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High-order Localized Wave Solutions of the New (3+1)-dimensional Kadomtsev-Petviashvili Equation

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Constructing three-dimensional nonlinear evolution equations and exploring their exact solutions have always been important and open problems in real-world applications. The celebrated Korteweg-de Vries equation [KdV] and Kadomtsev-Petviashvili [KP] equation are typical examples of one-dimensional and two-dimensional integrable equations respectively. A natural issue is whether there are integrable analogs of these equations in three-dimensional space. In this talk, we give a positive answer. Through special reduction of an (4 + 2)-dimensional KP equation depending on four spatial dimensions and two temporal dimensions, which was introduced by Thanasis Fokas in an early paper [1], a new (3+1)-dimensional complex-valued KP equation is obtained. We show its Lax pair, smooth multi-soliton and high-order breathers by the Hirota bilinear method. Additionally, we also give the high-order rational solutions by using the long wave limit method. Local characteristics and key properties of these localized waves are discussed. Finally, a family of novel semi-rational solutions of the new (3+1)-dimensional complex-valued KP equation are also presented. This talk is based on a joint paper [2] with Thanasis Fokas and Yulei Cao.

References

[1] A. S. Fokas, "Integrable Nonlinear Evolution Partial Differential Equations in 4 + 2 and 3 + 1 Dimensions", *Phys. Rev. Lett.* **96**, 190201 (2006).

[2] A. S. Fokas, Y. L. Cao and J. S. He, "Multi-Solitons, Multi-breathers and Multi-rational Solutions of Integrable Extensions of the Kadomtsev-Petviashvili Equation in Three-dimensions", submitted, May 2022.