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Abstract for an Invited Paper
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**Petascale Kinetic Simulations in Space Sciences: New Simulations and Data Discovery Techniques
and Physics Results**
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Recent advances in simulation technology and hardware are enabling breakthrough science where many longstanding problems can now be addressed for the first time. In this talk, we focus on kinetic simulations of the Earth's magnetosphere and magnetic reconnection process which is the key mechanism that breaks the protective shield of the Earth's dipole field, allowing the solar wind to enter the Earth's magnetosphere. This leads to the so-called space weather where storms on the Sun can affect space-borne and ground-based technological systems on Earth. The talk will consist of three parts: (a) overview of a new multi-scale simulation technique where each computational grid is updated based on its own unique timestep, (b) Presentation of a new approach to data analysis that we refer to as Physics Mining which entails combining data mining and computer vision algorithms with scientific visualization to extract physics from the resulting massive data sets. (c) Presentation of several recent discoveries in studies of space plasmas including the role of vortex formation and resulting turbulence in magnetized plasmas.