# GPREOS

June 29, 2022

[8]:

```
# -*-coding:utf-8 -*-import matplotlib.pyplot as plt

import matplotlib.pyplot as plt
import numpy as np
from matplotlib.ticker import AutoMinorLocator
from sklearn.gaussian_process import GaussianProcessRegressor
from sklearn.gaussian_process.kernels import RBF , WhiteKernel
from sklearn.gaussian_process.kernels import RBF, ConstantKernel as C
```

[9]:

```
### Construct an axis: ###
plt.figure(figsize=(5,4.5))
ax = plt.subplot(111)
## The setting of the axes:
#plt.rcParams['xtick.direction']='in' # set ticks' direction
#plt.rcParams['ytick.direction']='in'
#plt.rcParams['xtick.top']=True
#plt.rcParams['ytick.right']=True
#ax.spines['bottom'].set_linewidth(1.5)
#ax.spines['top'].set_linewidth(1.5)
#ax.spines['left'].set_linewidth(1.5)
#ax.spines['right'].set_linewidth(1.5)
#ax.xaxis.set_minor_locator(AutoMinorLocator(5)) # set the locator of x axis
#ax.yaxis.set_minor_locator(AutoMinorLocator(5))  # set the locator of y axis
#ax.tick_params(length=5,which='major',width=1.5,labelsize=14) # set the length␣
 ↪of the majorticks
#ax.tick_params(length=3,which='minor',width=1.5,labelsize=14) # set the length␣
 ↪of the minor ticks

############################## Interpolation with GPR method:␣
 ↪#################################
'''  *** feos: the input file.
               In file "eos.dat", the first column is the baryon number␣
 ↪density,
             the second column is the pressure.  The first half of the data is␣
 ↪the
             EoS of the hadron phase, and the second half is the EoS of quark␣
 ↪phase.
```

```
               You just need to replace the input file, "eos.dat", and reset the
             interpolation interval (xL, xU). Notice that:
              1) You need to put all the training data in one file;
              2) the training set and the testing set shouldn't be too far apart. For example,
                 if the density of the interpolation starts at 0.3fm^-3 the input baryon density should
                 start from about 0.2 fm^-3 or 0.25 fm^-3 instead of start from 0.001 fm^-3;
              3) When interpolating, the order of magnitude between the input values x and y  shouldn't
                 differ too much, otherwise, take the logarithm of the input values with large order of magnitude.
   *** Variables:
               x, y: training data (In file 'eos.dat', x is the baryon density; y is the pressure)
                 xL: the lower limit of interpolation region;
                 xU: the upper limit of interpolation region;
                  n: the number of points between xL and xU;
             test_x: the test set (take n points between xL and xU);
             test_y: the output of the variable test_x that need to be predicted;
 (test_yL, test_yU): 95% confidence interval(Pink shade).    '''

# input Data:
feos = np.loadtxt('eos.dat',dtype=np.float)
x, y = feos[:,0], feos[:,1] #input the baryon density and the pressure
ax.scatter(x, y)
y = np.log10(y)

# crossover window:
xL, xU, n = 0.3, 0.6, 100 #the interpolated baryon density ranges from 0.3 to 0.6 and 100 points are taken
test_x = np.linspace(xL, xU, n) #the test set
kernel = C(10, (1e-5, 1e4)) * RBF(length_scale = 1)+ WhiteKernel(noise_level=5e-3, noise_level_bounds=(1.8e-3, 3e-3)) #chose the SE kernel
gp = GaussianProcessRegressor (kernel=kernel).fit(x[:, np.newaxis], y) #the GPR method
test_y, y_std = gp.predict(test_x[:, np.newaxis], return_std =True) #predicted pressures and the uncertainties

# 95% confidence interval
y_uncertainty = 1.96*y_std
test_yL, test_yU=10**(test_y-y_uncertainty), 10**(test_y+y_uncertainty)
```

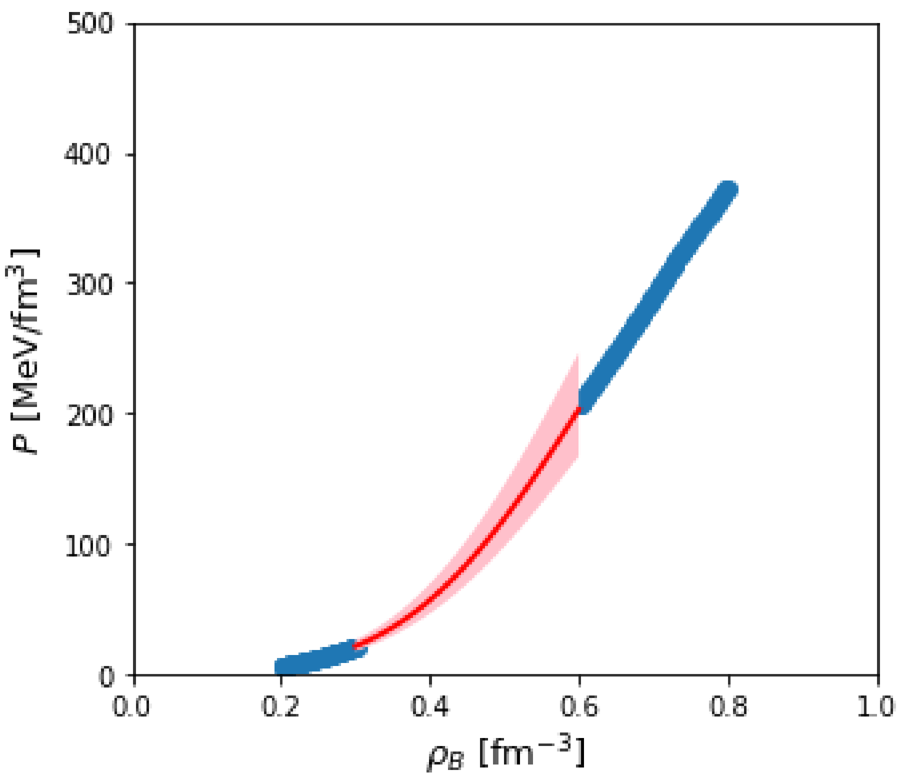
```
test_y=10**(test_y)

####################################### plot:␣
 ↪##########################################
ax.plot(test_x, test_y, c='r', lw=2)
ax.fill_between(test_x, test_yL, test_yU, facecolor='pink')

ax.legend(fontsize=11,loc=2,frameon=False)
ax.set_xlim(0.0, 1.0)
ax.set_ylim(0, 500)
ax.set_ylabel(r'$P~[\rm MeV/fm^{3}]$',size=13)
ax.set_xlabel(r'$\rho_B~[\rm fm^{-3}]$',size=13)
```

```
C:\Users\DELL\AppData\Local\Temp/ipykernel_860/2720128055.py:42:
DeprecationWarning: `np.float` is a deprecated alias for the builtin `float`. To
silence this warning, use `float` by itself. Doing this will not modify any
behavior and is safe. If you specifically wanted the numpy scalar type, use
`np.float64` here.
Deprecated in NumPy 1.20; for more details and guidance:
https://numpy.org/devdocs/release/1.20.0-notes.html#deprecations
  feos = np.loadtxt('eos.dat',dtype=np.float)
d:\python\lib\site-packages\sklearn\gaussian_process\kernels.py:402:
ConvergenceWarning: The optimal value found for dimension 0 of parameter
k2__noise_level is close to the specified lower bound 0.0018. Decreasing the
bound and calling fit again may find a better value.
  warnings.warn("The optimal value found for "
No handles with labels found to put in legend.
```

```
[9]: Text(0.5, 0, '$\\rho_B~[\\rm fm^{-3}]$')
```


500
400
300
200
100
0
0.0
0.2
0.4
0.6
0.8
1.0
$P$ [MeV/fm$^3$]
$\rho_B$ [fm$^{-3}$]

[ ]: