On P, T Breaking Properties of Anyons

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We study P, T breaking physical properties of anyons. In particular we consider anyon models of high T_c superconductivity. We believe more theoretical work is necessary in view of the current experimental investigations. We obtain low energy effective Lagrangian in a systematic expansion around the constant average statistical magnetic field. We show that anyons possess no magnetic moment and exhibit no zero magnetic fied Hall effect in accord with the Galilei invariance at the zero temperature. Concerning static properties, we find no magnetic field in the anyon superconductor and very small magnetic field in the mormal state. Concerning optical properties, we have derived Wen-Zee type effective Lagrangian. Therefore anyons exhibit P, T breaking optical properties without suppression. We emphasize that the P, T breaking optical properties do not conflict with the Galilei invariance. We conclude that anyon models can be experimentally tested through their P, T breaking optical properties.

Fractronsl Spin Particles in (2+1) Relativistic Theory

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(2+1) Poincaré group の unitary な既約表現をことごとく求め，相対論的に可能な粒子像を網羅する。その結果， fractional spin（スピンを s とするとき2｜S｜≠ 整数）の粒子は massive, massless のいずれにも存在し得ることが示されるが，ここでは話を限定して，非相対論的極限を有する massive の場合を議論する。

このような粒子の従う共変的な波動方程式を求めてみると，（i）無限成分の方程式となり，（ii）positive frequency と negative frequency の amplitude は別々の共変的な方程式に従う，ことが導かれる。

つぎに，fractional spin を記述する既約表現の基底ベクトルと共変な無限成分振幅とを関係づける式を構築する。これを用い，(3+1)のときと同様にして第２量子化を行うと，causality の破綻が導かれ，fractional spin particle に対しては，consistent な相対論的場の量子論が存在しないことが結論される。

さらに光速を無限大にして表現の contraction を行い，この粒子に対する Galilei 群の表現を

*) massless の場合は，もっと奇妙な粒子を与える既約表現も存在する。

導く。このとき得られる非相対論的な fractional spin の粒子は，全角運動量の定義を単に $-i\left(x_1\frac{\partial}{\partial x_2}-x_2\frac{\partial}{\partial x_1}\right)+\mathrm{S}$ としただけの trivial な自由粒子に帰着し，anyon とは無関係な結果を与える。この事実は，anyon に対しては，漸近的な自由粒子描象が存在し得ず，また通常の意味での場の量子論的な記述が不可能であることを示している。

Anyonic Quantum Theories

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Anyon is expected to play an important role in understanding a mechanism of the high-Tc superconductivity. We investigate quantum theories of anyons in the framework of the canonical quantization. The analysis presented here is very general. We consider the U(1) gauge theories with the Chern-Simons term as the kinetic term of the gauge field. The matter sector is generic. We only assume that the interaction is minimal. Using the symplectic geometric method of quantization, the theory is quantized canonically. After that, the Gauss law constraint, which guarantees the gauge invariance of the theory, is solved explicitly. The vector potential is expressed by using the charge density operator of the matter and a multi-valued function. Then we introduce a new basis of the matter field operator which absorbs the vector potential by a singular gauge transformation. The new field operator satisfies a graded equaltime commutation relation. The commutation relation means that the new field operator obeys exotic statistics. Thus the theories can be "anyonized". This analysis gives us a canonical description of anyonic quantum theories.

More details and furter development have been apeared in the following references.

References

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