In memoriam—Tito Arecchi (11 December 1933–15 February 2021)

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The nonlinear science community experienced a painful loss with the sudden death of our colleague and friend, Professor Tito Arecchi. Professor Arecchi was one of the 12 founding editors of the board of *Chaos* and later he became an Honorary Editor. He was very active and stimulating in forming and evolving this journal, resulting in such a serious and influencing journal for nonlinear sciences and manifold applications.

Tito Arecchi was a pioneer of nonlinear optics and laser physics, as well as nonlinear dynamics. His contributions have been so significant as to constitute milestones in the field of photon statistics and in that of nonlinear dynamics not limited to lasers. To this aim, we would like to emphasize the year 1965 as emblematic of his brilliant personality. He published two fundamental contributions: In the first one,[1] he gave the first experimental evidence of the statistical difference between a laser and a random field obtained by *photon statistics*. In the second one, in collaboration with his first student Rodolfo Bonifacio, they derived the nonlinear equations that describe an electromagnetic pulse interacting self-consistently with an ensemble of two-level atoms under the assumption of a homogeneously broadened electric-dipole transition with two Bloch relaxation times $T_2(\gamma_\perp = 1/T_2)$ and $T_1(\gamma_\parallel = 1/T_1)$ and a linear broadband loss mechanism.[2] These equations are usually referred to as the Maxwell–Bloch equations where they should indeed be referred as the Arecchi–Bonifacio equations.[3] In these equations, the Slowly Varying Envelope Approximation (SVEA) for the electromagnetic pulse was introduced for the first time.

The Arecchi–Bonifacio equations are universally used to describe the dynamics of a single mode laser. Nowadays, it is well known that they are formally equivalent to those of the Lorenz model[4] and, therefore, chaotic behavior is inherent in a laser.[5] However, we had to wait until 1982 to give an experimental confirmation using a single mode CO_2 laser with sinusoidal modulation of the cavity losses.[6] This is due to the fact that in a large class of lasers, the so-called class B lasers, the macroscopic polarization evolves on fast time scales compared with the other two dynamical variables, i.e., the laser intensity, which is proportional to the photon number of the laser field mode, and the population inversion ($\gamma_\perp > k > \gamma_\parallel$, where k is the decay rate for the electric field). A few years later, Lorenz type chaos has been demonstrated for class C lasers, where the three decay rates are of the same order of magnitude.[7] The above classification of lasers is another crucial contribution by Tito Arecchi.[8] However, it would be a narrow-band to link the scientific activities of Tito only to these aspects. Tito has developed, with several colleagues, other important lines of research in the fields of complex systems both from a theoretical and experimental point of view, among them, we recall the optical vortices and their statistics, control and synchronization of chaos, multistability, and even applications to neuroscience.[9] It is important to emphasize that Riccardo Meucci *et al.* have recently revisited the rather simple laser model used in 1982.[6] They have highlighted new aspects on the relationship between multistability and dissipativity as well as its control.[10] Generalized multistability, another pioneering contribution by Tito, has become a focusing issue in many different fields as the numerous papers published in *Chaos* demonstrate.[11]

In this latest period, when the pandemic has profoundly changed our lives, Tito's enthusiasm and passion for physics have not diminished, until few days before his departure, and no one who has interacted with him can forget it. This is his greatest legacy to science. He will be greatly missed by his many colleagues, former students, and friends.

AUTHOR DECLARATIONS

Author Contributions

Riccardo Meucci: Writing – original draft (equal). **Juergen Kurths:** Writing – original draft (equal).

REFERENCES

1. F. T. Arecchi, "Measurement of the statistical distribution of Gaussian and laser sources," Phys. Rev. Lett. **15**, 912 (1965).
2. F. T. Arecchi and R. Bonifacio, "Theory of optical maser amplifiers," IEEE J. Quantum Electron. **1**, 169 (1965).
3. B. McNeil, "Due credit for Maxwell–Bloch equations," Nat. Photonics **9**, 207 (2015).
4. E. N. Lorenz, "Deterministic nonperiodic flow," J. Atmos. Sci. **20**, 130 (1963).
5. H. Haken, "Analogy between higher instabilities in fluids and lasers," Phys. Lett. A **53**, 77 (1975).
6. F. T. Arecchi, R. Meucci, G. Puccioni, and J. Tredicce, "Experimental evidence of subharmonic bifurcations, multistability, and turbulence in a Q-switched gas laser," Phys. Rev. Lett. **49**(17), 1217 (1982).
7. C. O. Weiss and J. Brock, "Evidence for Lorenz-type chaos in a laser," Phys. Rev. Lett. **57**, 2804 (1986).
8. F. T. Arecchi, G. L. Lippi, G. Puccioni, and J. R. Tredicce, "Deterministic chaos in laser with injected signal," Opt. Commun. **51**, 308 (1984).
9. F. T. Arecchi and J. Kurths, "Introduction to focus issue: Nonlinear dynamics in cognitive and neural systems," Chaos **19**, 015101 (2009).
10. R. Meucci, J. M. Ginoux, M. Mehrabbeik, S. Jafari, and J. C. Sprott, "Generalized multistability and its control in a laser," Chaos (in press 2022).
11. U. Feudel, A. N. Pisarchik, and K. Showalter, "Multistability and tipping: From mathematics and physics to climate and brain—Minireview and preface to the focus issue," Chaos **28**, 033501 (2018).