

International Conference on

Physics

June 27-29, 2016 New Orleans, USA



Bruce J West

US Army Research Office, USA

Tomorrow's science: Fractional calculus view of complexity

Leonardo da Vinci was the last artist/scientist to make lasting contributions to scientific knowledge, before science broke away from Natural Philosophy. The scientific method, introduced in this breakup, was a strategy for a new way of knowing, involving quantification through the synthesis of simple phenomenological models and measurement. After 300 years of scientific success, we have run out of simple models, and are back with da Vinci at recognizing the importance of the qualitative in addition to the quantitative. Stock market crashes, flash mobs, power grid failures, earthquakes, forest fires, heart attacks, urban growth and even citations, are all exemplars of the ubiquitous complexity that characterize the signature events in our lives. The simplifying assumptions of normalcy, linearity, continuity, stability, ergodicity, and many others, central to modern science, are no longer tenable and require re-examination. A number of attempts have been made to develop new ways of doing science, which are respectful of the complexity of the phenomena being studied. Examples of such efforts that come to mind include Cybernetics, Systems Theory, Catastrophe Theory, Complexity Theory, Nonlinear Dynamics and their subsequent generalizations. The common element of these and other such efforts is the recognition that complex phenomena, whether natural or artificially constructed, ought to be treated as a whole and not selectively dissected and once understood, stitched back together. This talk does not seek to accomplish this Herculean task, but has the more modest goal of juxtaposing a few of the disparate contributions, made by a number of gifted scientists, into a single strategy for gaining understanding and acquiring a new kind of knowledge; one in which the qualitative can be, and often is, as important as the quantitative. This strategy is an application of da Vinci's approach to understanding and it forms the basis of *Tomorrow's Science* (a new book by the speaker), which in reality is five centuries old. Just as Newton's calculus replaced the geometric description of mechanical phenomena, a more general calculus is necessary to replace the fractal geometry of complex phenomena and this requires a new way of thinking. The fractal trajectories of complex dynamics are non-differentiable, and averages over ensembles of such trajectories are described by fractional derivatives of probability densities, in space, in time, or both. The solution to the fractional phase space equation is an inverse power-law probability density function, which describes all the phenomena mentioned earlier and many more. However, rather than focusing on mathematical formalism, this talk addresses the meaning of the mathematics and attempts to answer the question: Why is the fractional calculus entailed by complexity?

Biography

Bruce J West is the Senior Scientist Mathematics (ST) in the Army Research Office of the Army Research Laboratory. He was elected as a Fellow of American Association for the Advancement of Science in 2012; and received the Presidential Meritorious Rank Award in 2012; Army Samuel S. Wilks Memorial Award 2011; Army Research and Development Achievement Award 2010; ARL Publication Award in 2003 & 2010; Professional of the Year in Applied Physical Science & Mathematics 2009 & 2011, Cambridge Who's Who; Chair 2010-12 Army ST Corps; Commander's Award for Civilian Service 2010; Founding Editor-in-Charge of *Frontiers in Fractal Physiology* 2010; Fellow of the American Physical Society since 1992; past chair of the ARL Fellows; Member of the American Association for the Advancement of Science, American Geophysical Union, American Physiological Society and the American Physical Society. He authored over 300 peer reviewed journal articles and 17 books garnering over 16,000 citations resulting in an h-factor of 61.

bruce.j.west.civ@mail.mil