Jean Vincent Bellissard

Between Classical and Quantum Mechanics

I was born in Lyon on March 1 1946 as a result of the Peace and the return of my father, who was a prisoner of war in Germany during the disastrous Second World War. I got my degree in Physics and Mathematics in Lyon in 1967, where I graduated in 1968 and became a *Professeur Agrégé* in Physics in 1969. In October 1970 I went to Marseille to the Université de Provence, where I taught for 21 years (first as Assistant Professor, Associate Professor in 1980, Full Professor in 1986). Besides, I had the opportunity to lecture and conduct further research at several universities and institutions in Germany, Switzerland, Japan, Israel, and the USA. I have mainly carried out my research at the Centre de Physique Théorique, a CNRS-Institute in Marseille, internationally known for its contribution to Mathematical Physics. Since October 1991, I have been *Professeur de Classe Exceptionelle* at the Université Paul Sabatier of Toulouse, where I am in charge of creating a new CNRS group of theoretical physicists. — Address: Laboratoire de Physique Quantique, Université Paul Sabatier, 118, route de Narbonne, F-31062 Toulouse Cedex.

Non-Commutative Geometry is a mathematical tool which enables the study of the geometrical properties of Quantum Systems. Quantization occurs whenever the particles of a system have to be described on a small scale, by waves rather than pointlike objects subject to the laws of Classical Mechanics. In the event of such conditions, interference phenomena occur producing responses quite different from what could be expected from a classical point of view.

In Classical Mechanics, several properties of the time evolution have their origin in the Topology or the Geometry of the phase space in which one must describe the motion. In their Quantal counterpart, the interference effects are reminiscent of that geometry, and may sometimes produce spectacular results. They explain, in particular, the very high stability of matter. Non-Commutative Geometry is especially efficient in dealing

with complex systems. Moreover, it is extremely useful in investigating borderline problems between Classical and Quantum Mechanics.

During the last ten years, I have applied this technique to various problems of low temperature Solid State Physics, such as conduction electrons of a solid in a magnetic field. It is also useful in describing the electronic properties of aperiodic crystals, such as Quasicrystals or Superlattices. One can, for example, provide comprehensive labelling of the gaps in the energy spectrum, or a complete account of the quantization of the Hall conductance, the so-called Quantum Hall effect, in a slightly disordered system, by using a sophisticated version of Non-Commutative Geometry. The localization produced by impurities is also an interference effect which traps particles in the defects of a crystal. Such an effect also occurs dynamically in systems driven in time, for which classical chaos is present; this is one of the main features of Quantum Chaos.

In 1990-91, a special program entitled "Physics and Geometry" was jointly organized by the *Wissenschaftskolleg zu Berlin*, the *Technische Universität* (Professor R. Seiler), the *Freie Universität* (Professor R. Schrader), and the *Humboldt Universität* (Professor Friedrichs). The Fellows who participated in the program were Professor Bernard Helfer from the *Ecole Normale Supérieure* (Paris), Professor Volker Enss from Aachen, Dr. Victor Tchoulaevski from Pushchino (USSR), Dr. Peter Zograf from the Steklov Institute in Saint Petersburg and myself. Professors C. Bardos (Paris), R. Dobrushin (Moscow), E. Lieb (Princeton University), Ya. Sinai (Landau Institute, Moscow) and T. Spencer (IAS; Princeton) were special guests of the Rektor.

A series of seminars were held in rotation by the four above mentioned institutions throughout the year. The topics dealt with the relationship between Classical and Quantum Mechanics, so-called "semiclassical analysis", the Geometry of surfaces, applications of Non-Commutative Geometry, localization phenomena, and some aspects of Quantum Chaos. In the course of these events, I was asked to give a ten-week advanced course at the *Humboldt Universität* on applications of Non-Commutative Geometry in Solid State Physics, which was attended by 40 scientists and students.

During the year, the facilities provided by the Wissenschaftskolleg and the financial support of the DAAD, the DFG, the Berlin Academy of Sciences in Germany, and the CNRS in France, allowed me to invite three students of my group (Mrs Annelle Barelli, Lakhdar Dahmani and Philippe Hauguel) to work on semiclassical methods and the electronic properties of quasicrystals for the entire year, as well as several short-term visitors from Germany, France, Italy, England, the Soviet Union, the Un-

ited States, and Israel. With some of the participants, it was also possible to either initiate or develop collaborative projects.

For my own part, I managed to write seven articles between October 90 and July 91, which have all been accepted by journals, or, in the case of two of them, by collective books. I also had the opportunity of visiting several groups specializing in Theoretical Physics and Mathematics in Germany (Frankfurt a. M., Bonn, Bochum, Bielefeld), as well as similar groups in France (Meudon, Toulouse, Marseille, Orsay, Nantes, Grenoble) or elsewhere in Europe (Prague, Copenhagen, Montecatini Terme in Italy), where I gave talks and exchanged information with my colleagues. I participated in four international conferences: Marseille in December 90 (here I was responsible for the organization), Copenhagen in May 91, Nantes in June 91, Montecatini Terme in July 91, where I read from my work and organized two courses.

Like my Fellow colleagues in the group "Physics and Geometry", I also became involved in the activities of the Wissenschaftskolleg. The Tuesday colloquium proved especially important as it exposed us to the work of other Fellows in more detail, particularly those specializing in the Humanities. The members of our group "Physics and Geometry" granted me the honor of presenting their work in the colloquium on March 12th, 1991, in the form of a talk entitled "Determinism and Unpredictability in Classical and Quantum Mechanics".

Last but not least, the very important daily meeting at lunchtime in the restaurant of the Kolleg must be commended as one of the main opportunities to socialize, engage in lively debate with other Fellows on themes as vast as "The fate of the world following the fall of the iron curtain", and to savour German *nouvelle cuisine*, a cultural event in itself of major significance!