Computer Physics

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1 Project 1

In this project I calculate the energy spectrum of $H = H_0 + \lambda V$ where H_0 is the harmonic oscillator and $V = \hbar\omega(\frac{x}{a})^4$ where $a = \sqrt{\frac{\hbar}{m\omega}}$ is the natural length of the system.

This is achieved by adding the matrices of H_0 and V in the basis of the eigenvectors of H_0 and then truncating the basis. We know the matrix representation of $\frac{x}{a}$ in this basis is

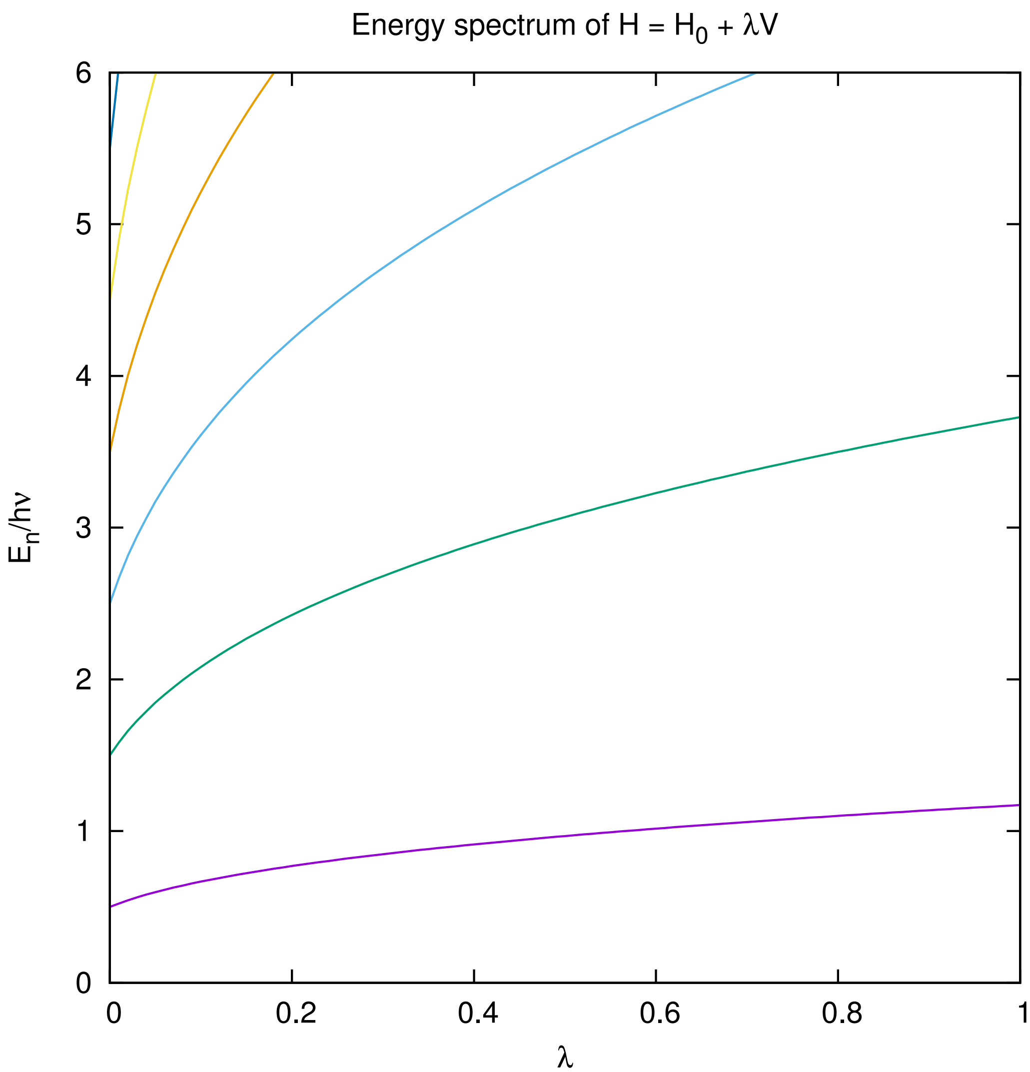
$$\not{x} = \frac{1}{2}\begin{bmatrix} 0 & 2 & 0 & 0 & \dots \\ 2 & 0 & \sqrt{6} & 0 & \dots \\ 0 & \sqrt{6} & 0 & \sqrt{8} & \dots \\ 0 & 0 & \sqrt{8} & 0 & \dots \\ \vdots & \vdots & \vdots & \vdots & \ddots \end{bmatrix}$$

and the matrix for V is simply $\hbar\omega\not{x}^4$. We add this (multiplied by some λ) to

$$H_0 = \hbar\omega\begin{bmatrix} 0.5 & 0 & 0 & 0 & \dots \\ 0 & 1.5 & 0 & 0 & \dots \\ 0 & 0 & 2.5 & 0 & \dots \\ 0 & 0 & 0 & 3.5 & \dots \\ \vdots & \vdots & \vdots & \vdots & \ddots \end{bmatrix}$$

and then truncate. In our case we used a basis of 128 eigenvectors of H_0.

The eigenvalues of the resulting matrix are of course the possible values of energy of the system. The following is a graph of the first six eigenvalues as a function of λ.


Energy spectrum of H = H0 + λV
E_n/hν
λ
0
1
2
3
4
5
6
0
0.2
0.4
0.6
0.8
1