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Trinhammer, Ole Lynnerup

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

Ole L. Trinhhammer.

Department of Physics, Technical University of Denmark (DTU)

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 proton state to space via the exterior derivative on u(3). We predict scarce neutral-flavour singlets which should be visible in neutrino diffusion dissociation experiments or in invariant mass spectra of protons and negatives pions in B-decays and in photoproduction on neutrons. The presence of such singlets distinguishes experimentally the present model from the standard model as does the prediction of the neutron to proton mass splitting. Concretely the hamiltonian may describe an effective phenomenology or more radically describe interior dynamics implying sparks and glazes as projections from u(3) which we then call allospatial.

The allospatial hypothesis

We wish to generate projection fields transforming under the SU(3) algebra with variable of a sole baryonic entity and space and assume the following Hamiltonian

\[ \hat{H} = \sum_{i,j} \lambda_{ij} \mathbf{r}_i \cdot \mathbf{r}_j \]

resulting in combinations of three colour singlet states.

The theory unfolded

The Laplacian in (1) contains off-diagonal derivatives which are represented by the off-diagonal Goldstone matrice. We choose three of these to represent spin and group them into \( (\mathbf{r}, \mathbf{r}, \mathbf{r}) \). 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 systems between dynamic systems and static body fixed coordinate systems for the description of rotational degrees of freedom. The remaining three are grouped into \( (\mathbf{r}, \mathbf{r}, \mathbf{r}) \), which is related to hypercharge and isospin. They can be added by commuting into the subspace of \( \mathbf{r} \). The fully parametrized Laplacian in polar decomposition reads

\[ \Delta = \sum_{k,j} \frac{\theta_{ij}}{r^2} \sum_{k,j} k^2_j n_k \frac{\partial^2}{\partial x_k^2} \]

The constant term is interpreted as a curvature potential and the off-diagonal term is analogous to the centrifugal term in the usual treatment of the radial wave function for the hydrogen atom.

The potential in (2) is called the Schrödinger equation.

\[ \mathbf{H} = \mathbf{r} + \frac{\mathbf{r}}{r^2} + \frac{1}{2} \mathbf{r} \cdot \mathbf{r} \]

and a similar factorization of \( H = H_{11} + H_{22} + H_{33} + \cdots \) gives for \( \mathbf{H} = \mathbf{r} + \mathbf{r} \cdot \mathbf{r} \).

\[ \Delta + F \]

Parton distributions

We boost a proton from rest to energy \( E \) by impacting upon it a massless four-vector \( \Delta \) which yields for the parton fraction

\[ P(x) = \frac{1}{1 + x^2} \]

and boost parameter

\[ \Delta = \frac{1}{1 + x^2} \]

We scale the boost with different isotopic variations.

Conclusions

The allospatial Hamiltonian in (1) or (2) may be seen as an effective phenomenology or interpreted more radically in a conceptual interpretation where we see

\[ \phi_\theta = \phi_\theta \]

Resonances - from space: The impact momentum as strangeness operators generate the maximal torus of u(3).

The momenta form quark on field lines.

The Hamiltonian has no fit parameters except the scale \( \Delta \) and \( \mathbf{r} \cdot \mathbf{r} \) as

\[ \phi_\theta = \phi_\theta \]

A quite accurate prediction of the relative neutron to proton mass shift is 138% follows from approximate solutions to the Schrödinger equation. A projection of states to space is given via the exterior derivatives. This projection has yielded 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 unfold in the global group space and an asymptotic free domain where the algebras approximate the group. A promising ratio between the Al(3) and H(3) masses has been calculated based on specific D-strings. We expect the allospatial energy eigenvalues of specific spin and parity via expansions on specific combinations of D-functions. Single neutral flavour resonances are predicted above the free charm threshold of \( 1 + \frac{1}{2} \)).