Non-Hermiticity and Disorder

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Abstract

The exceptional properties of double poles of the S-matrix are known for a long time but their influence on the spectra of quantum systems at high level density is studied only recently. A hint to them is the avoided level crossing appearing for states below as well as above particle decay thresholds at a critical value $\alpha_{\rm cr}$ of a certain parameter α [1]. It reflects the strong mutual influence of one state to another one and can be traced directly in the spectra of a microwave resonator [2] and also in the laser induced manipulation of spectra of atoms [3].

If the avoided level crossing is caused by the direct interaction of the two states then level repulsion along the real energy axis occurs for $\alpha > \alpha_{\rm cr}$. This fact is very well known and basic for the discussion of quantum chaos in closed quantum systems with many states. If the two levels interact, however, mainly via the continuum, level repulsion along the imaginary energy axis appears. In this case, different time scales are formed at $\alpha > \alpha_{\rm cr}$. One of the states will be trapped while the other one aligns with one decay channel and becomes short-lived. In a system with many states, K states align eventually with the K open decay channels and the remaining ones become trapped.

In atoms in a strong laser field, both the direct interaction of the states as well as the interaction via the continuum may be important. Additional interference phenomena will therefore occur which lead, under certain conditions, to population trapping [3]. In this case, the width of one of the states vanishes at a finite value $\alpha > \alpha_{\rm cr}$. Thus, population trapping is a signature of a double pole of the S matrix *and* can be studied experimentally.

If the crossing of the states is avoided not only for two states but for all states of the system at (almost) the same value $\alpha_{\rm cr}$ (i.e. the S matrix has a multiple pole instead of a double pole), then the quantum system suffers a second-order phase transition [4]. This may happen in the one-channel case. The characteristic features of the phase transition are well expressed already for a finite number of states (about 100) as numerical studies showed [1,4].

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