Pier A. Mello

Statistical Problems in Disordered Systems

Born October 15, 1939 in Pray, Italy. Ph. D. degree from UNAM (National University of Mexico), 1965. Postdoctoral position at the Institute of Advanced Study, Princeton, NJ, 1965-67. Full Professor at UNAM since 1974. Visiting Professorships at the University of Wisconsin at Madison, at Saclay, France, University of Washington at Seattle. Member of the referee staff for *Physical Review, Physical Review Letters* and *Nuclear Physics.* Courses on Mechanics, Electrodynamics, Thermodynamics, Statistical Mechanics, Quantum Mechanics and Nuclear Physics. Publications: 88 articles in international journals. — Address: Instituto de Fisica, Universidad Nacional Aut6noma de México, 01000 México, D.F.

During my stay at the Wissenschaftskolleg my interest in research has focused on statistical problems in disordered systems. In particular, I completed the research on a problem in magnetism and on one in mesoscopic systems and I wrote the corresponding papers:

1. "Strongly coupled Ising chain under a weak random field". By P. A. Mello and A. Robledo, *Physica A,* under discussion (see abstract).
2. "Random-matrix study of multiprobe mesoscopic devices. II. A four-probe one-dimensional system". By V. A. Gopar, M. Martinez and P. A. Mello, to be submitted to *Phys. Rev. B* (see abstract).

I also started working on some new topics:

1. Quantum transport in a normal mesoscopic conductor-superconductor junction: collaboration with J.-L. Pichard. The paper will be submitted to *Phys. Rev. B* (see preliminary abstract).
2. Surface magnetization in a semi-infinite 2D Ising system having random bonds with a layered structure: collaboration initiated with I. Peschel, Freie Universität Berlin.
3. Corrections to Rayleigh's law on random scattering: collaboration initiated with B. Shapiro, Technion, Haifa (at present at Saclay).
4. Possibility of describing the distribution of the conductance at the metal-insulator transition using a random-matrix model: collaboration started with B. Shapiro.

During the academic year I gave a number of lectures:
1. Various seminars inside the physics group at the Kolleg.
2. "Universality in the statistical description of physical phenomena". (Tuesday-Colloquium at the Kolleg, March 1993, see pages 163-170.
3. "Analysis of an Ising chain in a random magnetic field". (Freie Universität Berlin, February 1993/Saclay, May 1993).
4. "The physics of mesoscopic systems" (Freie Universität Berlin, June 1993).
5. "Random matrices and applications" (Hahn-Meitner-Institut, Berlin, July 1993).

I was invited by the Centre for Theoretical Physics, Trieste (Italy), to give a course on "Random Matrices", for the Workshop on Mesoscopic Systems and Chaos, 26 July to 6 August 1993. I thus spent some time in the preparation of these lectures and the corresponding notes.

1 would like to stress the relevance, for my academic work, of the visit of two colleagues, A. Robledo (one week in January, 1993), and J.-L. Pichard (3 weeks, February-March, 1993). These visits allowed me to finish a paper and to initiate a research whose respective summaries follow hereafter.

I visited Saclay (France) during 10 days in May. Thanks to this visit I could continue the collaboration with J.-L. Pichard and initiate the one indicated above with B. Shapiro.

<u>Strongly coupled Ising chain under a weak random field</u> (Summary)
(Co-authored with Alberto Robledo)

We present here an analytical method based on the transfer matrix M to study quenched disorder in one-dimensional spin systems in the limit of strong couplings and weak disorder. The procedure is formulated for the random-field Ising chain of finite length L, and its properties, represented as functions of M, satisfy a differential equation of the Fokker-Planck type. This equation describes "evolution" with L, and a central-limit theorem of a novel kind provides the equation and its solution with universal character. We obtain analytical expressions for the moments of the magnetization of the infinite length chain and study the approach to the infinite coupling limit. We find that the random-field free energy f_H and the Edwards-Anderson order parameter m_2 satisfy a simple relation. We discuss our results in connection to previous work by Luck and Nieuwenhuizen.

Random-Matrix Study of Multiprobe Mesoscopic Devices. II A Four-Probe One-Dimensional System (Summary)

(Co-authored with Victor A. Gopar and Moisés Marténez)

A random-matrix analysis is presented for a four-terminal device consisting of one dimensional mesoscopic wires. Interest is focused on the potential difference v measured between the two sides of a weakly disordered conductor. Various interference effects are found in statistical distributions w(*v) of* v. Both the centroid and width of w(v) oscillate as a function of the probe separation, the size of the oscillations depending on the coupling constant *s* between the probes and the wire. For *s <z 1, w (y)* is wide enough to yield a nonzero probability to find a potential rise instead of a potential drop.

Quantum Transport in a Normal Mesoscopic Conductor-Superconductor Junction (Summary)

(Co-authored with Jean-Louis Pichard)

Motivated by recent experimental and theoretical studies, we present a random-matrix model for quantum electronic transport in a normal mesoscopic conductor coupled to a superconductor. Electrons that are incident on the superconductor below the energy gap do not propagate in the superconductor, and thus suffer an Andreev reflection at the junction. For the statistical analysis, the standard transfer matrix model is used for the normal part.

In a simple 1-channel problem $(N = 1)$, the average conductance *decreases* as the length L of the normal part increases, as long as the strength of the Schottky barrier at the junction is below a critical value; above that critical value, the conductance first *increases* and then eventually goes to zero for large *L*.

In a multichannel problem and when the normal metal is in the ballistic regime, we find a behaviour similar to that for $N = 1$ in the orthogonal case (ᵢ3 = 1), while we observe a *monotonic* decrease of the conductance with increasing L for $ß = 2$. We should remark that, in the absence of a Schottky barrier and for $L = 0$ (no disorder normal part), $g = 4N$*: i.* e., as a result of Andreev's reflection, one obtains twice the value in the absence of the superconductor. On the other hand, again in the absence of the barrier but in the diffusive regime, the superconductor has *no* effect on the average conductance. In this regime, the effect of the barrier and of a magnetic field are now under study.