(Dated: 23 September 2020)

I. TRIBUTE TO ENRIQUE BY S. RICA

Enrique Tirapegui was born in 1940 in Santiago, Chile, where he grew up and did all his studies. After finishing his undergraduate education at Universidad de Chile (1962) he left to France, to do graduate studies and prepared his Ph.D. (3^{me} cycle) in 1965, and then in 1969 his "Thèse d'État" both with Bernard Jouvet as an advisor. He joined the Faculty of Engineering at Universidad de Chile in 1969, as an assistant Profesor, then in 1970 he left to take a Postdoctoral Position in Princeton and Rutgers and then in Marseille under the advice of Raymond Stora. Enrique contributed to the early ideas of the so-called BRS symmetry. In 1973 Enrique got a Professorship at Université de Nice, then in 1975 at the Katholieke Universiteit in Leuven. At that moment he decided to switch his area of research from the renormalization group in field theory to functional integration, and more precisely to applications of functional integration to stochastic processes, a subject in which he continued to work and make contributions until his untimely passing.

In 1981 he returned to Universidad de Chile in which he remained until his death, extending his research interests from stochastic processes to other non-equilibrium systems in general. In 1985 he founded the International Workshop "Instabilities and Non- Equilibrium Structures" which is still running. This volume commemorate the 17th version which took place during the first week of December 2019. Since the beginning this workshop played a key role in the development of nonlinear science in Chile, allowing to several dozen of Chilean graduate and undergraduate students to initiate contact and collaborate with the international scientific community.

Enrique passed away during the night from March 10^{th} to 11^{th}, 2020 at Santiago.

Along a career which spanned a period of 50 years, Enrique made contributions to field theory, stochastic processes and functional integration, the theory of bifurcations, dynamical systems and normal forms, partial differential equations, the problem of irreversibility, fluid mechanics, neuron dynamics, etc. These beautiful theoretical works paved the way to numerous applications and experimental studies.

His remarkable scientific work earned him national and international recognition and tributes: Fellow and President of the Academia Chilena de Ciencias (Chile, 1984), National Science Prize (Chile, 1991), Medalla Rectoral of Universidad de Chile (1997), TWAS (Third World Academy of Sciences) Prize of Physics (1997).

I first met Enrique in 1987. From an intellectual side he was always a provocateur, a faithful survivor of the "revolution" of May of 1968. We could say that his life was boundless as well as his passing. He could have not passed away in an usual way, could have he chosen a normal way to do it? I don't think so.

This boundless was reflected in every aspect of his life. He was full of energy, generous without limits, extremely hard-working, extremely unpunctual, always looking for the deeper meaning of things, academically extremely honest and strict. It comes to my remembrance and occasion in which we were talking about a Shakespeare's sonnet (it was probably the 116^{th}), and he could recite it entirely by memory. In my MSc. thesis on defect interactions, I added a quotation by William Blake and he naturally, criticized me saying that this was one of the worst Blake's poems. This was the first and last time I wrote a quotation...



FIG. 1. A street lunch meeting with Fernando Mora (center) in front of the School of Engineering (Universidad de Chile, April 2017).

As it occurs sometimes in life he confessed once to me that his greatest bitterness was having left Stora's group in Marseille a few months before the BRS symmetry work was completed. Despite this frustration, Enrique remained, as always was, a creative and productive researcher. He continued working on a diversity of topics, expanding the frontier of knowledge; his generosity, his depth, his rectitude, allowed him to form a school.

Enrique has been an important person and influence in the lives of those of us who were his students and I particularly appreciate him, not only because he gave me the opportunity to do good research, but he also helped me develop my own security and the need to fly with my own wings. Fortunately, a few years ago we joined our paths as equals, although with the respect that someone who is admired like him deserves, in a couple of works that turned out to be very beautiful.

The first one concerned the application of a coarse graining approach introduced by Catherine Nicolis and Gregoire Nicolis to a reversible and conservative automaton model (The Q2R model). The method leads to a master equation which governs the macroscopic irreversible dynamics of the reversible automaton. Moreover, in the case of small systems, it can be shown that the master equation leads to a tractable probability transfer matrix of moderate size which provides a master equation for a coarse-grained probability distribution.

In a second work we considered the numerical path integral calculation of the probability function as well as exit-time for

systems in one and two dimensions. This work was formally Fernando Mora's Ph.D. Physics Thesis which was co-advised jointly with Pierre Coullet, who was Enrique first doctoral student. Strictly speaking, Fernando was Enrique's last student.

Thanks to my friend Thomas Frisch, I received a copy of a message sent to him by his father Uriel Frisch: "*Une grande lumière, loin au Sud Ouest mais très proche de nos coeurs vient de s'éteindre. Heureusement que ses enfants intellectuels sont partout.*" [which I translated more or less like this: "A great light, far to the Southwest but very close to our hearts, has departed. Fortunately, his intellectual children are everywhere."]

For Enrique, the theoretical formalism was the center of gravity, a theoretical calculation was most important than a numerical one, even more important than an experiment! (partially a consequence of Once he told me about a joke which happened to him in a Conference in Sitges in the 80s (if I remember correctly). He finished a seminar on stochastic processes in many dimensions with a lot of indices μ, ν, etc., then Maxi San Miguel remarked to him: "If I understand well, for you all the physics is included into the indexes...." Enrique was very proud of that remark. Enrique, on some occasion, confessed: "When the clouds appear and the situation becomes complicated, I study mathematics..."

Since the time I lived in France, from 1990 up to 2010, I met Enrique in various circumstances and places that he loved, mainly Paris, Leuven, and Nice. I met Enrique at all these places, Leuven, being his main commandment center. His life in Leuven was fine with several well established routines: lunch at the student restaurant "ALMA 2", followed by the *Stuk Café*, the cinemas, the journeys to Brussels. He liked Paris also, but I am certain that for both, Gloria and Enrique, Nice was their favorite city. They lived just a coupled of years there, but they returned every year to feel the goodness of the *Côte d'Azur* living style. Probably, the main reason for that, was because of Pierre Coullet, Enrique's first graduate student. Pierre was not only the first, but the most brilliant, Enrique knew that and appreciated his intellect. Nonetheless, Pierre contributed significantly to fundamental knowledge, not only for his contributions to the theory of chaos but for several new ideas which illuminated nonlinear physics for more than two decades. And, still, after a period of administrative duties in the last years, his mind remains amazingly creative, looking differently for what is new and endlessly searching for the best and simpler understanding of phenomena.

Since the beginning when I met Enrique, he believed that numerical simulations were not interesting. It was Pierre who convinced him that one can learn unexpected new behaviors from a numerical simulation. In recent years, Enrique learned how to program in *Mathematica*, he did numerical path integral calculations on his own, moreover, he followed a lecture given by Pierre in January 2017, on the new release of the Swift Programming Language.

This attraction was mutual, Pierre also loved Enrique, he has spent every summer in Chile since the mid-eighties, having the necessary leisure to do physics and clear his mind. Because of that the "Instabilities and Non- Equilibrium Structures" workshop took-off as a reference conference in nonlinear physics, Pierre attracted people like Guyon, Newell, Pomeau, Procaccia, and others to the south every two Christmas since 1985. Therefore, the main reason Gloria and he felt so well at Nice was Pierre.



FIG. 2. Enrique with Pierre Coullet in February 2015 (Photo taken by Fernando Mora.)



FIG. 3. At the Château Valrose, Université de Nice, *ca.* Jun-Jul 1991. Top, from the right: Thomas Frisch, Guillaume Huyet, Kjartan Emilsson, Philippe De Brouwer, and Dalla Johannsdottir. Down, Enrique Tirapegui and myself. We can see also a the top left Monique Dubois, and Gerard Iooss at the top right. (Photo taken probably by Sonia Chakoff.)

Searching in my memory on which one (or which) have been the happiest moments I had with him, there is one in particular which I would like to keep always on my mind: I think were those occasions in which we were going to eat *pizzas à emporter* on the beach at the *Promenade dès Anglais* of Nice where he could freely swim.