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The quantum Hall effect, the Θ angle, instantons and all that

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The quantum Hall effect as observed in semiconductor devices is one of the most interesting and outstanding experimental realizations of the so called θ vacuum concept in quantum field theory. In this talk, I will review some of the major advances and persistent mistakes that have spanned the subject for more than three decades. I will show how the physics of the quantum Hall effect sheds new light on the notorious strong coupling problems in theoretical physics.This includes the concept of integral topological charge and the conflicting ideas pursued by different schools of thought, in particular, the instanton picture of the θ vacuum and the large N picture. As a second novel feature I will address the topological classification of field configurations in the bulk and edge modes. This classification has major consequences for quantum field theory where the existence of massless chiral edge excitations was historically unrecognized. I will discuss how the concept of super universality emerges from the existence of these critical edge modes. In dramatic contrast to the historical expectations, super universality tells us that the basic feautures of the quantum Hall effect (i.e. robust quantization, quantum criticality of the plateau transitions etc.) are all intrinsic topological features of the θ vacuum which are independent of the mathematical details (such as the number of field components or replica method) as well as physical details of the theory (such as the presence or absence of interaction effects). In the last part of this talk I will present the recent advances made on super universality in dimerised SU(N) quantum spin chains. This includes the Haldane mapping onto the sigma model and the numerical simulations that demonstrate the basic principlles of super universality.

Biography

Adrianus M M Pruisken completed his PhD from Brown University. After postdoctoral studies at Heidelberg University and being a Member at the Institute for Advanced Study in Princeton he joined the Columbia University faculty in New York. His current research interests cover the topological and non-perturbative aspects of quantum field theory, primarily focused on applications in condensed matter physics and statistical mechanics. He has contributed to a variety of fields including quantum critical phenomena, Anderson localization and interaction phenomena, the quantum Hall effect, the Coulomb blockade, single electron transistors and quantum spin chains. He is the Lead Researcher of many of the ground breaking experiments, conducted at Princeton and Amsterdam, on the nature of the quantum Hall plateau transition.

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