Linear Operator and Spontaneous Breaking in $\mathcal{PT}$-Symmetry

Prachiprava Mohapatra

Physics Department ,N.C.College ,Jajpur ,Odisha,INDIA

Department of Physics, North Orissa University, Takatpur, Baripada -757003, Odisha, INDIA

prachipravamohaptra82@gmail.com

Abstract

We study spectral behavior of linear operator using matrix diagonalisation method and notice that spectral breaking is an inherent behavior in $\mathcal{PT}$-symmetry .

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Introduction

Spectral study of quantum operator took a turning point since the discovery of $\mathcal{PT}$-symmetry [1]. However none of the literature deals with pure linear operator . Recently Lombard and Mezhoud [2] have studied spectral breaking in $\mathcal{PT}$-symmetry of the Hamiltonian

$$H = p^2 + \lambda|x| + cix \tag{1}$$

and noticed that for $\lambda = 1$ the system possess non zero ground state energy. In the above Hamiltonian the quadratic operator has been replaced by linear operator as $x^2 \rightarrow |x|$ to justify the term linear complex potential. Similarly if one can replace the kinetic energy term p^2 as $|p|$ then the above operator becomes linear $\mathcal{PT}$-symmetry opertor. As we believe previous method [2] can not be suitable for studying spectral behaviour of the linear operator

$$H = \beta|p| + \lambda|x| + cix \tag{2}$$

However here we use matrix diagonalisation method [3,4] by expressing x and p as

$$x = \frac{1}{\sqrt{2}}[a + a^\dagger] \tag{3}$$

$$p = \frac{i}{\sqrt{2}}[a^\dagger - a] \tag{4}$$

$$[a, a^\dagger] = 1 \tag{5}$$

The results we get are really interesting and displayed in fig:1-3 Here we notice that for $\alpha = 1; \beta = 1$ with varying c the real spectra gradually decreases and finally for large c=100 ,the system possess no real spectra.. In other words the linear $\mathcal{PT}$-symmetry operator part plays the major role in realspectra breaking.

References

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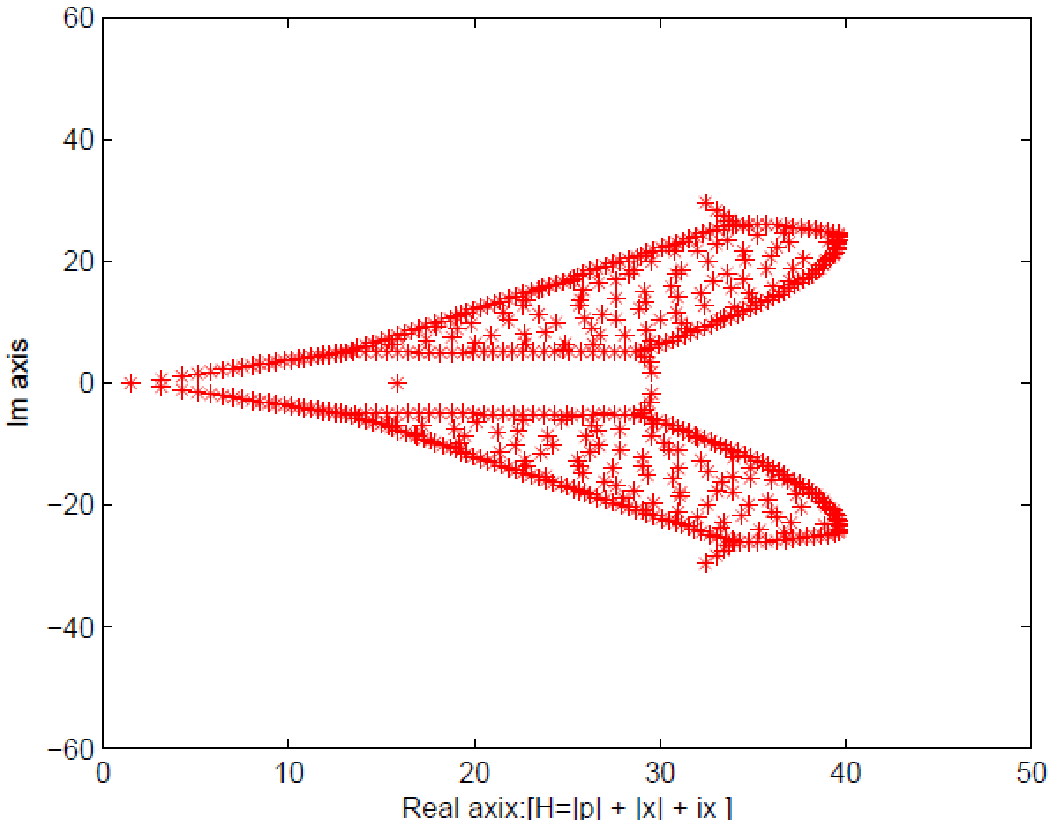

Figure 1. $H_1 = |p| + |x| + ix$

: Spectral breaking

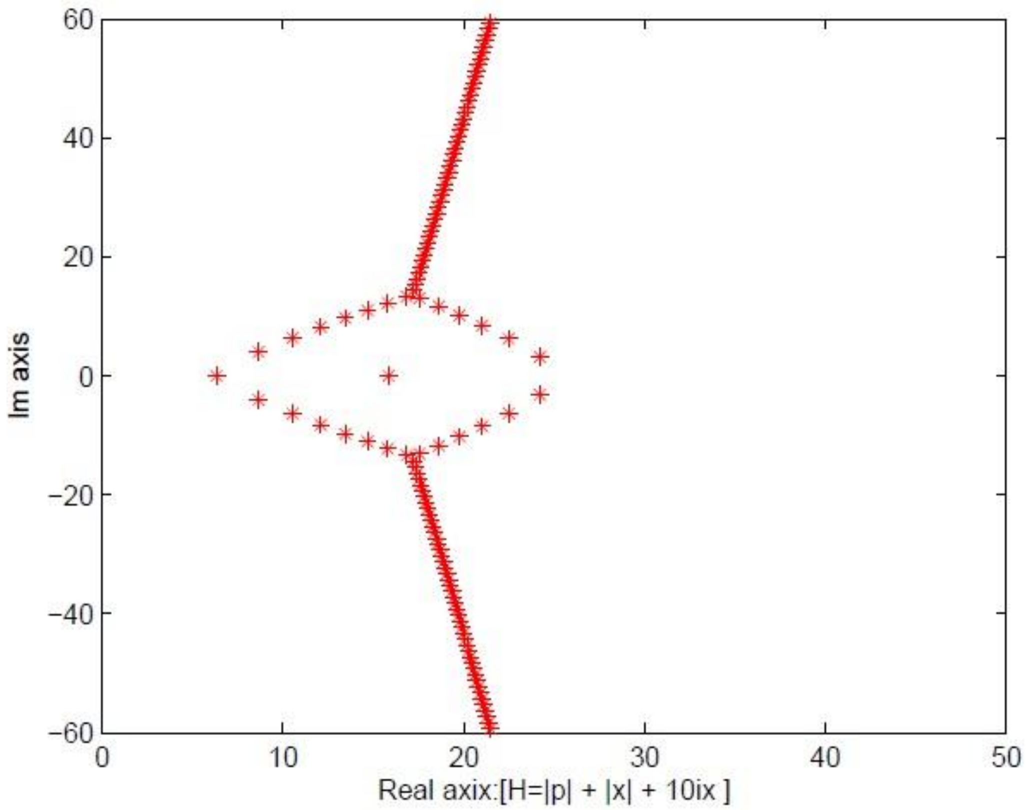

Figure 2. $H_2 = |p| + |x| + 10ix$

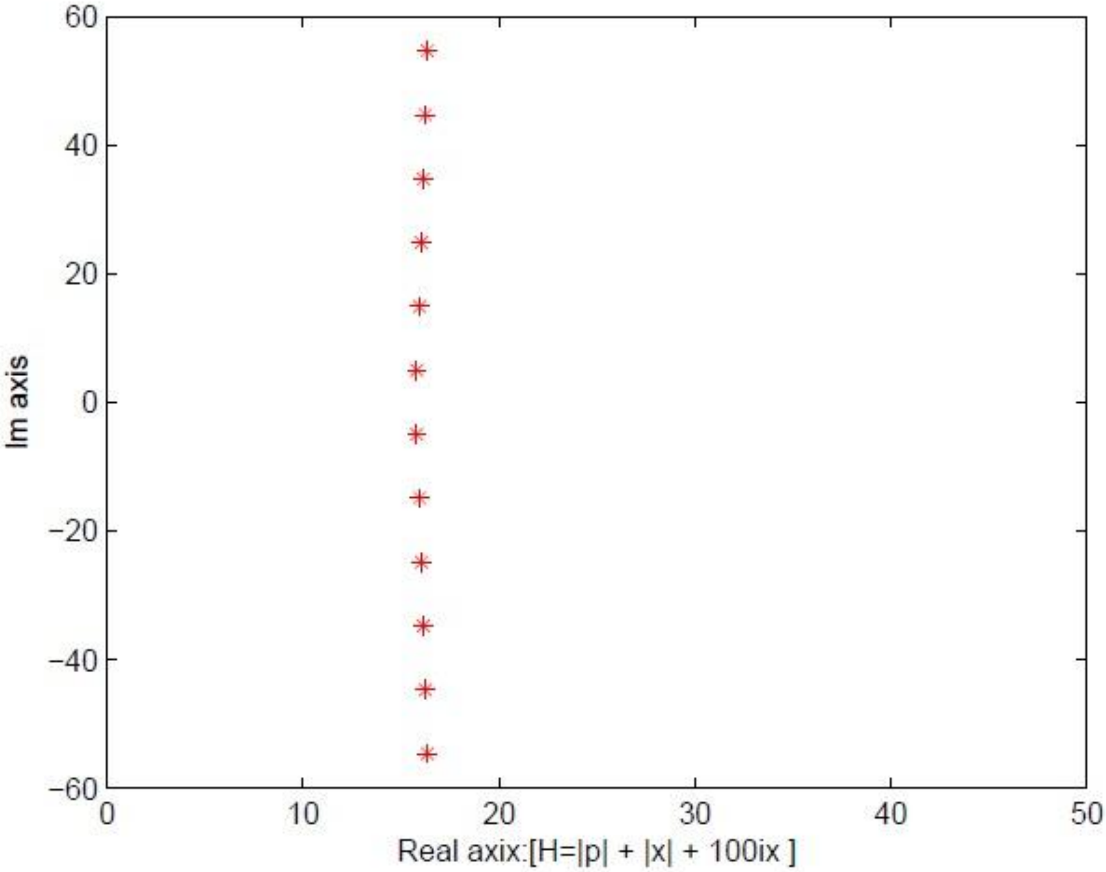

Figure 3. $H_3 = |p| + |x| + 100ix$

No real spectra