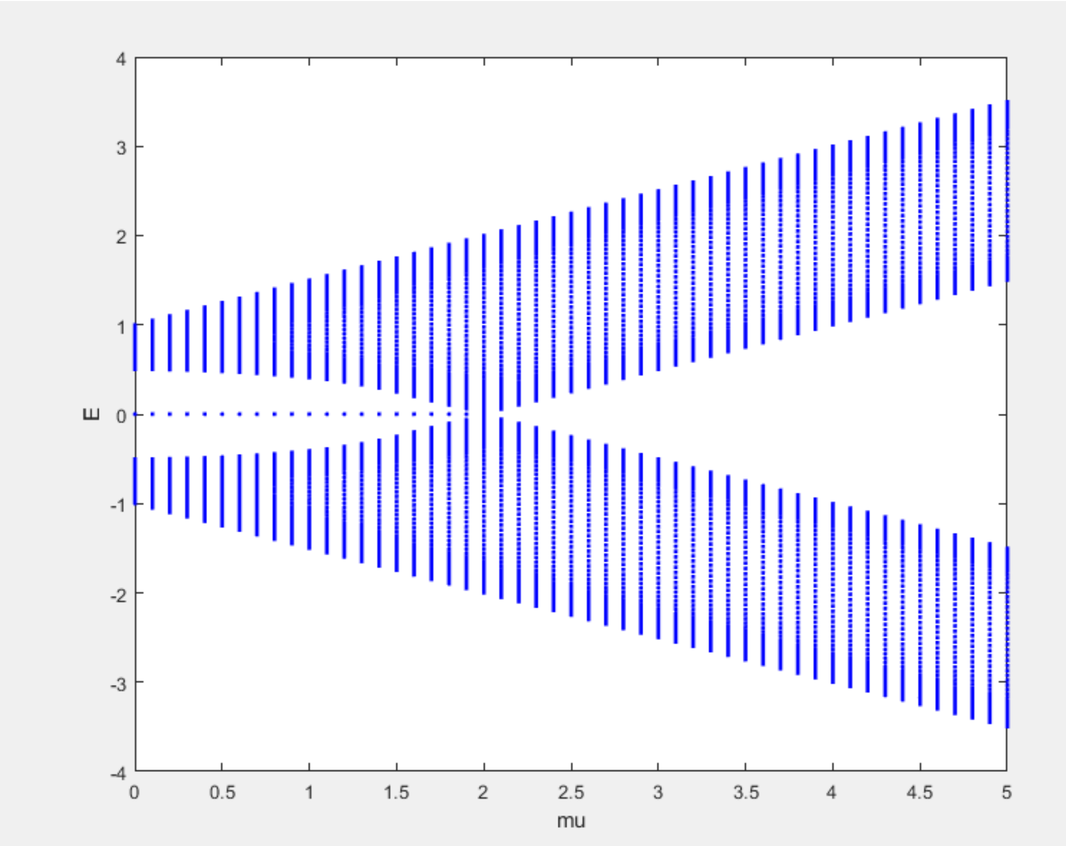
1d Kitaev chain

$$H=\sum_i -tc_i^\dagger c_{i+1}+\Delta c_i^\dagger c_{i+1}^\dagger+h.c.-\sum_i \mu c_i^\dagger c_i$$

考虑到OBC，可以将哈密顿量写为实空间BdG的形式，并且由于是Fermion可以直接对其进行对角化求得能谱。我们取t=1; delta=0.5; N=50; 我们利用matlab进行程序编写：

```
clear;
N = 50;
t = 1;
delta = 0.5;

for mu = 0:0.1:5

mulist = -mu*ones(1,N);
Hmu = diag(mulist ,0);

Ht = diag(ones(1,N-1)*(-t),-1)+diag(ones(1,N-1)*(-t),1);

Hmt = Ht + Hmu;

Hd = diag(ones(1,N-1)*(-delta),-1)+diag(ones(1,N-1)*(delta),1);

H = [Hmt,Hd;Hd',-Hmt]/2;

E=eig(H);

plot(mu*ones(length(E)),E,'b.');
xlabel('mu');
ylabel('E');
hold on;
end
```

调整化学势mu，从0到5，间隔为0.1得到下图：



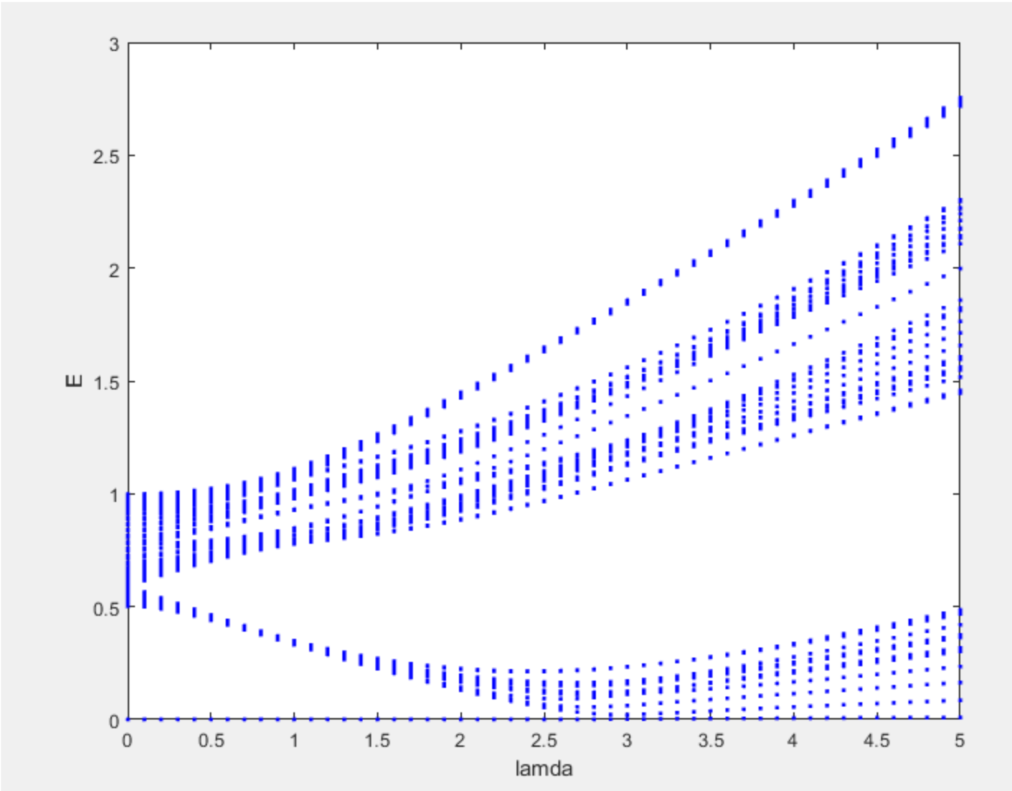
之后加入disorder项，从而哈密顿量写为：

$$H = \sum_i -t c_i^\dagger c_{i+1} + \Delta c_i^\dagger c_{i+1}^\dagger + h.c. + \sum_i \lambda \cos(2\pi\alpha i) c_i^\dagger c_i$$

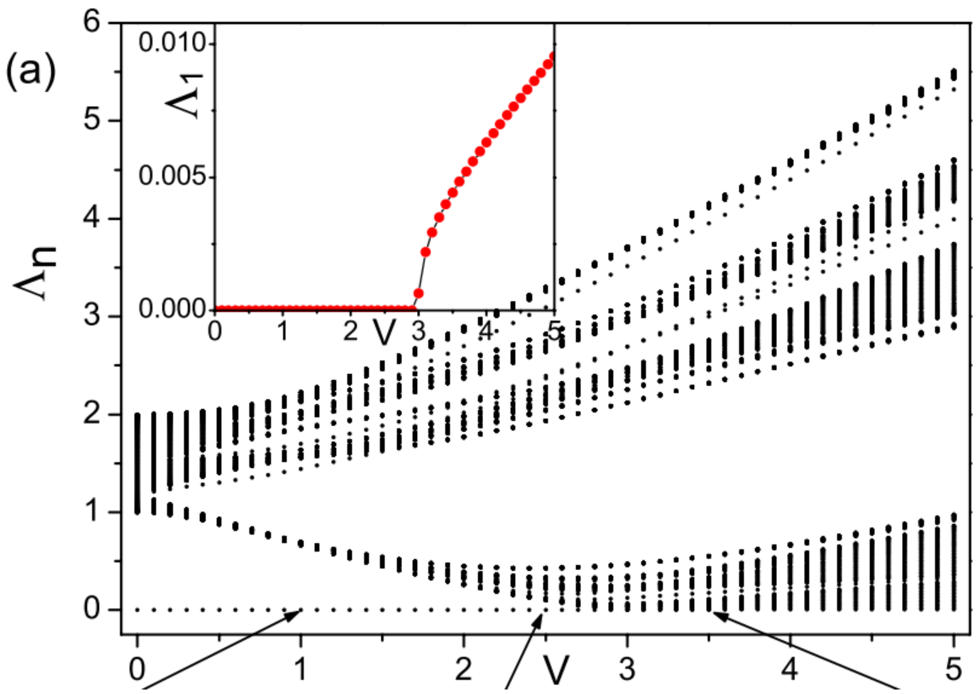
利用相同的思路，可以编写如下的matlab程序：

```
clear;
N = 50;
t = 1;
delta = 0.5;
alpha = (sqrt(5)-1)/2;

for lamda = 0:0.1:5

mulist = zeros(1,N);
for i = 1:N
mulist(i) = lamda*cos(2*pi*alpha*i);
end
Hmu = diag(mulist ,0);

Ht = diag(ones(1,N-1)*(-t),-1)+diag(ones(1,N-1)*(-t),1);

Hmt = Ht + Hmu;

Hd = diag(ones(1,N-1)*(-delta),-1)+diag(ones(1,N-1)*(delta),1);

H = [Hmt,Hd;Hd',-Hmt]/2;

E=abs(eig(H));

plot(lamda*ones(length(E)),E,'b.');
xlabel('lamda');
ylabel('E');
hold on;
end
```

计算结果如
下：



这一结果与论文当中的结果相吻
合：



1d bose gas

对于bose气体的哈密顿
量：

$$H=\sum_i -t b_i^\dagger b_{i+1}+\frac{1}{2} g n_0 b_i^\dagger b_i^\dagger + h.c.+\sum_i(-\mu+g n_0) b_i^\dagger b_i$$

由于要保持玻色子的对易关系，因此我们需要在对角化之前给矩阵乘以对角的方块z方向的泡利矩阵，具体的matlab代码如下：

```
clear;
N = 500;
t = 1;
g = 1.000;
n0 = 1;
mu = 5;

for mu = 0:0.5:5

mulist = (-mu+g*n0)*ones(1,N);
Hmu = diag(mulist ,0);

Ht = diag(ones(1,N-1)*(-t),-1)+diag(ones(1,N-1)*(-t),1);
Hmt = Ht + Hmu;

Hd = diag(0.5*g*n0*ones(1,N),0);

H = [Hmt,Hd;Hd',Hmt]/2;
H = [diag(ones(1,N)),zeros(N,N);zeros(N,N),-diag(ones(1,N))]*H;

E=(eig(H));

plot(mu*ones(length(E)),E,'b.');
xlabel('mu');
ylabel('E');
hold on
end
```

其求解出来的能谱为：