

M.G. Velarde: Highlights of Research Achievements

Yu.S. Ryazantsev

For a list of publications with full details see www.ucm.es/info/fluidos, under Personnel, Manuel G. Velarde, cv.

1965–1969–1971: Established domain of validity of Gibbs local equilibrium assumption at the core of the Non-Equilibrium Thermodynamics of L. Onsager and I. Prigogine.

1966–1973: Studied the core nature of non-analytic density expansions of transport coefficients, like self-diffusion, originating in the BBGKY hierarchy and I. Prigogine's non-equilibrium Statistical Mechanics.

1971–1973: Theory of convective instability and criteria to eliminate undesirable effects when measuring the cross-transport thermal diffusion coefficient (Soret effect). Verified in numerous experiments first by H.J.V. Tyrrell (Chelsea College, London) [Trans. Faraday Soc. 71 (1975) 42]. Criteria still used in 2002 and later on by J.V. Sengers (Maryland, College Park), etc.

1972–2011: Theory of instability for fluid systems (nematic liquid crystals, EHD, MHD, falling liquid films, etc.), including features of transverse and longitudinal/dilational interfacial waves.

1979: Mathematical model description of aerobic-anaerobic alternance in the respiration process of *Klebsiella aerogenes* (bacterial culture) motivated and in agreement with experiments by H. Degn (Odense).

1981–1982: Theory providing known and new features of Q-switch laser with absorber. Agreement with experiments by E. Arimondo (Pisa), by C.O. Weiss (Braunschweig), and others using CO₂-SF₆ laser.

1994: Non-linear non-equilibrium thermodynamic theory of convective instability in agreement with experiment by M. Zamora (Seville) [J. Fluid Mech. 167 (1986) 427].

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- 1994:** Thresholds for self-propulsion of drops due to surface tension gradients, variable effective gravity, micro-gravity and g-jitter, thus illuminating the path for space experiments. In agreement with experiments by J.W. Bush (Cambridge) [J. Fluid Mech. 352 (1997) 283] and by A. M-Tatsis (Imperial College, London) in microgravity experiments. Theory has been incorporated in ESA and NASA specialists books: in 1997 by S.S. Sadhal (USC, LA) and in 2001 by R.S. Subramanian (Clarkson College, Potsdam, NY).
- 1995:** Introduction of the “dissipative soliton” concept to describe onset and features of non-linear surface waves due to surface tension gradients (Marangoni effect). It has proven to be of universal value well beyond its original hydrodynamics context, as there are now books and international meetings organized with precisely that same title. Although he had used this concept in several papers already in 1991, it was in a paper published in 1995 in *Physica D* where the term appeared in the title of the paper.
- 1996:** Avalanche-collapse model for “excitability” in non-linear dynamics, in agreement with laser experiments by F.T. Arecchi (Florence) using a laser with intracavity absorber [*Europhys. Lett.* 38 (1997) 85].
- 1996:** Theory about the onset of form by replication (with controllable degree of fidelity) in active systems. Results incorporated in books in 1999 and in 2003 by A.C. Scott (Tucson U., AZ) with discussion supporting their significance to understand early stages of prebiotic evolution.
- 1997–Present:** Theory describing universal laws of wetting and spreading processes over smooth and porous, isothermal and heated substrates, verified by experiments.
- 1999:** Theory describing features of huge internal waves (100 m amplitude along the pycnocline) in the Strait of Gibraltar and other straits, in agreement with field data from several authors.
- 2001:** Theory of generalized stochastic (coherence) resonance: there are systems with excitability-oscillatory behavior that take advantage of noise to operate meaningfully with no need of external drive, in agreement with experiment by O. Piro [*Phys. Rev. Lett.* 92 (2004) 073901], who has proposed a thermo-optical device.
- 2001:** Theory of universal features of wavy phenomena, leading to dewetting and film rupture over smooth and porous, isothermal and heated substrates. Agreement with the available data of 1949 by P. Kapitza, by G. Reiter (1992–1993), and by J. Becker (2003).
- 2001–2003:** Theory of significant features of solitonic collisions in Bose–Einstein condensates.
- 2002–2011:** Mathematical models of neurons, cerebellar function and CPGs (memory and learning) in agreement with available data.
- 2009–2012:** Theory of “memotaxis”, a novel strategy concept for search and survival. Observed by R. Strauss in Mainz in *Drosophila melanogaster* under humidity and/or temperature gradients. Implemented in robots by P. Arena and engineers in Catania (EU Consortium SPARK).

2010–2011: Theory of “internal representation layers” in mathematical brain models of perception for action. Implemented in robots by P. Arena and engineers in Catania (EU Consortium SPARK).

2005–Present: Theory of a new form of fast, long range electron transfer assisted by solitons (e.g. a transition from Ohmic to field-independent non-Ohmic, generally, supersonic conduction). Coined the concepts of electron “surfing” and “solelectron” (2005) to account for the coupling of nonlinear elasticity to quantum mechanics, as a generalization of Landau and Pekar’s “polaron” (nowadays textbook) concept. The theory predicts a kind of ballistic/losses-free electric transport at ambient temperatures. It also leads to a new form of “electron pairing” both in momentum space and in real space (accounting for Coulomb repulsion and Pauli’s exclusion principle).

Without Bounds: A Scientific Canvas of Nonlinearity and
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