Francesco, a first class scientist and a committed intellectual

This volume contains more than 50 articles of well-known scientists dedicated to Francesco Calogero, on the occasion of his 70th birthday. The idea of this volume has been entirely conceived and pursued by Norbert Euler, and we are all very grateful to him for that. Norbert has invited me to write this Introduction, and I of course accepted with great pleasure.

Francesco Calogero, Professor of Theoretical Physics at the University of Roma "La Sapienza", is a remarkable example of a first class scientist and intellectual deeply immersed in the life of his time.

His research activity has covered several areas of Mathematical Physics and Theoretical Physics. In his first research period, from 1958 to 1970 approximately, he concentrated on quantum field theory, on the theory of scattering and on the study of many-body problems in Nuclear Physics. In the period of his maturity, from 1971 to 1999 approximately, he made several important contributions to the theory of integrable nonlinear equations: ordinary differential equations (ODEs), partial differential equations (PDEs) and functional equations, as well as on special functions, matrices, polynomials, and on finite-dimensional representations of differential operators. Lately, most of his efforts are devoted to the study of partially integrable nonlinear systems exhibiting a very rich dynamics, from complete periodicity to chaos, and to the development of a paradigm of "chaos as motion on Riemann surfaces". All these activities are illustrated by more than 300 scientific articles and 3 books. A good percentage of his co-authored publications have been written with Antonio Degasperis who, after having been his student, has been his closest collaborator throughout the years, as well as a good friend of him.

Francesco has always impressed me for his fervent imagination and for a formidable intuition for good problems, two essential qualities for doing original and creative research, together with a unique skill in uncovering distinguished mathematical structures and equations using relatively simple mathematical tools.

One of his most relevant contributions is the discovery in 1971 of the integrability properties of the (quantum) Calogero–Moser model, which has played a seminal role since then in the theory of integrable dynamical systems and appears to be one of the most ubiquitous integrable models. Hundreds of articles related to this model appear every year in the specialized literature.

In his restless search for analytically distinguished many-body problems, which has been one of the leit-motives of his research activity, Francesco has discovered an impressive number of interconnected results in different areas of Mathematics. He has been a pioneer in the quite exotic theory of functional equations, introducing and solving some basic nonlinear examples which characterize classes of interaction potentials corresponding to integrable dynamics. Another by-product of the above research has been the identification of some remarkable matrices which are finite dimensional representations of differential and partial differential operators on the space of polynomials, and their deep connections with the Lagrangian interpolation problem and with integrable many-body problems in one and more dimensions. The list of remarkable matrices and of their associated identities constructed by him is quite long; some of them have become classical examples and can be found, for instance, in the "Table of Integrals, Series and Products" of Gradshtein

and Ryzhik. Francesco has also shown to us how fruitful it is, to search for analytically distinguished dynamical system, to investigate dynamical systems in the complex field, or matrix evolution equations, or the motion of the zeroes of solutions of linear PDEs.

In the recent past he has constructed, via an ingenious and largely applicable change of variables (the "trick"), a large class of nonlinear systems in the complex field exhibiting a very rich dynamics. The most impressive example of this class is the "goldfish", a Newtonian dynamical system which, in different regions of its phase space, can be either completely periodic, actually isochronous of period 1, or completely periodic but with other integer periods, or aperiodic and possibly chaotic. Via the above change of variables, the real dynamics is transformed to a travel on a complicated Riemann surface, which explains the analytical mechanisms for such a rich behaviour. The last example, chronologically, of his creative vein is a three body problem of Archimedian type, whose general solution lives on an "explicit" non algebraic Riemann surface. The study of the rich topological properties of this surface should allow one to unveil the basic analytic mechanisms underlying the paradigm of "chaos as motion on Riemann surfaces".

Francesco has made important contributions also in the theory of integrable PDEs. One of the most outstanding problems in this theory consists in constructing meaningful extensions of the known classes of integrable 1+1 dimensional equations to an arbitrary number of dimensions, and Francesco found a distinguished way to do so. He also constructed integrable PDEs with coefficients depending on the space-time variables, as well as examples of physically interesting integrable systems of PDEs exhibiting, together with the classical solitons, a large zoo of explicit solutions of novel type, like those that come back (the boomerons) and those that oscillate in a finite region (the trappons). The list of his relevant contributions includes also some basic studies on the Bäcklund transformations, distinguished discrete symmetries of integrable nonlinear PDEs, unveiling their group theoretical and spectral properties, and his works on nonlinear PDEs which are integrable by a change of variables (he coined for them the term "C-integrable systems", used now by all of us). I chose to close this impressive list with one of the results I personally like more: his elegant, simple and profound explanation of why basic model equations for a large variety of natural phenomena are also very special from a mathematical point of view, often so special to be even integrable.

As we all know, Francesco is not only a first class scientist, but he is also an example of a fine intellectual deeply immersed in the life of his time and, in particular, in the basic problems involving Science, Society and World Affairs. Perhaps the example of his father Guido, an eminent philosopher who experienced with his family the political confinement during the dark times of Fascism, when Francesco was very young, could have played an important role in the development of these interests.

Indeed, since 1963, Francesco has been actively involved in arms control, disarmament and conflict resolution, publishing more than 300 articles and four books on these subjects (this production has been as prolific as the scientific one!). He has served as Secretary General of the Pugwash Conferences on Science and World Affairs in the period 1989-1997. In this capacity, he has organized more than 70 international Conferences throughout the World, and received the 1995 Nobel Peace Prize awarded to Pugwash. He has also served as Chairman of the Pugwash Council (1997-2002) and he has been one of the initiators and main organizers of the ISODARCO (International School on Disarmament and Research on Conflicts) and of the USPID (Unione Scienziati Per Il Disarmo). Reading

some of his publications on these subjects, I understood that the main role of Pugwash, during the Cold War and, after that, until our difficult days, has been to provide an ideal environment for the exchange of frank (and often different) views among scientists coming from different geopolitical and cultural backgrounds, but with a common interest for the good of mankind. All nations protagonists in the international chessboard have always been well represented in the Pugwash organization and, consequently, Pugwash has been always respected and has been able to influence positively governments and military officials on their decisions on important matters like defence and arms control.

Francesco's energies have not been exhausted in his important activities of researcher and committed intellectual. Indeed he has also been the main reference point in the creation and development of a strong group of Italian scientists working in basically all the aspects of the theory of integrable and partially integrable nonlinear equations. He is the national coordinator of a research project on the above subjects involving several Italian universities. He has promoted and encouraged cultural and scientific exchange agreements between the University of Roma "La Sapienza" and distinguished European and extra-European research centers. He has promoted and organized several important scientific events and, in particular, he has conceived and organized a long series of NEEDS (Nonlinear Evolution Equations and Dynamical Systems) conferences, which have been an important meeting point for the "nonlinear community" and, especially in the past, have offered unique opportunities to scientists of the East and of the West to meet, exchange informations and start collaborations.

Together with Antonio Degasperis, Decio Levi, Carlo Marchioro and others, I belong to the group of scientists who had the privilege to be pupils of Francesco. Although only very recently I have began a direct collaboration with him, on the study of a new paradigm of chaos, his example, his enthusiasm and his suggestions have always influenced the development of my scientific life. It was him, for instance, who encouraged me, after I graduated in Physics under his supervision, to start an interaction with the Clarkson group of Mark Ablowitz and Thanasis Fokas, so important for my scientific growth. His activity as "enthusiastic" teacher continues also nowadays, and his propulsive force and his example keep having a strong impact on students and young researchers.

For all these reasons, I consider myself particularly honored to be asked to write this introduction, and if I succeeded in giving just a small idea of what Francesco has meant for our community, and for me in particular, through all these years, then this introduction will have reached its main goal.

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Rome, December 14, 2004