pathlist_Hall_Bar_6_IVs_warmup_longsweep_offsetted):

   #print(i)

    data = np.loadtxt(path,delimiter = ",",skiprows = 1,usecols = (1,2),unpack = True)
    current = data[0]*1E6
    V_Keithley = data[1]*1E3

    threshold = 2.5
    current_masked = ma.masked_array(current, mask = np.logical_and(current<threshold,current>-threshold) )

    plt.plot(current_masked,V_Keithley,color=cm(i/len(temperature_list_warmup)+0.1))
    R=np.polyfit(current,V_Keithley, 1)[0]

    ax.set_ylim(-125,125)
    ax.plot(current,current*R,color= "blue",linewidth=1, alpha = 0.5)


    df = pd.DataFrame({'current':current,'V_Keithley':V_Keithley,'Line Fit':current*R})
    df.to_csv(r'C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Warmup\Cut and Fitted\ '  + str(i) + '_' + str(i) + " " + 'FM301 Hall Bar 6 Cut and Fitted Warmup IVs' + " " + s


ax.set_xlabel("$I (\mu A)$ ",fontsize=40,labelpad = 25)
ax.set_ylabel(r'$V(mV)$',fontsize=40,labelpad = 25)
```

```
ax.tick_params(axis = 'x', which='major', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, top = True)
ax.tick_params(axis = 'y', which='major', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, right = True)
ax.tick_params(axis = 'y', which='minor', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, right = True)


ax.spines["top"].set_linewidth(2.5)
ax.spines["bottom"].set_linewidth(2.5)
ax.spines["right"].set_linewidth(2.5)
ax.spines["left"].set_linewidth(2.5)


norm = mpl.colors.Normalize(vmin=1.5, vmax=300)
sm = plt.cm.ScalarMappable(cmap=cm1,norm = norm)
cax = fig.add_axes([0.25, 0.6, 0.02, 0.2])
#tick_list = np.arange(temperature_list.min(),temperature_list.max(),80)
tick_list1 = [300,200,100,1.5]
cbar = plt.colorbar(sm, cax=cax, shrink = 0.01, orientation='vertical')
cbar.set_ticks(tick_list1[::-1])
cbar.set_ticklabels(list(map(str, tick_list1)))
cbar.ax.tick_params(labelsize=15)
cbar.ax.set_title('T(K)', fontsize = 20, pad = 20)


plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM301\Figures\FM301 Hall_Bar_6_Cut_Warmup_IVs_with_Line.png",bbox_inches = "tight")
plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM301\Figures\FM301_Hall_Bar_6_Cut_Warmup_IVs_with_Line.pdf",bbox_inches = "tight", format = "pdf")
plt.show()
```


T(K)
1.5
100
200
300
100
50
0
−50
−100
V(mV)



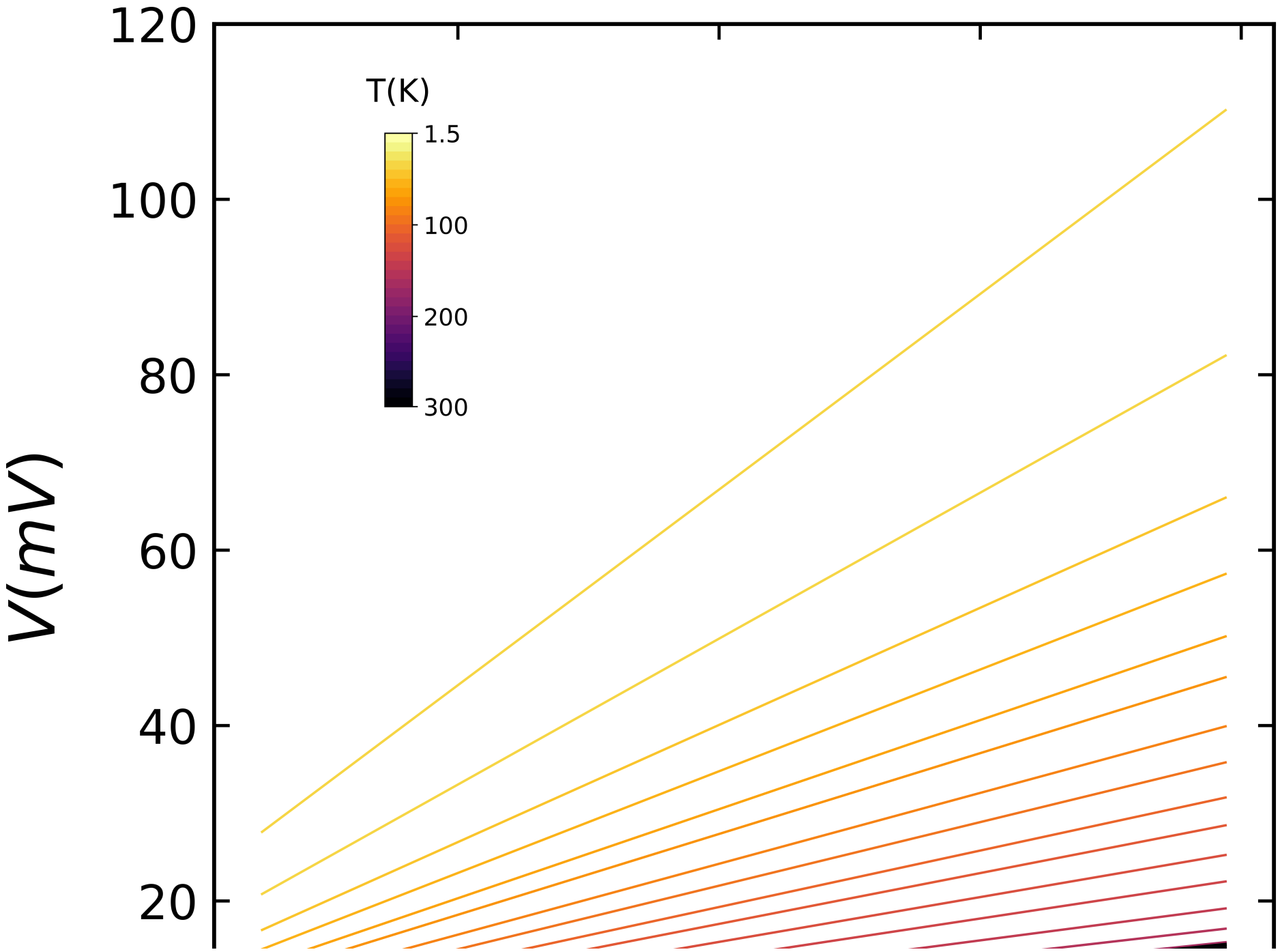
Symmetrising

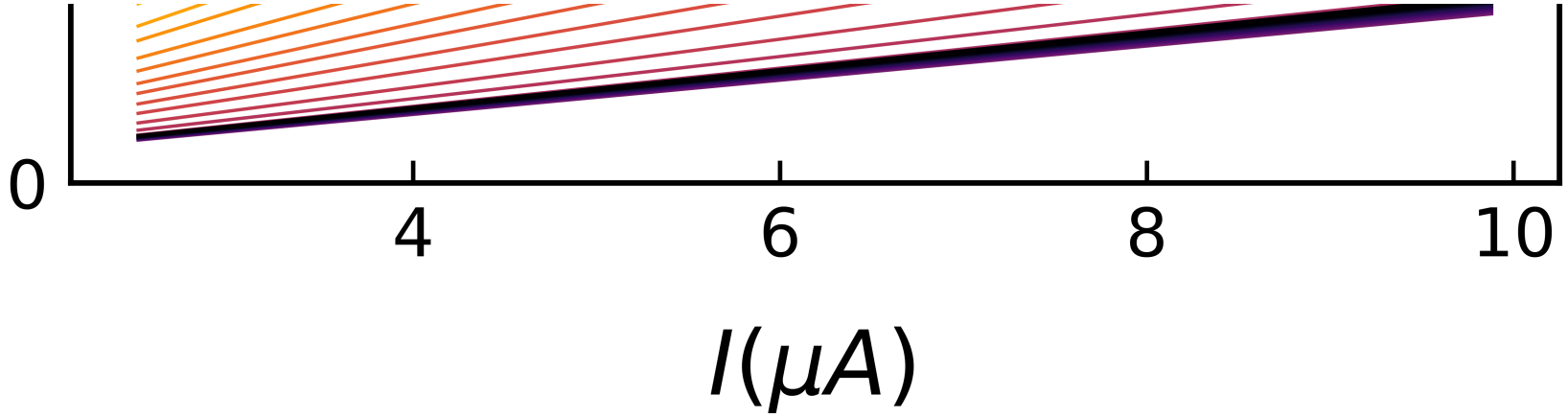
In [17]:
```
fig, ax = plt.subplots(figsize=(12, 12), dpi = 500)
temperature_list_warmup = findtemperature(pathlist_Hall_Bar_6_IVs_warmup_longsweep)
cm = plt.get_cmap('inferno_r', 30)
cm1 = plt.get_cmap('inferno', 30)

for i,path in enumerate(pathlist_Hall_Bar_6_IVs_longsweep_warmup_cut_and_fitted):


    data = np.loadtxt(path,delimiter = ",",skiprows = 1,usecols = (1,2,3),unpack = True)
    current = data[0]
    V_Keithley = data[1]
    Line_Fit = data[2]




    plus2uA = closest_element_index(current,2.5)
    plus10uA = closest_element_index(current,10)
    minus2uA = closest_element_index(current,-2.5)
    minus10uA = closest_element_index(current,-9.89)



    b1_start = current[int(plus2uA[0])]
    b1_end = current[int(plus10uA[0])]
    b2_start = current[int(plus10uA[0])]
    b2_end = current[int(plus2uA[1])]
    b3_start = current[int(minus2uA[0])]
    b3_end = current[int(minus10uA[0])]
    b4_start = current[int(minus10uA[0])]
    b4_end = current[int(minus2uA[0])]
    b1_start_index = np.where(current == b1_start)[0][0]
    b1_end_index = np.where(current == b1_end)[0][0]
    b2_start_index = np.where(current == b2_start)[0][0]
    b2_end_index = np.where(current == b2_end)[0][0]
    b3_start_index = np.where(current == b3_start)[0][0]
```

```
    b3_end_index = np.where(current == b3_end)[0][0]
    b4_start_index = np.where(current == b4_start)[0][0]
    b4_end_index = np.where(current == b4_end)[0][1]


    branch1_x = current[b1_start_index:b1_end_index]
    branch2_x = current[b2_start_index:b2_end_index]
    branch3_x = current[b3_start_index:b3_end_index]
    branch4_x = current[b4_start_index:b4_end_index+1]


    branch1_y = Line_Fit[b1_start_index:b1_end_index]
    branch2_y = Line_Fit[b2_start_index:b2_end_index]
    branch3_y = Line_Fit[b3_start_index:b3_end_index]
    branch4_y = Line_Fit[b4_start_index:b4_end_index+1]



    f_1 = interpolate.interp1d(branch1_x, branch1_y,fill_value="extrapolate")
    V_Keithley_1_int = f_1(branch1_x)

    f_2 = interpolate.interp1d(branch2_x, branch2_y,fill_value="extrapolate")
    V_Keithley_2_int = f_2(branch1_x[::-1])
    V_Keithley_2_int = V_Keithley_2_int[::-1]


    f_3 = interpolate.interp1d(branch3_x, branch3_y,fill_value="extrapolate")
    V_Keithley_3_int = f_3(branch1_x[::-1])
    V_Keithley_3_int = V_Keithley_3_int[::-1]


    f_4 = interpolate.interp1d(branch4_x, branch4_y,fill_value="extrapolate")
    V_Keithley_4_int = f_4(branch1_x)

    Sym_1_3 = (V_Keithley_1_int + V_Keithley_3_int)/2
    Sym_2_4 = (V_Keithley_2_int + V_Keithley_4_int)/2

    Sym_1_2 = (V_Keithley_1_int + V_Keithley_2_int)/2



    Sym_both = (Sym_1_3 + Sym_2_4)/2

    ax.set_ylim(0,120)
    ax.plot(branch1_x,Sym_both,color=cm(i/len(temperature_list)+0.1))


    df = pd.DataFrame({'current':branch1_x,'V_Keithley':Sym_1_2})
    df.to_csv(r'C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Warmup\Symmetrised\ '  + str(i) + '_' + str(i) + " " + 'FM301 Hall Bar 6 Warmup Symmetrised IVs' + " " + str(tem

ax.set_xlabel("$I (\mu A)$ ",fontsize=40,labelpad = 25)
ax.set_ylabel(r'$V (mV)$',fontsize=40,labelpad = 25)

ax.tick_params(axis = 'x', which='major', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, top = True)
```

```
ax.tick_params(axis = 'y', which='major', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, right = True)
ax.tick_params(axis = 'y', which='minor', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, right = True)


ax.spines["top"].set_linewidth(2.5)
ax.spines["bottom"].set_linewidth(2.5)
ax.spines["right"].set_linewidth(2.5)
ax.spines["left"].set_linewidth(2.5)


norm = mpl.colors.Normalize(vmin=1.5, vmax=300)
sm = plt.cm.ScalarMappable(cmap=cm1,norm = norm)
cax = fig.add_axes([0.25, 0.6, 0.02, 0.2])
#tick_list = np.arange(temperature_list.min(),temperature_list.max(),80)
tick_list1 = [300,200,100,1.5]
cbar = plt.colorbar(sm, cax=cax, shrink = 0.01, orientation='vertical')
cbar.set_ticks(tick_list1[::-1])
cbar.set_ticklabels(list(map(str, tick_list1)))
cbar.ax.tick_params(labelsize=15)
cbar.ax.set_title('T(K)', fontsize = 20, pad = 20)


plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM301\Figures\FM301_Hall_Bar_6_Symmetrised_Warmup_IVs.pdf",bbox_inches = "tight", format = "pdf")
plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM301\Figures\FM301_Hall_Bar_6_Symmetrised_Warmup_IVs.png",bbox_inches = "tight")
plt.show()



# print(current)
# print(V_Keithley)


# print("i",i)
# print("path",path)
# print(plus2uA)
# print(plus10uA)
# print(minus2uA)
# print(minus10uA)

# print('b1_start',b1_start,b1_start_index)
# print('b1_end',b1_end,b1_end_index)
# print('b2_start',b2_start,b2_start_index)
# print('b2_end',b2_end,b2_end_index)
# print('b3_start',b3_start,b3_start_index)
# print('b3_end',b3_end,b3_end_index)
# print('b4_start',b4_start,b4_start_index)
# print('b4_end',b4_end,b4_end_index)

# print('branch1_x',len(branch1_x),branch1_x)
# print('branch2_x',len(branch2_x),branch2_x)
# print('branch3_x',len(branch3_x),branch3_x)
# print('branch4_x',len(branch4_x),branch4_x)
```

```
# print('V_Keithley_1_int',V_Keithley_1_int)
# print('V_Keithley_2_int',V_Keithley_2_int)
# print('V_Keithley_3_int',V_Keithley_3_int)
# print('V_Keithley_4_int',V_Keithley_4_int)


# plt.scatter(current,V_Keithley, s = 1)
#ax.xaxis.offsetText.set_fontsize(24)
#plt.legend(labels = temperature_list)
```

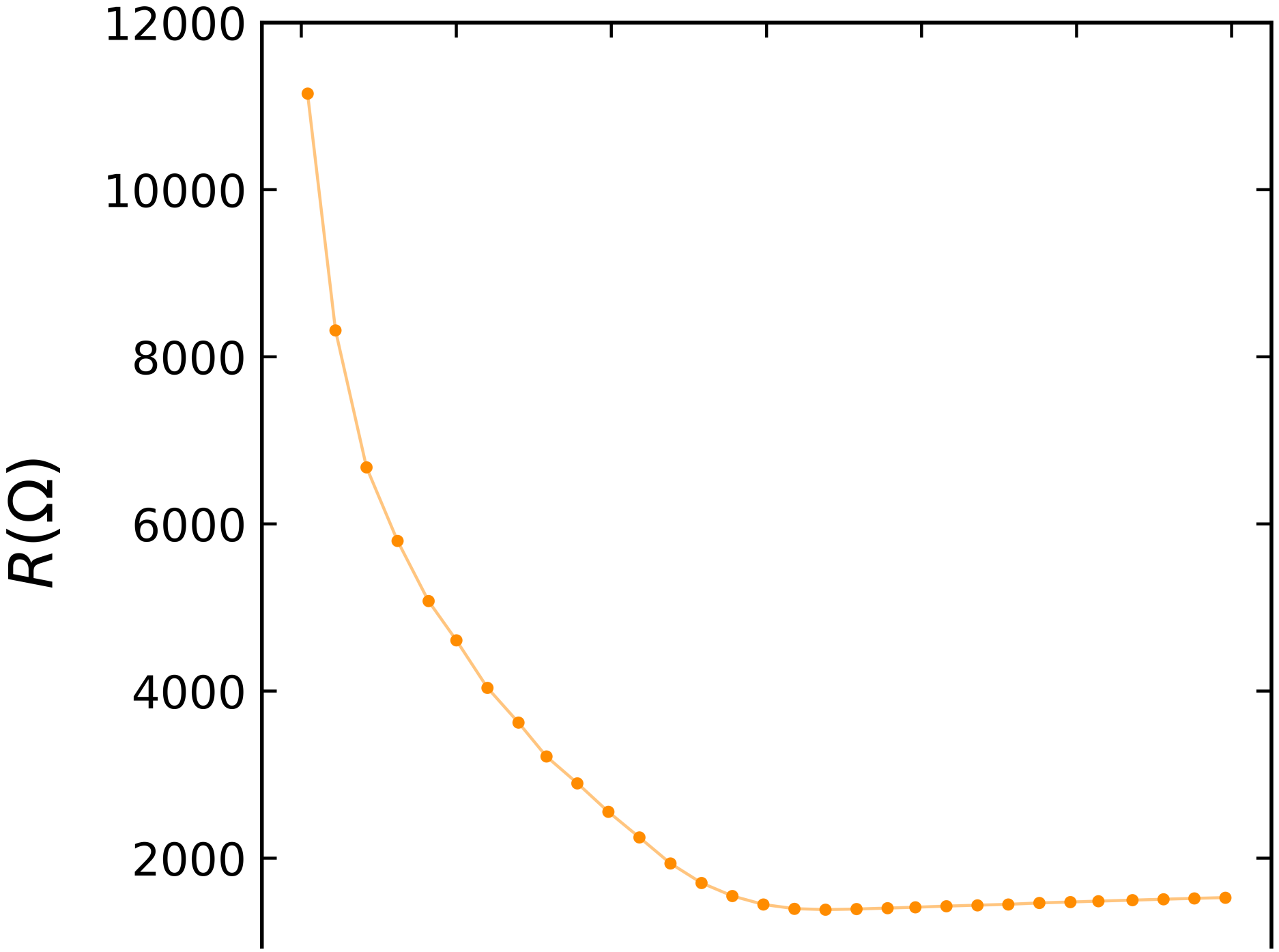

120
100
80
60
40
20
V(mV)
T(K)
1.5
100
200
300

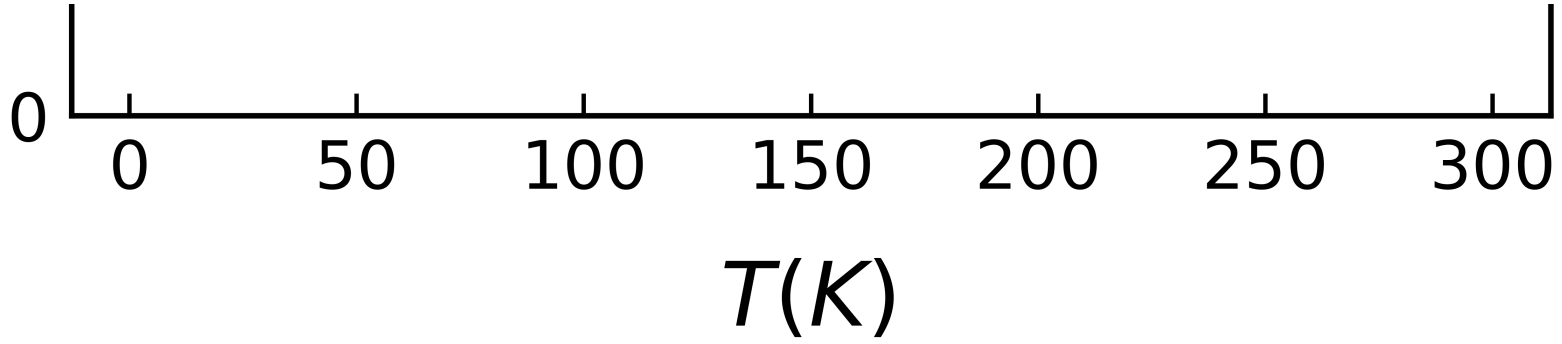


R vs T

In [19]:
```
fig, ax = plt.subplots(figsize=(12, 12), dpi = 500)
temperature_list_warmup = findtemperature(pathlist_Hall_Bar_6_IVs_warmup_longsweep)

values_at_10uA_warmup = []


for i,path in enumerate(pathlist_Hall_Bar_6_IVs_longsweep_warmup_symmetrised_data):


    data = np.loadtxt(path,delimiter = ",",skiprows = 1,usecols = (1,2),unpack = True)
    current = data[0]
    V_Keithley = data[1]

    dV_dI_crude_10uA = (V_Keithley[-1]/current[-1])
    values_at_10uA_warmup = np.append(values_at_10uA_warmup,dV_dI_crude_10uA)

ax.set_ylim(0,12000)
ax.scatter(temperature_list_warmup,values_at_10uA_warmup*1E3, color = 'darkorange', s=50)
ax.plot(temperature_list_warmup,values_at_10uA_warmup*1E3, color = 'darkorange', lw = 2, alpha = 0.5)


ax.set_xlabel("$T(K)$ ",fontsize=40,labelpad = 25)
ax.set_ylabel(r'$R(\Omega)$',fontsize=40,labelpad = 25)

ax.tick_params(axis = 'x', which='major', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, top = True)
ax.tick_params(axis = 'y', which='major', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, right = True)
ax.tick_params(axis = 'y', which='minor', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, right = True)


ax.spines["top"].set_linewidth(2.5)
ax.spines["bottom"].set_linewidth(2.5)
ax.spines["right"].set_linewidth(2.5)
```

```
ax.spines["left"].set_linewidth(2.5)

plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM301\Figures\FM301_Hall_Bar_6_IVs_Warmup_dV_dI_vs_T.pdf", bbox_inches = "tight", format = "pdf")
plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM301\Figures\FM301_Hall_Bar_6_IVs_Warmup_dV_dI_vs_T.png", bbox_inches = "tight")


plt.show()
```

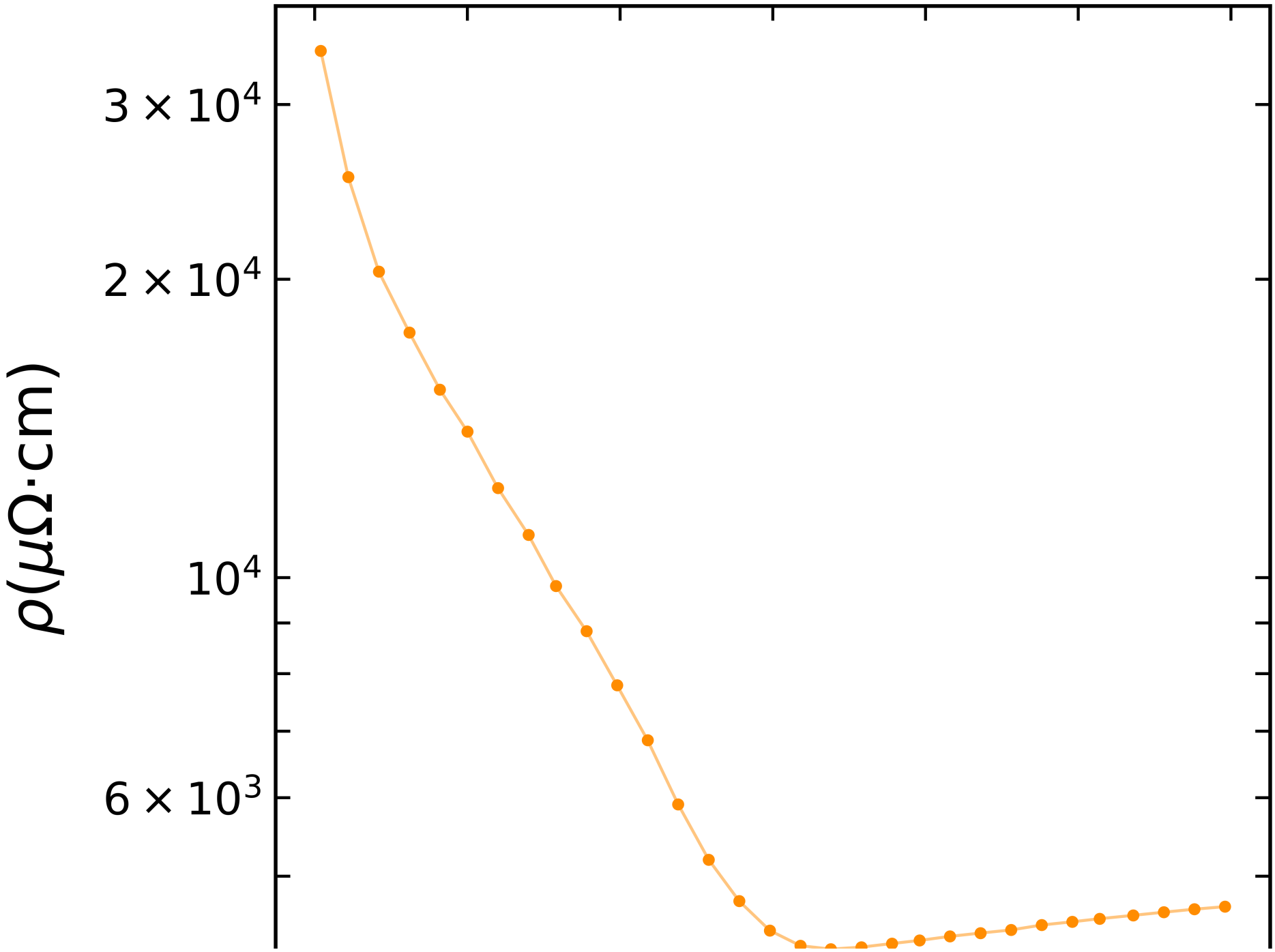

12000
10000
8000
6000
4000
2000
R(Ω)

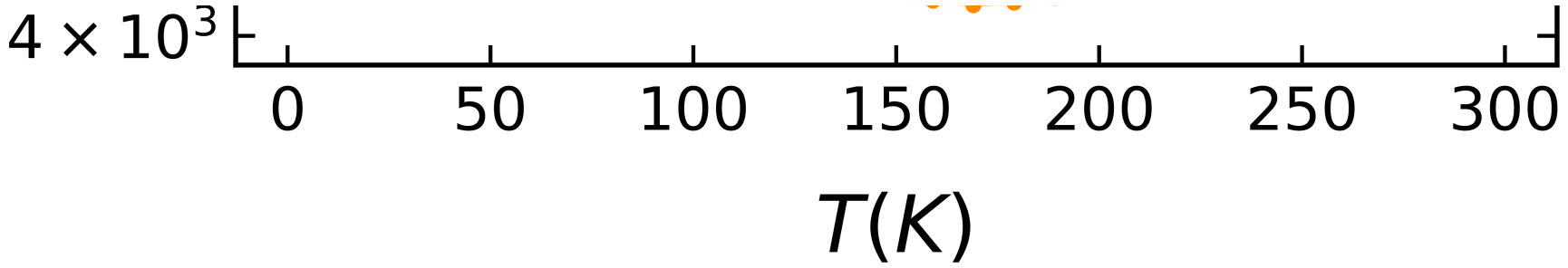


Resitivity vs T

In [25]:
```
fig, ax = plt.subplots(figsize=(12, 12), dpi = 500)


ax.scatter(temperature_list_warmup, values_at_10uA_warmup*1E3 *(30.48E-9*10/10)*1E2*1E6, color = 'darkorange', s=50)
ax.plot(temperature_list_warmup,values_at_10uA_warmup*1E3 *(30.48E-9*10/10)*1E2*1E6, color = 'darkorange', lw = 2, alpha = 0.5)


ax.set_ylabel(r'$\rho$($\mu$$\Omega$·cm)',fontsize=40,labelpad = 25)
ax.set_xlabel("$T(K)$ ",fontsize=40,labelpad = 25)


ax.tick_params(axis = 'x', which='major', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, top = True)
ax.tick_params(axis = 'y', which='major', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, right = True)
ax.tick_params(axis = 'y', which='minor', labelsize=30, length = 10, width = 2, direction = 'in', pad = 10, right = True)


plt.yscale("log")
ax.get_yaxis().set_major_formatter(ticker.LogFormatterSciNotation(base=10))
#ax.get_yaxis().set_minor_formatter(ticker.LogFormatterSciNotation(base=10, minor_thresholds = (10,1)))

ax.spines["top"].set_linewidth(2.5)
ax.spines["bottom"].set_linewidth(2.5)
ax.spines["right"].set_linewidth(2.5)
ax.spines["left"].set_linewidth(2.5)

df = pd.DataFrame({'temperature_list_warmup':temperature_list_warmup,'values_at_10uA_warmup':values_at_10uA_warmup*1E3 *(30.48E-9*10/10)*1E2*1E6})
df1 = pd.DataFrame({'temperature_list':temperature_list_warmup,'values_at_10uA':values_at_10uA_warmup*1E3 *(30.48E-9*10/10)*1E2*1E6})
df.to_csv(r'C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\Warmup\R vs T\FM301 Hall Bar 6 Resitivity vs T warmup.csv')
df1.to_csv(r'C:\Users\pblah\Data\Navy Beach\FM301\Data\Resitivity Combined Pandas\FM301 Hall Bar 6 Resitivity vs T warmup.csv')


plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM301\Figures\FM301_Hall_Bar_6_IVs_Cooldown_Resitivity_vs_T_Warmup.pdf", bbox_inches = "tight", format = "pdf")
plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM301\Figures\FM301_Hall_Bar_6_IVs_Cooldown_Resitivity_vs_T_Warmup.png", bbox_inches = "tight")

plt.show()
```

```
#### For Log Plot #########
#plt.yscale("log")
#ax.get_yaxis().set_major_formatter(matplotlib.ticker.LogFormatterSciNotation(base=10))
#ax.get_yaxis().set_minor_formatter(matplotlib.ticker.LogFormatterSciNotation(base=10, minor_thresholds = (10,0.1)))
#locmin = matplotlib.ticker.LogLocator(base=10.0, subs=(1,2,3,4,5,6))
#ax.yaxis.set_minor_locator(locmin)
#ax.yaxis.set_minor_formatter(matplotlib.ticker.LogFormatterSciNotation(base=10))
#ax.tick_params(axis='y', which='major', labelsize=30, direction = 'in')
#ax.tick_params(axis='y', which='minor', labelsize=20, width = 1, length = 10, direction = 'in')
#plt.ylim(1E3,1E5)
##################################
```


3×10^4
2×10^4
10^4
6×10^3
$\rho(\mu\Omega \cdot \mathrm{cm})$



Quick check of both

In [ ]:
```
fig = plt.figure(figsize=(12,12))
ax = fig.add_subplot(111)
labels = ['Cooldown','Warmup']

plt.scatter(temperature_list[0:len(temperature_list)-1],values_at_10uA[0:len(values_at_10uA)-1]*1E3, color = "green", alpha = 1, linewidth = 3 )
plt.plot(temperature_list[0:len(temperature_list)-1],values_at_10uA[0:len(values_at_10uA)-1]*1E3, alpha = 0.5)
plt.scatter(temperature_list_warmup[1::],values_at_10uA_warmup[1::]*1E3 , color = "darkorange", alpha = 1, linewidth = 3 )
plt.plot(temperature_list_warmup[1::],values_at_10uA_warmup[1::]*1E3, alpha = 0.5)



plt.legend(labels = labels, fontsize = 30)
plt.title(r'R vs T Cooldown vs Warmup',fontsize = 30, pad = 20)
plt.ylabel(r'R ($\Omega$)',fontsize =30, labelpad = 20)
plt.xlabel("$T(K)$ ",fontsize =30,labelpad = 20)
plt.xticks(fontsize = 25)
plt.yticks(fontsize = 25)
```

Fitting

Metallic Region

Resitivity

In [ ]:
```
"10.1126/sciadv.1500797"

import sys
np.set_printoptions(threshold=1000) # can change to sys.maxsize, default is 1000


fig = plt.figure(figsize=(12,12))
ax = fig.add_subplot(111)
```

```
#print(CCLXXX)
#print(CC)


for i in np.arange(0,1,1):



    if i==0:

        temperature = temperature_list
        resitivity4pt = values_at_10uA*1E3 *(30.48E-9*10/10)*1E2*1E6

        CCLXXX = int(closest_element_index(temperature,280)[0])
        CC = int(closest_element_index(temperature,165)[0])

        temperature_metallic_region = temperature[CCLXXX:CC]
        resitivity4pt_metallic_region = resitivity4pt[CCLXXX:CC]

        plt.plot(temperature_metallic_region,resitivity4pt_metallic_region, color = 'black')

        ##### Numpy Polynomial Fit 1st Order #####

        a, b = np.polynomial.polynomial.polyfit(temperature_metallic_region,resitivity4pt_metallic_region, 1)
        print('a',a)
        print('b',b)
        fit1 = a + b*temperature_metallic_region
        print('Polynomial Fit 1st Order', np.polynomial.polynomial.Polynomial([a,b]))
        plt.plot(temperature_metallic_region, fit1, linestyle = "--", linewidth = 2, color = 'orange', alpha = 1)

        #pd.DataFrame({'a':[a],'b':[b]}).to_csv(r'C:\Users\pblah\Data\Navy Beach\FM318\Data\Film\RT\Fitting Parameters\Linear Fit\ ' +
        #'Linear_Fitting_Params' + '.csv')

        ##################################

        ##### Numpy Polynomial Fit 2nd Order #####

        c, d, e = np.polynomial.polynomial.polyfit(temperature_metallic_region,resitivity4pt_metallic_region, 2)
        print('c',c)
        print('d',d)
        print('e',e)
        fit2 = c + d*temperature_metallic_region +e*(temperature_metallic_region)**2
        print('Polynomial Fit 2nd Order', np.polynomial.polynomial.Polynomial([c,d,e]))
        plt.plot(temperature_metallic_region, fit2, linestyle = "--", linewidth = 2, color = 'red', alpha = 1)

        ##################################


        #plt.title("FM318 Film RT",fontsize = 30)
        #plt.ylabel(r'$Ln(d\rho_{xx}/dT)$',fontsize =30, labelpad = 20)
        #plt.xlabel("$Ln(T)$(K)",fontsize =30,labelpad = 20)
        #plt.yticks(fontsize=20)
```

```
        #plt.xticks(fontsize=20)
        #plt.ylim(-5,5)



        #slope = np.gradient(np.log(gradient),np.log(temperature_metallic_region))

        #n = slope + 1

#plt.plot(np.log(temperature_metallic_region),n)

#plt.ylim(-0.25E6,0.25E6)

#plt.title("n")
plt.show()

#temperature_insulating_region = temperature[CC::]
```

Conductivity

In [ ]:
```
"10.1126/sciadv.1500797"

import sys
np.set_printoptions(threshold=1000) # can change to sys.maxsize, default is 1000


fig = plt.figure(figsize=(12,12))
ax = fig.add_subplot(111)



#print(CCLXXX)
#print(CC)


for i in np.arange(0,1,1):



    if i==0:

        temperature = temperature_list
        resitivity4pt = values_at_10uA*1E3 *(30.48E-9*10/10)*1E2*1E6

        CCLXXX = int(closest_element_index(temperature,280)[0])
        CC = int(closest_element_index(temperature,165)[0])

        temperature_metallic_region = temperature[CCLXXX:CC]
        resitivity4pt_metallic_region = resitivity4pt[CCLXXX:CC]

        conductivity4pt_metallic_region = 1/(resitivity4pt[CCLXXX:CC])
```

```
        plt.plot(temperature_metallic_region,conductivity4pt_metallic_region, color = 'black')

        ##### Numpy Polynomial Fit 1st Order #####

        a, b = np.polynomial.polynomial.polyfit(temperature_metallic_region,conductivity4pt_metallic_region, 1)
        print('a',a)
        print('b',b)
        fit1 = a + b*temperature_metallic_region
        print('Polynomial Fit 1st Order', np.polynomial.polynomial.Polynomial([a,b]))
        plt.plot(temperature_metallic_region, fit1, linestyle = "--", linewidth = 2, color = 'orange', alpha = 1)

        pd.DataFrame({'a':[a],'b':[b]}).to_csv(r'C:\Users\pblah\Data\Navy Beach\FM301\Data\IVS\R vs T\Fitting Parameters\Linear Fit\ ' +
        'Linear_Fitting_Params' + '.csv')

        ################################

        ##### Numpy Polynomial Fit 2nd Order #####

        c, d, e = np.polynomial.polynomial.polyfit(temperature_metallic_region,conductivity4pt_metallic_region, 2)
        print('c',c)
        print('d',d)
        print('e',e)
        fit2 = c + d*temperature_metallic_region +e*(temperature_metallic_region)**2
        print('Polynomial Fit 2nd Order', np.polynomial.polynomial.Polynomial([c,d,e]))
        plt.plot(temperature_metallic_region, fit2, linestyle = "--", linewidth = 2, color = 'red', alpha = 1)

        ################################


        plt.title("FM301 Membrane Conductivity",fontsize = 30)
        #plt.ylabel(r'$Ln(d\rho_{xx}/dT)$',fontsize =30, labelpad = 20)
        #plt.xlabel("$Ln(T)$(K)",fontsize =30,labelpad = 20)
        #plt.yticks(fontsize=20)
        #plt.xticks(fontsize=20)
        #plt.ylim(-5,5)



        #slope = np.gradient(np.log(gradient),np.log(temperature_metallic_region))

        #n = slope + 1

#plt.plot(np.log(temperature_metallic_region),n)

#plt.ylim(-0.25E6,0.25E6)

#plt.title("n")
plt.show()

#temperature_insulating_region = temperature[CC::]
```

Combining into one curve

In [ ]:
```
labels = ["FM301_Hall_Bar"]
samples_dict = {}

single_curves_list_temperature = []
single_curves_list_resitivity4pt = []

for i,path in enumerate(pathlist_Hall_Bar_6_IVs_combining_pandas[::-1]):

    print(path)

    x = pd.read_csv(path)
    Temperature = pd.DataFrame(x).temperature_list.values.tolist()
    Resitivity_4pt = pd.DataFrame(x).values_at_10uA.values.tolist()
    print(Resitivity_4pt)

    single_curves_list_temperature.append(Temperature)
    single_curves_list_resitivity4pt.append(Resitivity_4pt)



for i, name in enumerate(labels):

    samples_dict[labels[i] + '_' + 'temperature_list' + '_' + 'full'] = single_curves_list_temperature[i*2] + single_curves_list_temperature[(i*2)+1]
    samples_dict[labels[i] + '_' + 'values_at_10uA' + '_' + 'full'] = single_curves_list_resitivity4pt[i*2] + single_curves_list_resitivity4pt[(i*2)+1]

    pd.DataFrame({'temperature':samples_dict[labels[i] + '_' + 't' + '_' + 'full'],'resitivity4pt':samples_dict[labels[i] + '_' + 'r4pt' + '_' + 'full']}).to_csv(r'C:\Users\p
    str(labels[0]) + '_' + 'RvsT_Full' + '.csv')
```

Legacy Code

In [ ]:
```
fig = plt.figure(figsize=(12,12))
ax = fig.add_subplot(111)

temperature_list = findtemperature(pathlist_Hall_Bar_6_IVs_longsweep)


for i,path in enumerate(pathlist_Hall_Bar_6_IVs_longsweep_normalised_data):

    #print(path)

    data = np.loadtxt(path,delimiter = ",",skiprows = 1,usecols = (1,2),unpack = True)
    branch1_x = data[0]
    Sym_both = data[1]
    dI_dV = np.gradient(Sym_both,branch1_x)
    a, b = np.polyfit(branch1_x, dI_dV, 1)
    #plt.scatter(current,dI_dV,s=1)
    plt.plot(branch1_x, a*branch1_x+b,label = temperature_list[i])
```

```
plt.legend(labels = temperature_list)
plt.title("dV/dI vs I Long Sweep",fontsize = 30)
plt.ylabel(r'$dV/dI (K\Omega)$',fontsize =20)
plt.xlabel("$I (\mu A)$ ",fontsize =20)
#plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM301\Figures\FM301 Hall Bar 6 IVs Symmetrised dV_dI vs I.png")
plt.show()
```

In [ ]:

```
from scipy.interpolate import CubicSpline, PchipInterpolator, Akima1DInterpolator

fig = plt.figure(figsize=(12,12))
ax = fig.add_subplot(111)


temperature_list = findtemperature(pathlist_Hall_Bar_6_IVs_longsweep)
values_at_1uA = []


for i,path in enumerate(pathlist_Hall_Bar_6_IVs_longsweep_symmetrised_data):

    data = np.loadtxt(path,delimiter = ",",skiprows = 1,usecols = (1,2),unpack = True)
    branch1_x = data[0]

    Sym_both = data[1]
    dV_dI_crude_10uA = (Sym_both[-1])/branch1_x[-1]
    plt.scatter(temperature_list[i], dV_dI_crude_10uA,label = temperature_list[i])
    values_at_1uA = np.append(values_at_1uA,dV_dI_crude_10uA)




plt.title("dV/dI vs T",fontsize = 30)
plt.ylabel(r'$dV/dI (K\Omega)$',fontsize =20)
plt.xlabel("$T(K)$ ",fontsize =20)

temperature_list = temperature_list[::-1]
values_at_1uA = values_at_1uA[::-1]


f_cooldown = interpolate.PchipInterpolator(temperature_list, values_at_1uA)
xnew_cooldown = np.arange(temperature_list[0],temperature_list[len(temperature_list)-1],1)
ynew_cooldown = f_cooldown(xnew_cooldown)
plt.plot(xnew_cooldown, ynew_cooldown)
plt.title(r'R vs T',fontsize = 30, pad = 20)
plt.ylabel(r'R (k$\Omega$)',fontsize =30, labelpad = 20)
plt.xlabel("$T(K)$ ",fontsize =30,labelpad = 20)
plt.xticks(fontsize = 25)
plt.yticks(fontsize = 25)
#plt.savefig(r"C:\Users\pblah\Data\Navy Beach\FM301\Figures\FM301 Hall Bar 6 IVs Cooldown dV_dI vs T.png", bbox_inches = "tight")
plt.show()

#plt.legend(labels = temperature_list)
#dV_dI = np.gradient(Sym_both,branch1_x)
#a, b = np.polyfit(branch1_x, dV_dI, 1)
#plt.scatter(current,dI_dV)
```

```
#line = a*current+b

#print(line[-1])
#plt.legend(labels = temperature_list[i])

#plus10uA = int(closest_element_index(branch1_x,np.max(branch1_x))[0]))
#plt.scatter(temperature_list[i], line[-1],label = temperature_list[i])

#print(values_at_1uA)
#print(temperature_list)

#print(xnew_cooldown)
```

In [ ]: