MP 3 Hauptvorträge III

Zeit: Mittwoch 10:15–12:05 Raum: TU MA043

Hauptvortrag MP 3.1 Mi 10:15 TU MA043

Swimming lessons for microbots — •Joseph Avron — Department of Physics, Technion, Haifa, Israel

Swimming at low Reynolds number is geometric. A gauge theory of swimming due to Wilczek and Shapere, and going back to the 80's, shall be described with an eye on its implications to the swimming of micron size robots (microbots). The optimization problem associated to microbot swimming shall be formulated. In two dimensions one can use conformal methods to find explicit solutions and illustrate the optimal strokes of few swimming styles.

Hauptvortrag MP 3.2 Mi 11:10 TU MA043

Topological quantum field theories, Feynman path integrals, and R-matrices — •Atle Hahn — Mathematisches Institut, Universität Bonn

Topological quantum field theories provide some of the most interesting examples for the usefulness of path integrals. One of the best known of these examples was discovered in E. Witten's paper "Quantum field theory and the Jones polynomial". In this paper Witten studied one particular topological quantum field theory, Chern-Simons theory, and was finally able to compute the so-called "Wilson loop observables" (WLOs) of this theory explicitly. These WLO are heuristic path integral expressions and the interesting thing about the values Witten obtained for them is that they are given by highly non-trivial link invariants like the Jones, the Homfly or the Kauffman polynomial. The elaboration of Witten's ideas later led to a breakthrough in knot theory, the discovery of the universal Vassiliev invariants.

Unfortunately, it has not yet been possible to establish the aforementioned connection between path integrals and knot polynomials at a rigorous level. In the special case, however, where the base manifold M of the Chern-Simons model considered is of product form the situation looks much more promising and we believe that, at least for some of these special manifolds M, it will eventually be possible to obtain a rigorous definition of the WLOs in terms of Hida distributions (Step 1) and to prove that the values of the rigorously defined WLOs are indeed given by Witten's formulae (Step 2).

In the first part of my talk I will summarize some recent results for the manifold $M = R^3 \cong R^2 \times R$, for which Step 1 has already been carried out successfully with the help of axial gauge fixing. This manifold has the drawback of being noncompact and for this reason one cannot expect that the values of the WLOs are given by Witten's original formulae.

Fortunately, there is at least one compact manifold for which Step 1 can also be carried out, namely the manifold $M = S^2 \times S^1$. In the second part of my talk I will give an overview over the results obtained so far for this manifold with the help of what M. Blau and G. Thompson call "torus gauge fixing". In the last part of my talk I will sketch what remains to be done in order to complete Steps 1 and 2 for the latter manifold and I will explain why it is reasonable to expect that the completion of these two steps will finally give rise to a purely geometric derivation of the R-matrices of Jones and Turaev.