Quantum Hall effect and TGD

1. Quantum Hall effect (QHE).

   (a) Hall effect occurs in 2-D systems. Current flowing along voltage V in magnetic field B orthogonal to the direction of incoming current and experiences Lorentz force. current develops a transversal component proportional to the voltage V. Classically the transverse conductivity is $\sigma_{xy} = ne/B$, n 2D electron density.

   (b) In integer QHE this happens at quantum level the transversal conductivity is quantized as $\sigma_{xy} = \nu e^2 h$, ν an integer. This can be under stood from standard quantum mechanics just by solving Schrödinger equation in external magnetic field. n is is equals to $n = \nu eB/h$ guaranteeing that the number of electrons is ν-multiple of the magnetic flux using elementary flux quantum as unit.

   (c) For fractional QHE (FQHE) the ν is however fractional. The most plausible explanation is provided by composite electron moded reducing the effect to IQHE but replacing electron with a composite of electron anyon with even number of magnetic flux quanta extracted from the external magnetic field and forming a bound state with electron, which now responds to the external magnetic field.

   (d) Composite model fails to explain the fractions ν=5/2 and 7/2. The conjecture is that Cooper pair like bound stats are formed from anyons. Anyons obey fractional braid statistics made possible by 2-dimensionality of the system. One can generalize abelian braid statistics to non-abelian one so that rotating through 2 corresponds to multiplication with matrix rat her than phase factor. It has been proposed that the exotic states obey to non-abelian braid statistics.

   (e) The charge of the anyon is fractionized.

2. Composite model has at least following problems.

   (a) The flux quanta must be assumed to behave like fer mions. What gives them the fermionic statistics and may be also fermion number?

   (b) How both the number of flux quanta per electron and the number of electrons per flux quantum can be larger than one?

   (c) How to understand charge fractionization. How general phenomenon the fractioniza tion is?

3. Could TGD based model provide deeper justification for the composite model?

   (a) Composite model as starting point. Flux quanta now realized as magnetic flux tubes. An interesting possibility is that flux quanta correspond to mono pole fluxes for which the transversal section of the flux tube is closed 2 surface rather than disk or annulus.

   (b) Interesting possibility is that the underlying 2D system corresponds to a partonic 2-surface of macroscopic size at which electrons and accompanying flux tubes are attached. This kind of surfaces are proposed to appe ar even in astrophysical scales in TGD Universe and carry dark matter. This would give first a principle justification for braid statistics.

   (c) Could the braid statistics has justification in terms of hierarchy of Planck constants? The proposal is that $h_{eff} = n \times h$ corresponds to a formation of effective n-sheeted covering of imbedding space. $M^4(CP_2)$ could be covered n_1 (n_2) times. This means that ordinary rotations and color rotations in Cartan algebra induce only a phase correspond to $2\pi/n_1$ ($2\pi/n_2$). This would bring in various kinds of fractionizations.

   (d) A delocalization of em charge to n sheets implies 1/n fractionization.

   (e) Non-abelian braid statistics is possible only for $n > 4$ and $n = 4$ would be minimal value of n.

(f) What gives for the flux tube fermionic statistics? One possibility is based on the fact that a magnetic flux tube carrying Kähler magnetic flux equal to Kähler electric flux at its end is dyon with minimal magnetic charge and odd electric charge. By a well-known argument dyons obey fermionic statistics. The objection is that physical fermions are obtained by adding "urfermions" at dyonic wormhole throats. Does this mean that they are bosons after all!

(g) A solution of the problem consistent with basic TGD could be that the dyonic flux tube assignable to elementary particle defines only a classical space time correlate for fermion.

(h) An alternative explanation would be that the flux tube contains two parts located at parallel space-time sheets connected by wormhole contacts at the ends of the flux tubes so that a closed flux tube results (no genuine magnetic mono poles in TGD). One would have two flux tube portions of this kind and statistics would be bosonic. The appearance of monopole fluxes as pairs in FQHE would conform with this picture about electron.

(i) Another less attractive possibility is that covariantly constant right handed neutrino assignable to the flux tube gi ves rise to fermion number without con tributing to four-momentum. The first geometric explanation would only define space-time correlate for spin 1/2. Note that this is consistent with the assumption that neutrino pairs neutralizes the weak isospin of electron. For larger h_{eff} the fractionization of weak isospin would be required.