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Neutron to proton mass difference, parton distribution functions and baryon resonances from dynamics on the Lie group $u(3)$

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Abstract

We present a hamiltonian structure on the Lie group $u(3)$ to describe the baryon spectrum. The ground state is identified with the proton. From this single fit we calculate approximately the relative neutron to proton mass shift to within half a percentage of the experimental value. From the same fit we calculate the nucleon and delta resonance spectrum. For specific spin eigenfunctions we calculate the delta to nucleon mass ratio to within one percent.

We derive parton distribution functions. The distributions are generated by projecting the parton state to space via the exterior derivative on $u(3)$. We predict scarce neutral-flavour singlets which should be visible in neutron diffusion dissociation experiments or in invariant mass spectra of protons and negative pions in $\bar{K}\Lambda\Lambda$-decays and in photoproduction on neutron. The presence of such singlet states distinguishes experimentally the present model from the standard model as does the prediction of the neutron to proton mass splitting. Conceptually the Hamiltonian may describe an effective phenomenology or interpreted more radically in a conceptual interpretation where we see parton distribution functions that compares rather well with those of the proton valence quark distributions already in a first order approximation. A kinematical parameterization for the projection gives a natural transition between a confinement domain where the dynamics untwists in the domain global group space and an asymptotic free domain where the algebra approximates the group. A promising ratio between the $\Lambda(1405)$ and $N(1535)$ mass has been calculated based on specific O(3)-functions. We expect the allospatial eigenenergies to contribute to partial wave amplitude resonances of specific spin and parity via expansions on specific combinations of O(3)-functions. Single neutral flavour resonances are predicted above the free charm threshold of $\Lambda(1535)/210$ MeV.

The allospatial hypothesis

Approximate energy levels for baryonic states are found by combinations of three parameters: eigenvalues of the three torus angles. These eigenvalues originally have the same periodicity as the torus angles. However a coupled period doubling can decrease the total energy.

The theory unfolded

The Laplacian in (1) of fixed orthonormal derivatives which are represented by the off-diagonal Gell-Mann matrices. We choose three of these to represent spin and group them into $\eta, \alpha, \chi$. This interpretation is supported by their commutation relations as body fixed angular momentum. The relation between space and allospatial is like the relation in number theory between quadratic forms in integral systems and relics body fixed coordinate systems for the description of rotations of degrees of freedom. The remaining three are grouped into $\mu, \nu, \zeta$ - which is related to hypercharge and isospin. They cancel the algebra by commuting into the subspace of $K$. The fully parametrized Laplacian in polar decomposition reads

$$\frac{1}{2m^2r^2} \frac{\partial}{\partial r} \left[ r^2 \frac{\partial}{\partial r} - \frac{\partial}{\partial \theta} \left( \sin \theta \frac{\partial}{\partial \theta} \right) \right]$$

With the periodic potential in (2) our complete Schrödinger equation reads with $E = E/\Lambda$ and $\lambda/h^2 = h/210 \text{ MeV}$

$$\left[ -\Delta + \Phi \right] \psi_{\chi}^{\eta}(\theta_1, \theta_2, \theta_3) = 2E R_{\chi}^{\eta}(\theta_1, \theta_2, \theta_3)$$

And a similar factorization of $\Phi_{\chi}^{\eta}(\mu, \nu, \zeta)$ gives for $\Phi_{\chi}^{\eta} = \Phi_{\eta}^{\eta} F_{\eta}^{\eta} \Phi_{\eta}^{\eta}$ with $\Phi_{\eta}^{\eta} = \Phi_{\eta}^{\eta} F_{\eta}^{\eta} \Phi_{\eta}^{\eta}$

$$\left[-\Delta + \Phi \right] \Phi_{\eta}^{\eta}(\theta_1, \theta_2, \theta_3) = 2E R_{\eta}^{\eta}(\theta_1, \theta_2, \theta_3)$$

The figure shows parametric eigenstates with periodicity 2n to the left and 4p to the right for dimensionless states in the right column.

We can couple a dimensionless period doubling in level two with an existing period doubling in level one. We interpret these coupled period doublings as representing the transformation from a neutral state (e.g. the reaction) to a charged state (e.g. the proton): $n \rightarrow p$

$$\frac{\partial}{\partial \theta_1} \left[ \sin \theta_1 \frac{\partial}{\partial \theta_1} \right]$$

if it is similar to spin rotation functions

$$\frac{\partial}{\partial \theta_1} \left[ \sin \theta_1 \frac{\partial}{\partial \theta_1} \right]$$

Conclusions

We interpret the period doublings as related to the creation of the charge in the neutron decay. Similar states will the states may contribute to neutral states.

Parton distributions

We project from a state constructed from trigonometric functions to mimic the period doublings implied in the decay to the proton state

$$f(x) = <x|j\Phi_{\eta}^{\eta})> = \sum_{n=-\infty}^{\infty} \int dx f(n) = \sum_{n=-\infty}^{\infty} \int dx f(n)$$

We scale the boost with different toroidal generators.

References


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Appendix
