Contribution ID: **16** Type: **not specified**

THEORY AND EXPERIMENT OF GRAVITON PHYSICS

Wednesday, January 22, 2025 2:30 PM (30 minutes)

In the framework of physics beyond the Standard Model, an experiment is presented to search for a chiral graviton mode. These particles were found in a special type of liquid that behaves in a special way under the influence of a magnetic field. Studying the properties of graviton modes will provide an opportunity to understand quantum gravity.
To study gravitational modes, inelastic scattering of photons is considered, modeled using microscopic theory with Hamiltonians at different filling factors [1]. A common feature of fractional quantum Hall (FQH) fluids is multiple graviton modes (GMs) in different subspaces in one Landau level (LL). The number of observed GMs is dynamical and meaningful for specific interaction Hamiltonians. Each GM can be interpreted as the null spaces of model Hamiltonians within one LL.
Our goal is to present the geometric origin of GM and the hierarchical structure of conformal Hilbert spaces as null spaces of model Hamiltonians. We then introduce K-group theory to identify each set of GM excitations, which leads to a topological explanation of the emergence of multiple GM.
We'll use the following Hamiltonian
=$\sum_1^N \frac{1}{2m}\bar{g}^{ab}\hat{\pi}_{ia}\hat{\pi}_{ib}+\hat{V}_{int}, where\hat{\pi}_{ia} = \hat{p}_{ia}+e\hat{A}_{ia} thedynamicalmomentumoperatorofthei-thelectron$,A$_i$ is the external vector potential, connected with magnetic field by formula $B = \epsilon^{ab}\partial_a A_{ib}$. V_{int} describes the dynamics only within a single LL, the magnetic length is $l_B = \sqrt{\frac{1}{e}B}$. The Hilbert space of a single LL, referred to as the lowest LL (LLL), is parametrized by the metric $\bar{g}_{ab}$, which leads to density modes in higher LLs, known as "cyclotron gravitons". The Hilbert spaces like LLL are called conformal Hilbert spaces (CHSs) as they are generated by the conformal operators like the Virasoro algebra, known as the Virasoro constraint in string theory, applied only on the physical states. Such CHSs are built up with quasiparticles. We can use the apparatus of the K-group for calculation of Hilbert space states of charged particles for explanation of the FQHE, which are topological phases of LLLs. Since we are dealing with four types of interaction, it is appropriate to use the apparatus of vector bundles to describe a complex formation of D-brane type. B-field interacting with D-branes can be taken into account through the Dixmier-Douady invariant, which characterizes the bundles and describes the strength of the Neveu-Schwarz B-field interacting with D-branes. D-branes are topological solitons whose charges are described by Grothendieck K-groups. Reduction of twisted K-groups to an exact sequence of the form 0$\to Z \to Z \to Z_n \to 0 leadstotheresult K_0(S^3, n[H]) = Z_n. Thisgroupvaluedeterminesthetopologicalchargesof the D6-braneinthepresenceoftheNeveu-Schwarz-field[2]$.

1. Wang, Y., Yang, B., Phys. Rev. B 105, 035144 (2022).
2. Yu. Malyuta, T. Obikhod, Reports of the NAS № 6, 84 (2001).

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Session Classification: Session Contributed talks