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Introduction

The papers presented in this issue are dedicated with affection and admiration to Giovanni Jona-Lasinio by friends, students, and colleagues at the occasion of his 70th birthday.

G. Jona-Lasinio or, better, Gianni as he is best known, is a physicist with an unusually wide spectrum of scientific interests which, during his long scientific activity, covered elementary particles physics, critical phenomena, probability theory, quantum mechanics, history of science, and more recently, nonequilibrium statistical mechanics. He was always characterized, since the early days of his career, by a strong scientific curiosity, a very innovative way of thinking and a particular inclination to see deep analogies between different scientific contexts. He played an important role in bridging ideas and techniques between theoretical physics, mathematical physics and mathematics. He always emphasizes the importance of the use of the right language in order to convey original ideas from one field to another.

These specific aspects of his scientific personality, an unusual readiness to examine new ideas combined with an intense and sincere dedication and friendship for students and colleagues, made him a beloved teacher among the students and one of the outstanding scientific figures in the physics and mathematics communities in Rome.

At the early stages of his career, after some years at the Physics Institute of the University "La Sapienza" in Rome, Gianni joined Y. Nambu in '59 in Chicago. There, in a celebrated paper whose influence has not diminished over the past forty years (see the Nobel lectures of Glashow, Salam, and Weinberg), they developed the first relativistic field theoretic model of elementary particles exhibiting the possibility of a spontaneous breakdown of a symmetry. The work with Nambu is an excellent example of *cross fertilization* between different areas, in this case the BCS theory in condensed matter physics on one side and the theory of elementary particles on the other.

In 1964 starting from condensed matter physics and thermodynamics Gianni introduced in quantum field theory the concept of "effective

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action," which became the standard tool to describe spontaneous symmetry breaking and which is now found in textbooks.

Back to Italy, Gianni started to move toward statistical mechanics. In 1969, almost two years before the series of Wilson's celebrated papers, he, together with C. Di Castro, showed that the scaling laws and the universality of critical phenomena could be qualitatively understood with the application of field theoretic renormalization group ideas. Later, when a more quantitative analysis became possible through the ϵ-expansion, it was the field theoretic approach which permitted systematic calculations. A few years later he discussed the relationship between the different formulations of the renormalization group in a contribution to a Nobel Symposium held in Lerum in 1973, a theme that he has returned to recently.

During this period, deeply influenced by the ideas developed by the Moscow school, a brilliant and unique scientific environment with which he established a life-long, fruitful, scientific, and human relationship, he became more and more interested in mathematical physics and probability theory.

As a first result of his new interests, he showed in 1975 a precise connection between the renormalization group and limit theorems in probability theory, in two papers, one in collaboration with G. Gallavotti, which had a considerable influence in probability theory and constructive quantum field theory. In those years probability theory had become an essential tool in statistical mechanics and Euclidean QFT and the role of Gianni in transmitting, reformulating and applying the new ideas to theoretical and mathematical physics cannot be overestimated.

After a stay in Moscow in 1978 and back in Rome, he developed with F. Martinelli and E. Scoppola a new approach to the semi-classical limit of Quantum Mechanics which started from Nelson formulation of Quantum Mechanics and was based on ideas and methods from the theory of stochastic perturbations of dynamical systems due to the soviet mathematicians I. M. Freidlin and A. D. Ventzell. Through this approach an important physical effect was discovered: the strong instability of delocalized wave functions in a multi-well potential under small localized perturbations of the potential. This effect, nicknamed by B. Simon "the flea over the elephant," has played a key role in understanding at a deeper level the low energy Anderson localization and provided the motivation for constructing with Martinelli and Scoppola random hierarchical models for which they proved Anderson localization. These simplified models, together with previous work by J. Fröhlich and T. Spencer, provided the key ideas and techniques in the subsequent analysis by Frölich, Martinelli, Scoppola, and Spencer of the localization phenomenon for the original Anderson model.

The phenomenon of strong instability of the tunneling effect in quantum mechanics had also considerable impact on subsequent important work by B. Helffer and J. Sjostrand on the semiclassical limit of quantum mechanics using micro-local analysis. The same phenomenon played a crucial role in Gianni's fruitful collaboration with P. Claverie, a French physicist working on quantum chemistry. They clarified the puzzle of the existence of chiral molecules, an open problem since 1927. Honoring a promise made to Claverie, who died prematurely at the age of 43, recently Gianni reconsidered this problem and provided, in collaboration with C. Presilla and C. Toninelli, a simple model of a gas of pyramidal molecules which explains, for the first time quantitatively, the shift to zero frequency of the inversion line observed upon increase of the pressure in an ammonia gas.

The work on the semi-classical limit of Quantum Mechanics led Gianni to analyze random perturbations of nonlinear PDE's, a difficult problem of great interest in statistical hydrodynamics and more generally in the theory of fluctuations of irreversible processes. With W. G. Faris he extended the Freidlin–Ventzel theory for stochastic ODE's to stochastic PDE's. With P. K. Mitter he developed for the first time the rigorous theory of stochastic reaction diffusion equations with renormalization, a problem originated in the so called stochastic quantization of Parisi and Wu. These works were considerably ahead of the mathematical techniques available at that time and represent another nice example of transfer of ideas, this time from Quantum Field Theory to stochastic processes in infinite dimensions.

Gianni also made other applications of the theory of stochastic processes in Quantum Mechanics by constructing, in collaboration with G. F. De Angelis and M. Sirugue, a Feynman–Kac like formula for the Pauli equation. More recently the same type of ideas has led him, in collaboration with G. F. De Angelis and V. Sidoravicius, to establish a general connection between anti-commutative calculus and Poisson processes which is now being exploited for a probabilistic description of Fermionic many-body problems.

In the last decade Gianni's interests to some extent came back to theoretical physics. At the end of the eighties, triggered by experimental work done by F. Capasso at Lucent Technologies Bell Labs on mesoscopic systems, he begun a fruitful collaboration with C. Presilla, at that time one of his students, on quantum chaos for nonlinear Schrödinger equations. Furthermore they pioneered the study of chaotic properties of quantum many body systems suggesting, in presence of a quantum statistics, a correspondence with dynamical chaotic features of the corresponding nonlinear mean field approximations.

Statistical mechanics however was not left behind. In the middle of the nineties and motivated by the dynamical theory of fluctuations for systems close to equilibrium developed by L. Onsager and by L. Onsager and S. Machlup long ago, Gianni started to work on a general theory of dynamical fluctuations for stationary nonequilibrium states in collaboration with L. Bertini, A. De Sole, D. Gabrielli, and C. Landim. Their results, very original and according to him among the best of his life, include a generalization of the Onsager–Machlup theory, a general Hamilton–Jacobi equation for the macroscopic entropy and a nonequilibrium, nonlinear fluctuation-dissipation theorem.

Gianni is still as active, scientifically demanding and caring about the young and old researchers as ever. Many have the privilege to be his colleagues and many have been, and in some sense continue to be, his students. With all of them Gianni has shared friendship, ideas, scientific advice and has listened to their projects. We all realize that not everybody has such a great fortune in her or his life.

Carlo Di Castro
Francesco Guerra
Fabio Martinelli