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Editorial: Analytical methods for nonlinear oscillators and solitary waves

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Editorial on the Research Topic
Analytical methods for nonlinear oscillators and solitary waves

1 Introduction

Physics is mathematical, new physical phenomena require new mathematical tools. This Research Topic is an attractive introduction of some new mathematical concepts, e.g., the two-scale fractal geometry, the fractal-fractional models, the homotopy perturbation method and the frequency formulation appliable to physics. The new findings of physical phenomena using the new mathematical tools have excited physicists with their potential to reveal secrets in physics and have triggered new research frontiers in physics. Here is an overview of the Research Topic.

2 Fractional soliton vs. fractal soliton

Fractional soliton is a new concept in mathematics, in this paper, Zeng et al. studied the fractional Kdv–Burgers equation to reveal that the soliton profile is not function of t and x, but t^{η} and x^{η}, where η is the fractional order.

Fractal soliton, on the other hand, is a solitary wave moving along an unsmooth boundary or through a porous medium [1]. When an attosecond electron beam is trapped in and propagate with the laser pulse, the travelling solitary wave can be modelled in a fractal space [2], and the attosecond physics won 2023 Nobel Prize in Physics [3]. Discontinuous time appears on an attosecond (10^{-18} s) scale, so fractal time has to be adopted [4, 5], and pinpointing the fractal dimensions is tricky, especially when the studied system has not

seeming self-similarity, now He-Liu's fractal dimensions formulation [6] makes the fractal theory accessible to porous media and discontinuous time.

3 Fractional vibration vs. fractal vibration

The fractional calculus can also be applied to model the memory property of a damped vibration system. In this paper, Zhang et al. studied a fractional stochastic vibration system by taking full advantage of the memory property of the Caputo fractional derivative.

A fractal vibration system, on the other hand, works in a fractal space. The fractal vibration theory allows scientists to insight into the vibration properties on a molecule scale. The traditional vibration theory cannot model the effects of molecules or nanoparticles' size and distribution in air on the vibrating properties. Tian et al. [7] considered the effect of the air pollution on the operation of the MEMS system, and concluded that the fractal dimensions can be used for controlling the pull-in instability. In this paper, Lin and Li applied the fractal vibration theory to elucidate the ions release mechanism instead of the traditional diffusion process, opening up a flood of promising opportunities to design new hollow fibers.

4 Homotopy perturbation method

The homotopy perturbation method (HPM) was proposed by Ji-Huan He [8], a heuristic review on the method is available in Ref. [9]. In an interview with ScienceWatch.com on February 2008, Ganji http://archive.sciencewatch.com/dr/fbp/2008/08febfbp/08febGanji/ emphasized the homotopy perturbation method (HPM), "wherever a nonlinear equation is found, Dr. He's HPM will be the primary tool of discovery," and he further concluded, "He's homotopy perturbation method itself is mathematically beautiful and extremely accessible to non-mathematicians." In the last two decades, Dr. Ganji's prediction is coming true. There are many modifications of the homotopy perturbation method, among which He-Laplace method is extremely suitable for fractional calculus [10–12], and Li-He's modified homotopy perturbation method [13–15] for forced oscillators.

In this paper, Qayyum et al. found that the homotopy perturbation method is extremely suitable for the search for fractional soliton solutions, Tao et al. coupled the Aboodh transformation with the homotopy perturbation method, a new hope for fractional calculus, Buhe et al. applied the method to study forest resource and there is the possibility to extend it to other natural resources, especially the grassland resources.

5 Frequency formulation

The simpler is the better for most physical problems. So far the simplest approach to a nonlinear oscillator is He's frequency formulation [16–18]. There are many modifications, the most famous one is the Hamiltonian-based frequency-amplitude formulation [19, 20]. El-Dib extended it to time-delayed vibration systems [21]. In this paper, Niu et al. extended the frequency formulation to fractal–fractional non-linear oscillators.

6 Concluding remarks

This Research Topic of *Frontiers in Physics* consists mainly of a Research Topic of mathematics methods appliable to physics, it is to bring to the fore the many new and exciting applications of some new mathematical theories of the two-scale fractal theory and the fractal-fractional calculus, it can attract much attention from different fields, such as mathematics, physics, artificial intelligence, neural network, computer science, textile engineering, material science and others. We hope that this Research Topic will prove to be a timely and valuable reference for researchers in this Research Topic.

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