Multi-scale nature of kinetic solitary waves and double layers: Theory, observations, and simulations

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The vast parameter space of kinetic solitary waves and double layers strongly indicates the multi-scale nature of these nonlinear electrostatic structures. These structures are so weakly constrained that for a fixed potential amplitude, they can exist in size ranging from one Debye length to above hundreds of Debye lengths. We present the first observational evidence of weakly constrained kinetic solitary waves detected by the Polar spacecraft. We show solitary structures observed in the magnetosheaths of Earth, Jupiter, Saturn, and a CME-driven interplanetary shock to further illustrate the diverse characteristics of the structures and the wide plasma regime that supports solitary structures. We discuss how multi-scale solitary structures can impact reconnection current layers. We present simulations of kinetic solitary waves to elucidate their stability in different regions of the parameter space.