**Chern-Simons theory and Quantum Hall states**

*Proposition de sujet de thèse*

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**Resumé: The thesis is devoted to study the links between quantum Chern-Simons theory and Quantum Hall states. The ground states of the CS theory correspond to the quantum Hall states in fractional quantum Hall effect. This correspondence can help elucidate the properties of the latter, such as projective flatness, topological degeneracy etc. Possible applications of the thesis include topological quantum computing.**

The topic of this thesis is at the interface of analysis, probability, geometry and quantum physics. The first main object of study is a quantum-mechanical wave function ("quantum Hall state") of $N$ particles on a manifold $M$. When $M = \mathbb{C}$, the wave function is a holomorphic degree-$d$ homogeneous polynomial in the polynomial ring in $N$ complex variables, completely symmetric or anti-symmetric, which belongs to certain ideals in $\mathbb{C}[z_1, ..., z_N]$. The best known case is the so-called Laughlin wave function, when the wave function belongs to the diagonal ideal, but more general choices of ideals are also interesting. Such wave functions describe the Quantum Hall effect in condensed matter physics. It is customary to define Quantum Hall states for $M$ being a compact Riemann surface.

The second object of study is the quantum Chern-Simons theory. For the abelian Chern-Simons theory with the gauge group $U(1)^k$ it is conjectured that the ground states are in one-to-one correspondence with the Laughlin states and multi-layer states in fractional QHE. For non-abelian gauge groups the ground states correspond to non-abelian QH states, such as Moore-Read and Read-Rezayi states, which were proposed as platforms for topological quantum computing.

The goal of the thesis is to use this correspondence between the QH states and CS theory in order to elucidate and rigorously prove the important properties of QH states, such as projective flatness of resulting vector bundles on the various parameter spaces (moduli space of flat connections, moduli space of complex structures) and topological degeneracy of ground states.

## References

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