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The Hong Kong University of Science and Technology

Department of Mathematics

Seminar in Applied Mathematics

Numerical Methods for Nonlinear Dirac Equations

By

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Abstract

The Dirac equation is a relativistic wave equation in particle physics, formulated in 1928, and describes fields corresponding to elementary spin-½ particles (such as the electron) as a vector of four complex numbers (a bi-spinor), in contrast to the Schrödinger equation which described a field of only one complex value. It implied the existence of a new form of matter, antimatter, hitherto unsuspected and unobserved, and actually predated its experimental discovery.

This talk concentrates on a (1+1)-dimensional nonlinear Dirac (NLD) equation with a general self-interaction, which is a linear combination of the scalar, pseudoscalar, vector and axial vector self-interactions to the power of the integer k. The solitary wave solutions to the NLD equation are analytically derived, and the number of solitary humps in the charge and energy densities is proved in theory. The results show that for a given integer k, the number of solitary humps for the charge density is not bigger than 4, while the number of solitary humps for the energy density is not bigger than 3.

This talk also presents some numerical methods for NLD equation and a careful numerical study of the interaction dynamics for the solitary waves of nonlinear Dirac equation with scalar self-interaction by using a fourth order accurate Runge–Kutta discontinuous Galerkin method and the phase plane method. Some new interaction phenomena are observed: (a) a new quasi-stable long-lived oscillating bound state from the binary collisions of a single-humped soliton and a two-humped soliton; (b) collapse in binary and ternary collisions; (c) strongly inelastic interaction in ternary collisions; and (d) bound states with a short or long lifetime from ternary collisions.

Date : ***Wednesday, 17 August 2016***

Time: ***11:00 a.m. – 12:00 a.m.***

Venue: ***Room 3494, Academic Building (near Lift 25&26), HKUST***

All are welcome!