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Resonances in the system with an internal degree of freedom

The Hamiltonian of the system with an additional internal degree of freedom is studied. For this purpose, the coupled channel formalism with the total Hilbert space consisting of two subspaces is used. Here, the external subspace corresponds to the relative motion of two particles and the internal one takes into account some other degrees of freedom. In the simplest case, the internal subspace is a single intruder state $|\alpha\rangle$ with energy E_0. Then, the total two-channel Hamiltonian has a form:
H=$\begin{pmatrix} h_{\rm ext} & \lambda|\phi\rangle\langle\alpha| \\ \lambda|\alpha\rangle\langle\phi| & E_0|\alpha\rangle\langle\alpha| \end{pmatrix}.Here,h_{\rm ext}$ is the external Hamiltonian which defines mainly the peripheral relative motion of particles, λ is the strength of coupling with the internal channel, and $|\phi\rangle$ is the coupling formfactor. The main goal of this research is to develop a method for calculating resonances in such systems and to study their properties according to the model parameters. An interesting problem here is a possibility for the formation of a bound state in continuum (BIC). Although the presence of the BIC does not lead to a resonance-like sharp behavior of amplitudes, it may have a significant impact on observables.

As a practical example, we consider the dibaryon model [1] for nucleon-nucleon (NN) interaction in which coupling to the internal state corresponds to account of the intermediate six-quark (dibaryon) state formation. This model allows [1] to reproduce the positions of the experimentally detected dibaryon resonances [2] and the partial scattering phase shifts, in particular, the partial NN channels. In the present study, a special attention is paid to two main NN channels $^1S_0$ and $^3S_1$-$^3D_1$ where experimental evidences for high lying dibaryon resonances have been found very recently [3].

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Primary author: Dr BELOV, Pavel (Spin Optics Laboratory, Saint-Petersburg State University)

Co-authors: Dr RUBTSOVA, Olga (Lomonosov Moscow State University, Skobeltsyn Institute of Nuclear Physics); Prof. KUKULIN, Vladimir (Lomonosov Moscow State University, Skobeltsyn Institute of Nuclear Physics)

Presenter: Dr BELOV, Pavel (Spin Optics Laboratory, Saint-Petersburg State University)

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