

Physics with **SPANDA**: A Rapid Automated Pipeline for Seismic Inference of Red Giants

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Abstract

Red giant oscillations offer an unprecedented window into stellar interiors and galactic history, yet mining these insights across massive space-mission datasets requires scalable, end-to-end spectral modeling. We introduce **SPANDA**, an automated asteroseismic framework constructed for accelerated, high-throughput peak bagging across large red giant cohorts observed by *Kepler*. Structured as a multi-tier hierarchy, **SPANDA** sequentially characterizes granulation backgrounds, acoustic envelope modes, and dense core-probing mixed modes. By fusing global optimization with probabilistic sampling, the pipeline is engineered to exploit modern accelerator architectures, achieving orders-of-magnitude faster execution while comprehensively charting multi-parameter degeneracies. This efficiency unlocks population-scale measurements of internal rotation, modal coupling, and core magnetism across diverse evolutionary stages. Deployed on more than 9,000 *Kepler* targets, **SPANDA** has already demonstrated that granulation and mesogranulation depart from self-similarity, showing decoupled temperature dependencies governed by their respective vertical formation zones. Active downstream investigations encompass systematic censuses of red giant binaries, explorations of suppressed dipole modes, and detections of magnetic asymmetries in stellar cores. Built for robust volume scaling, **SPANDA** provides an adaptive processing engine tailored for upcoming wide-field surveys including *PLATO*, *Roman*, and *Earth 2.0*. In this presentation, I will outline the pipeline’s computational design, benchmark its performance across red giant phases, and highlight emerging astrophysical applications.