PhD Dissertation Defense

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TITLE: Classification and Analysis of Rational Lump Solutions to the Kadomtsev-Petviashvili I Equation

ABSTRACT:

The Kadomtsev-Petviashvili (KP) I equation is a 2+1-dimensional nonlinear partial differential equation which describes propagation of small-amplitude quasi-two-dimensional dispersive waves. They are known to model ion-acoustic waves in plasmas and shallow water waves.

Mathematically, the KP equation belongs to the special class of completely integrable equations which admit large classes of exact solutions. In this thesis a large family of nonsingular rational solutions of the KPI equation are investigated. These solutions, referred to as lumps, are multi-peaked waveforms localized and decaying in the xy-plane, and are interesting because of their anomalous scattering after collision. A detailed study of the dynamics of these lumps, their interaction properties and long time behavior is carried out analytically, and their stability is investigated numerically. Furthermore, the thesis provides a complete classification of this class of rational solutions by establishing a deep connection between the solution class and the representation theory of symmetric groups and partitions of integers. This relationship is further exploited to explain the richness of the surface wave patterns formed by these solutions, and which are shown to be related to the zero distributions in the complex plane of certain well known polynomials arising in the theory of Painlevé equations.