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Extended supersymmetries for equation describing a nucleon in an external pionic field

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ABSTRACT

We consider a nonrelativistic approximation of the Dirac equation for nucleon in an pseudoscalar isovector pionic field $\vec{\pi}(\vec{x})$. This equation for stationary states reads

$$H\Psi = E\Psi, \qquad H = \frac{\vec{p}^{\,2}}{2m} + \frac{g^{\,2}}{2m}\vec{\pi}^{\,2}(\vec{x}) + \frac{g}{2m}\vec{\sigma}\frac{\partial}{\partial\vec{x}}\vec{\tau}\vec{\pi}(\vec{x}), \tag{1}$$

where

$$p_a = -i\frac{\partial}{\partial x_a}, \qquad a = 1,2,3, \qquad \vec{p}^{\,2} = p_1^2 + p_2^2 + p_3^2,$$

σ_a $(a = 1,2,3)$ are Pauli matrices; τ_a $(a = 1,2,3)$ are isotopic Pauli matrices; E is an eigenvalues of Hamiltonian; g is an dimensionless coupling constant.

We investigate the invariance of (1) with respect to the discrete transformation such as reflection, rotation and complex conjugation. It is shown that equation (1),admits the discrete symmetries if the external pionic field has definite parities.

An interesting application of discrete symmetries concerns a searching for extended supersymmetry (SUSY) [1,2].

It is well known [3] that equation (1) has a SUSY structure with two supercharges when $\vec{\pi}(\vec{x}) = (0,0,\pi(\vec{x}))$.

Using discrete symmetries we proved that $N = 2$ SUSY of equation (1) can be extended to $N = 3$ SUSY and $N = 4$ SUSY. We found a class of potentials that admit these extended SUSYs.

Another problem that we investigate in this note is a reduction of the equation (1) to uncoupled subsystem. We found the classes of unitary operators diagonalizing the discrete symmetries and reducing equation (1) to subsystems that can be solved independently.

References

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