Emerging Research Fronts in Nonlinear Science

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Abstract. This is a welcome address presented at 2007 International Symposium of Nonlinear Dynamics, 27-30 Oct., 2007, Shanghai, China, outlining emerging research fronts in nonlinear science including 1) complexity and nonlinear dynamics; 2) fractals; 3) turbulence; 4) E-infinity theory; and 5) analytical methods.

I am immensely pleased and honored to welcome you to Shanghai, which has been developing very fast, and will be strongly impressed on your memory.

2007 ISND is organized as a preeminent event for nonlinear science community and other science communities as well. It is a great pleasure and honor for Donghua University to host this very important conference.

The goal of this conference is to bring together the researchers from academia and industry to share ideas, problems and developments related to the multifaceted aspects of nonlinear dynamics, thereby capturing both the interest and imagination of the wider communities in various fields, such as in mathematics, physics, information science, computational science, biologics, medicine, and others.

The 2006 Impact Factors released by ISI brought the good news that most nonlinear journals are now being cited more than ever, reflecting the increasing awareness, visibility and importance of nonlinear sciences and revealing that the nonlinear science revolution did not wither way, but may have just started with profound applications in all ramifications of science and technology.

Triumph of Nonlinear Science

In recent years, nonlinear science has had quite a triumph in all conceivable applications in science and technology, especially in high energy physics and nanotechnology. Some of the most fundamental theories can be explained with considerable ease and elegance using nonlinear science. For instance COBE, which was awarded the physics Nobel Prize in 2006, might be probably more related to Nonlinear Science than the Big Bang Theory.

Similar to the nuclear age, the so-called nanoage is coming, the growing gap between nano have and nano have-nots, however, will remain, as has global competition. We are only just beginning to understand the depth and complexity of how nano-material behaves unusually well in many aspects, for example remarkable strength, high surface energy and surface reactivity, excellent thermal and electric conductivity, and to consider their roles in the scientific and economical revival, especially of the developing world. To explain the many fascinating phenomena arising in the big world of nano material, we should develop a new theory linked to both deterministic classic mechanics and chaotic

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quantum mechanics. There should be a law controlling the change from a classical object like a stone to a quantum object like an electron. Somewhere between these two scales these changes happen, but this does not happen suddenly. There is a grey area between these two scales which is neither classical nor quantum. And E-infinity theory provides a strong candidate theory to deal with this grey area. In experiment, we found an uncertainty phenomenon, which is similar to Heisenberg’s uncertainty principle in quantum mechanics, this is because, for example, the electrospun nanofibers are closer in scale to the quantum world than to the ordinary world, they frequently display quantum-like properties and have many fascinating nano-effects. Using these properties raises the potential of nanotechnology to make things possible at the nano level that are impossible at the level of the visible world. Nature’s principle might be deceptively simple, and we might marvel that use of nonlinear science can extremely simply and remarkably elegantly characterize complex systems. Take for example, the absolute zero temperature as derived by E-infinity

\[ T_0 = (4)(10)(1/\phi)^4 - 1 \text{ K} \]

or the mass of an expectation proton is

\[ m_p = (20)(1/\phi)^8 \text{ Mev}. \]

where \( \phi = (\sqrt{5} - 1)/2 \) is the golden mean. Then one notices that nonlinear dynamics is truly the way for standard nonlinear physics.

**E8: Bigger than the Human Genome**

Mathematicians have mapped the inner workings of one of the most complicated structures ever studied: the object known as the exceptional Lie group E8. This achievement is significant both as an advance in basic knowledge and because of the many connections between E8 and other areas, including string theory and geometry.

E8, however, can be explained in a deceptively simple and remarkable intuitive way by E-infinity theory.

I would like to introduce here five categories of nonlinear subjects which have been and will continue to be immensely important in science and technology.

1. **Complexity and Nonlinear Dynamics**
   First I must mention the work of Mitchell Feigenbaum, who laid the foundations for studying universalities. His fundamental work has proven to be incredibly significant in so many fields ranging from the stock exchange to fluid turbulence and lately, as pointed out by El Naschie in quantum field theory. Very recently El Naschie gave some fundamental and interesting connections between Feigenbaum’s golden mean renormalization group and turbulence on the one side and high energy particle physics on the other.

2. **Fractals**
   Second we have the work of Benoit Mandelbrot who single handedly revived the theory of transfinite geometry which he called fractals. Without Mandelbrot the work of Cantor, von Koch and Menger would have remained unknown for many decades and would never have found their way to physics and changed our view of fundamental things like space and time as can be seen from the amazing Cantorian spacetime theory proposed by M.S. El Naschie.

3. **Turbulence**
   The third category of nonlinear science is related to the modern work of D. Rouelle and F. Takeus on turbulence. Turbulence is one of the most difficult problems in science and engineering and suffice to know that the great Werner Heisenberg was quite capable of solving quantum mechanics but had great difficulties with fluid turbulence. E-infinity theory now sheds light on this problem.
4. E-infinity Theory
The fourth group is the application of the new deterministically chaotic mechanics and its associate fractal geometry to fundamental problems in quantum physics. As stated by NOBEL LAUREATE Gerhardus ‘tHooft discrete space time may be the most radical and logical viewpoint of reality. Unfortunately most mainstream physicists are unwilling to adopt the picture that space and time consist of a collection of isolated points, where particles can be only on those points, but not in between. E-Infinity theory extends this notion to a transfinite setting where the collection of points can mimic the continuum. Such a collection of unaccountably infinite set of points is said to possess the cardinality of the continuum and as such it is a compromise between the discrete and the continuum. The main application of E-infinity theory shows miraculous exactness, especially in predicting the theoretically coupling constants and the mass spectrum of the standard model of elementary particles. This theory is the only theory which explains why the COBE curve is the way it is. These results were published some 10 years ago but clearly they did not get the attention which they should have received and my guess is that this is because the papers were published in a nonlinear journal rather than the traditional mainstream journal of physics. In fact this theory makes many fundamental predictions and not only the one we have just mentioned. Furthermore, using this theory you can argue for the possible existence of a fractal quantum Hall effect. The mathematical structure of El Naschie’s theory is based entirely on the infinite dimensional but hierarchical Cantor sets which are the backbone of nonlinear dynamics and the essence of fractals. Using this theory many scientists, for instance Tanaka in Japan was able to predict the mass spectrum of the standard model with incredible accuracy in addition to predicting all the fundamental constants of nature as shown in the work of El Naschie and his associates.

5. Analytical Methods
Last but not least I should mention some useful tools for nonlinear sciences. Discovery of Neptune and Pluto was made by the perturbation method. It is often useful to solve a nonlinear equation arising in physics, so that its physical understanding can be fully revealed. Among various methods, perturbation method is widely used for this purpose, but the obtained results often deteriorate quickly as the degree of nonlinearity increases. Consequently, if we are really determined to extract meaning from analytic formulations of physical processes, we must resort to amelioration of the classical perturbation methods using modern mathematical tools, such as calculus of variation, homotopy technology, and others.

Recently some novel analytical methods have appeared, such as the variational iteration method, the exp-function method, to mention a few.

Hereby, I should express my thanks to Donghua University for their sponsorship of this conference. It is my greatest honor to invite Prof. Andrew N. Cleland and Dr. Hao Fong to give our audience important plenary lectures, which present an overview of the current status of their fields with a speculative outlook on what are to come out in the future, making the conference accessible to a broad audience.

I also appreciate very much all reviewers for their time and help and mini-symposium organizers, without their help, the success of the conference will be impossible.

As pointed out by Einstein, “The most incomprehensible thing about the world is that it is at all comprehensible”, but how do we fully understand incomprehensible things? This conference provides various useful clues. I can ensure you that it will be a mathematically enriching and socially exciting event.

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