LSST TVS Science Collaboration RoadMap Argonne National Laboratory, March 2016Meeting

Pulsating Variables Subgroup

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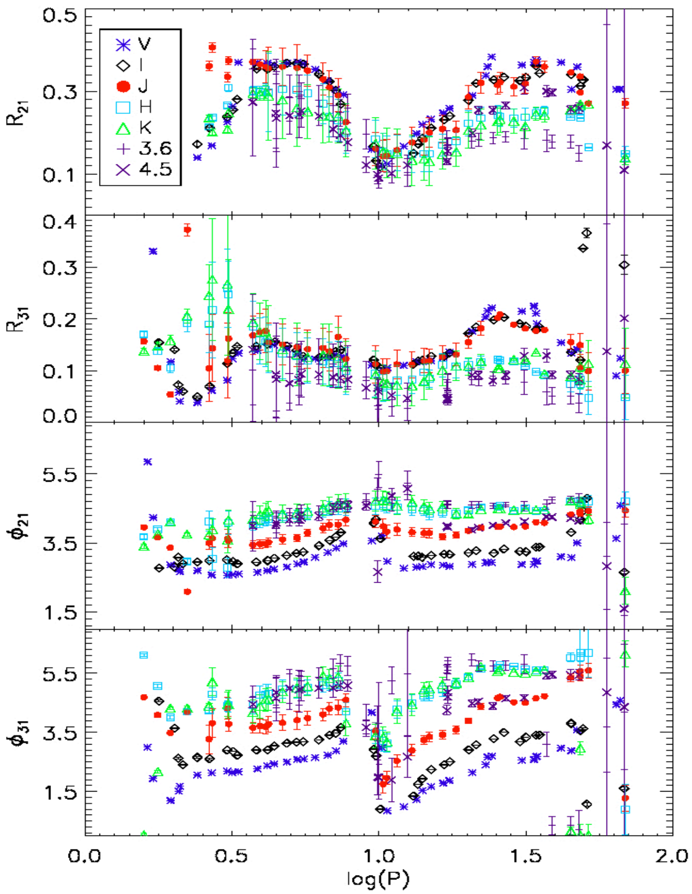
SUNY Oswego

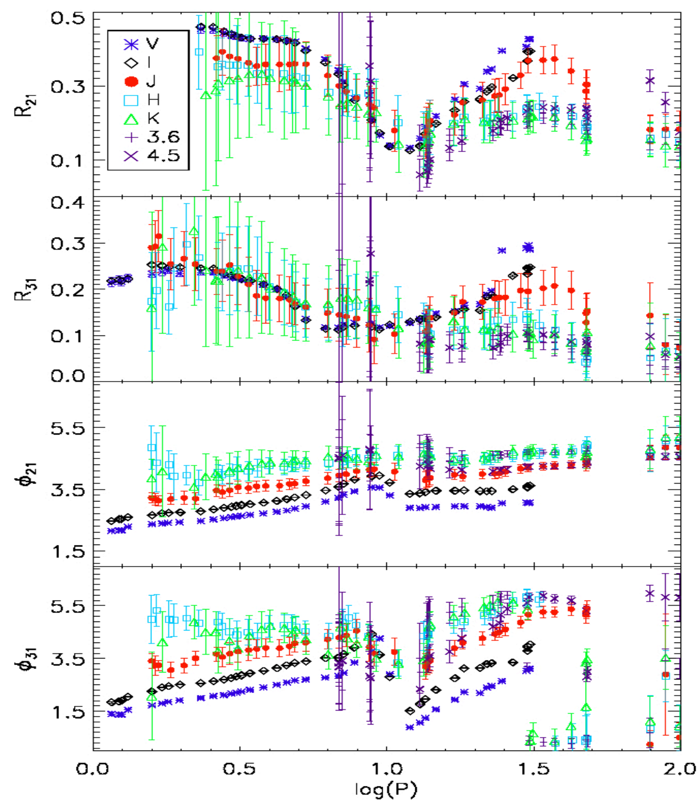
Cepheids and RR Lyraes

- Multiwavelength comparison of light curve structure of theoretical and observed light curves via Fourier decomposition

$$V = A_0 + \sum_{k=1}^{k=N} A_k \cos(k\omega t + \phi_k)$$

Theoretical and Observational Light Curves

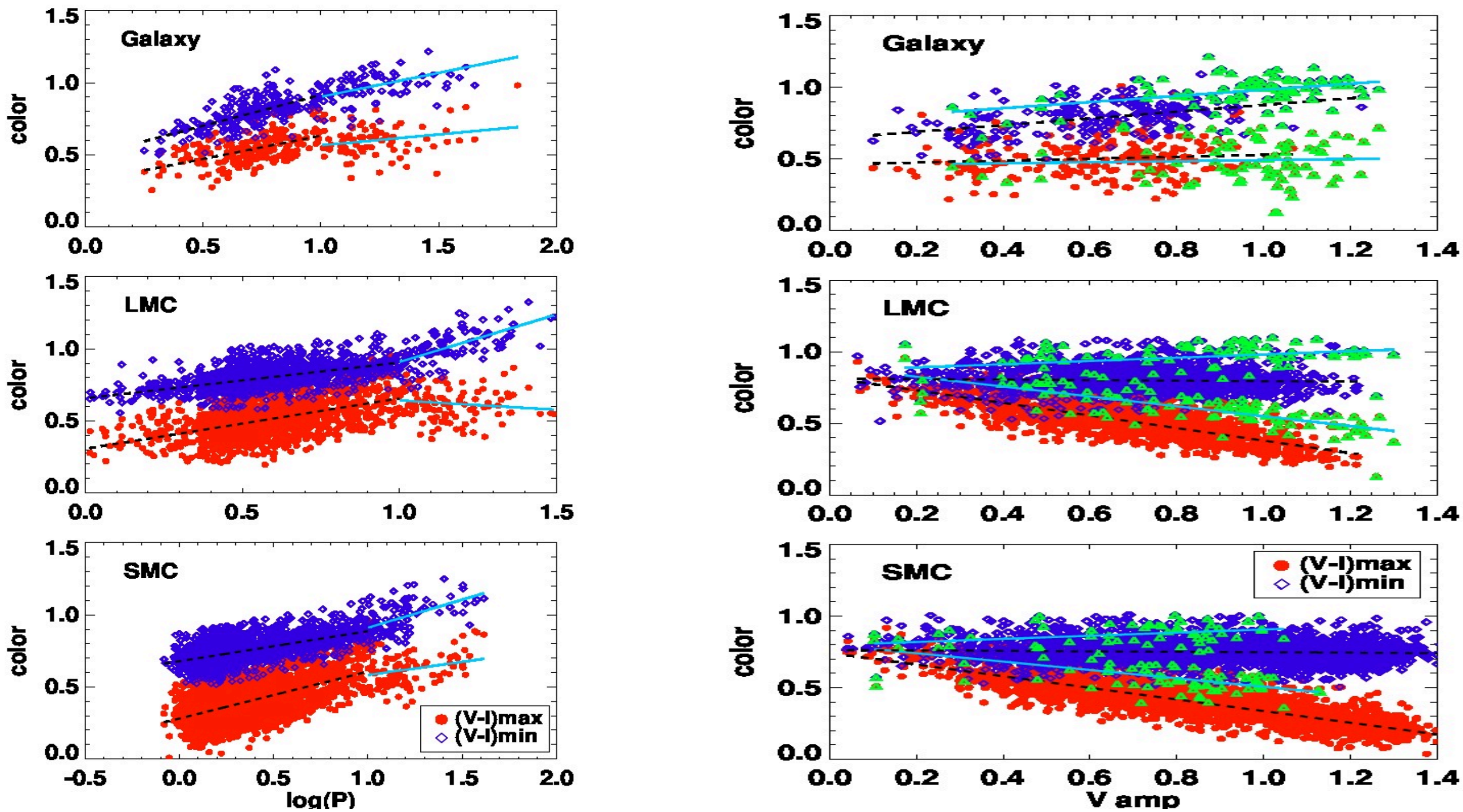




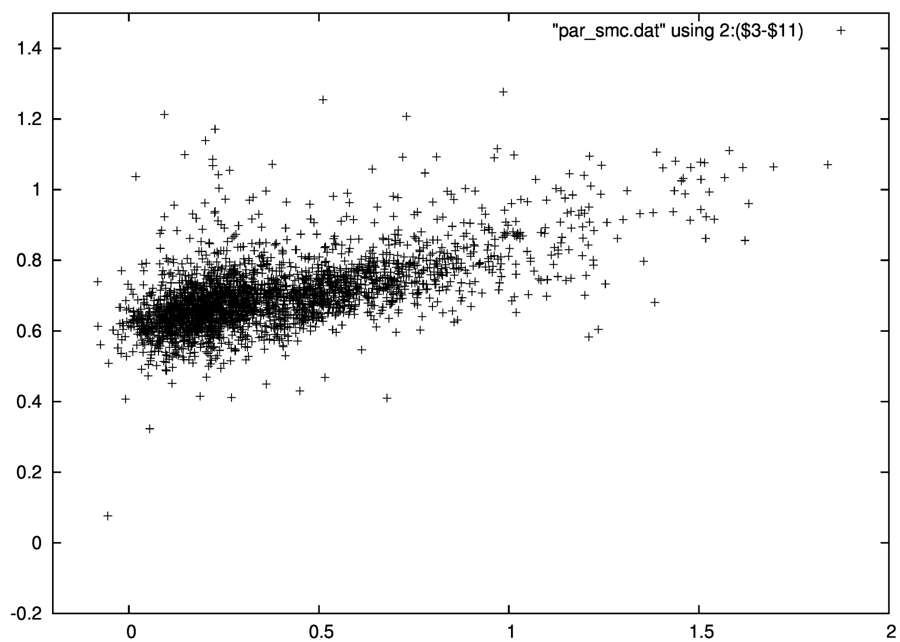
Theoretical and Observational Light Curve Structure

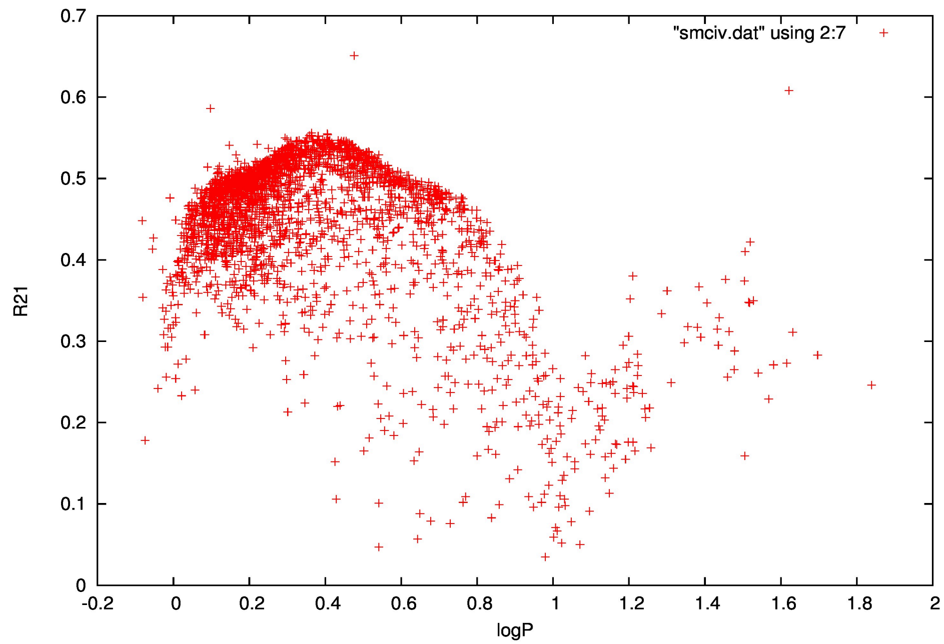
- Place constraints on theoretical models
- Constrain ML relation. This ML relation carries details of evolutionary physics such as amount of convective overshoot.
- Period range where models/light curves agree quantitatively, get distances directly.
- Associate physical parameters with light curve structure parameters
- LSST will be able to augment this plot with many more wavelengths and hence stronger constraints on models
- Multiwavelength observations of Blazhko RR Lyrae

PCAC Relations for Cepheids – Fundamental Mode

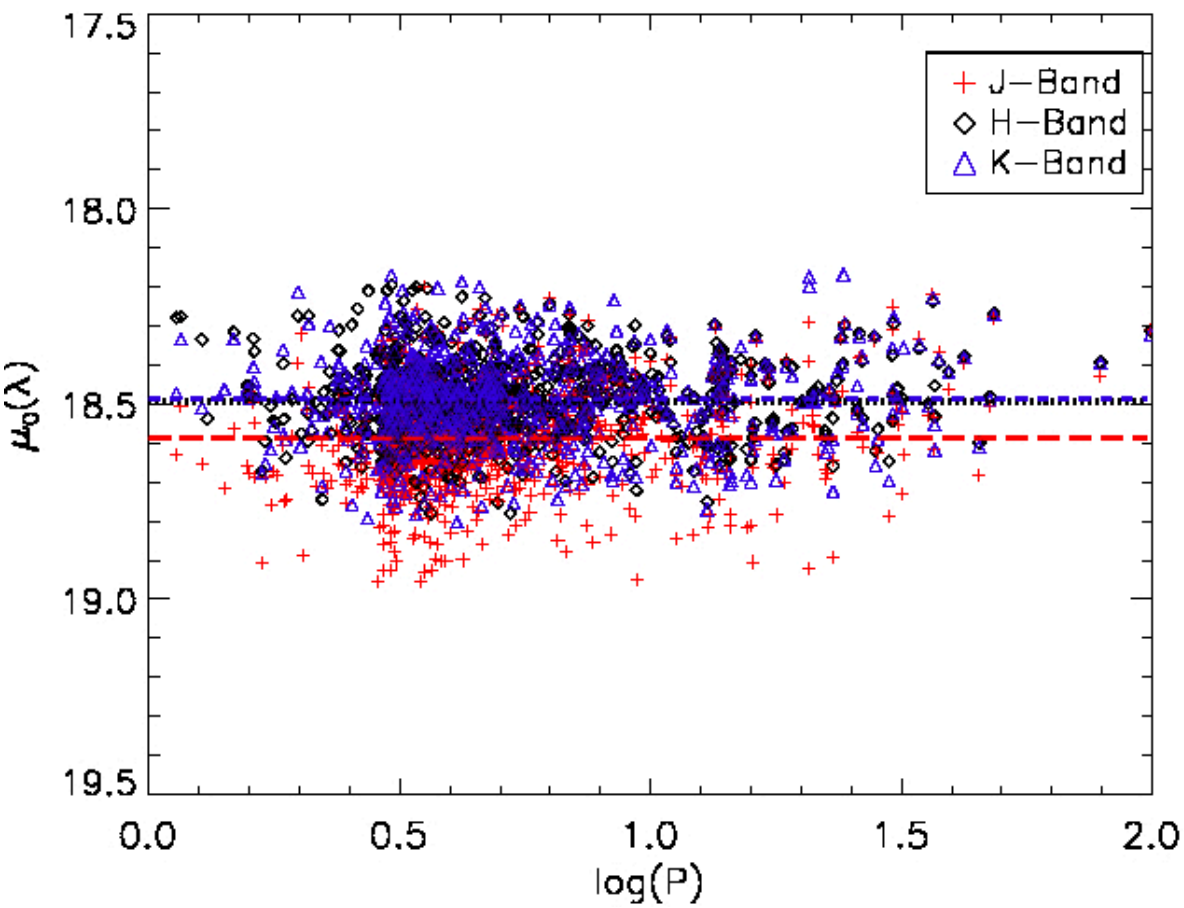


SMC FU PC relation using OGLE III V-I data

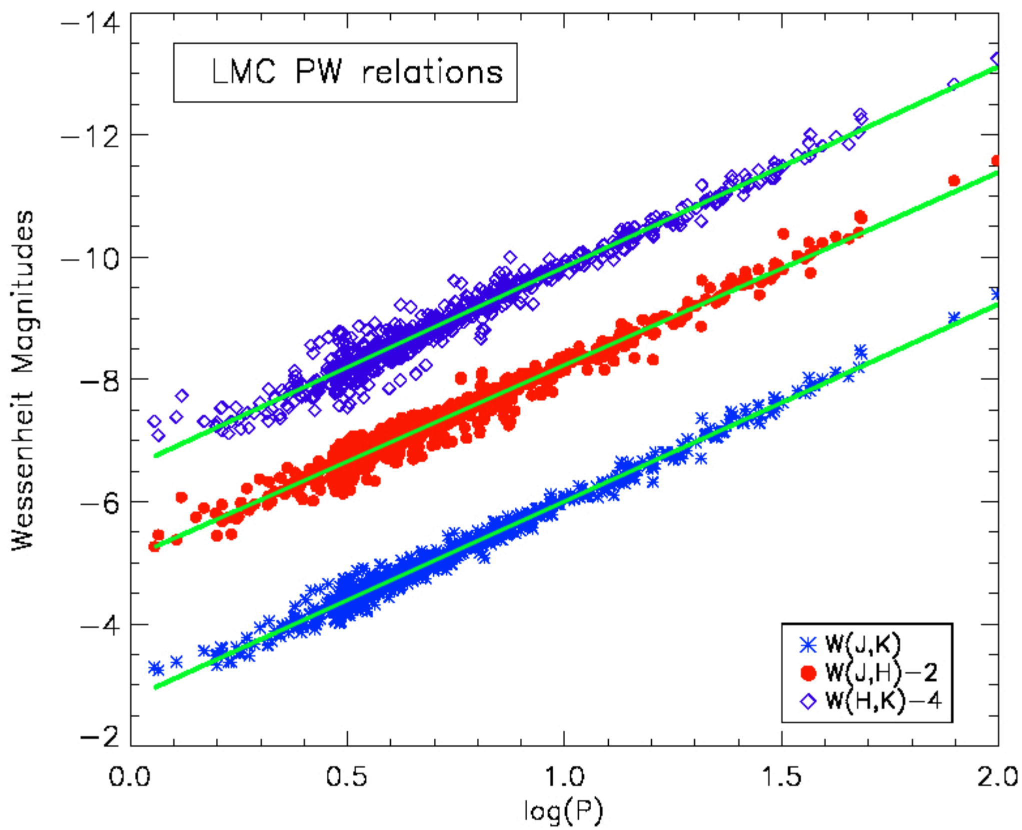




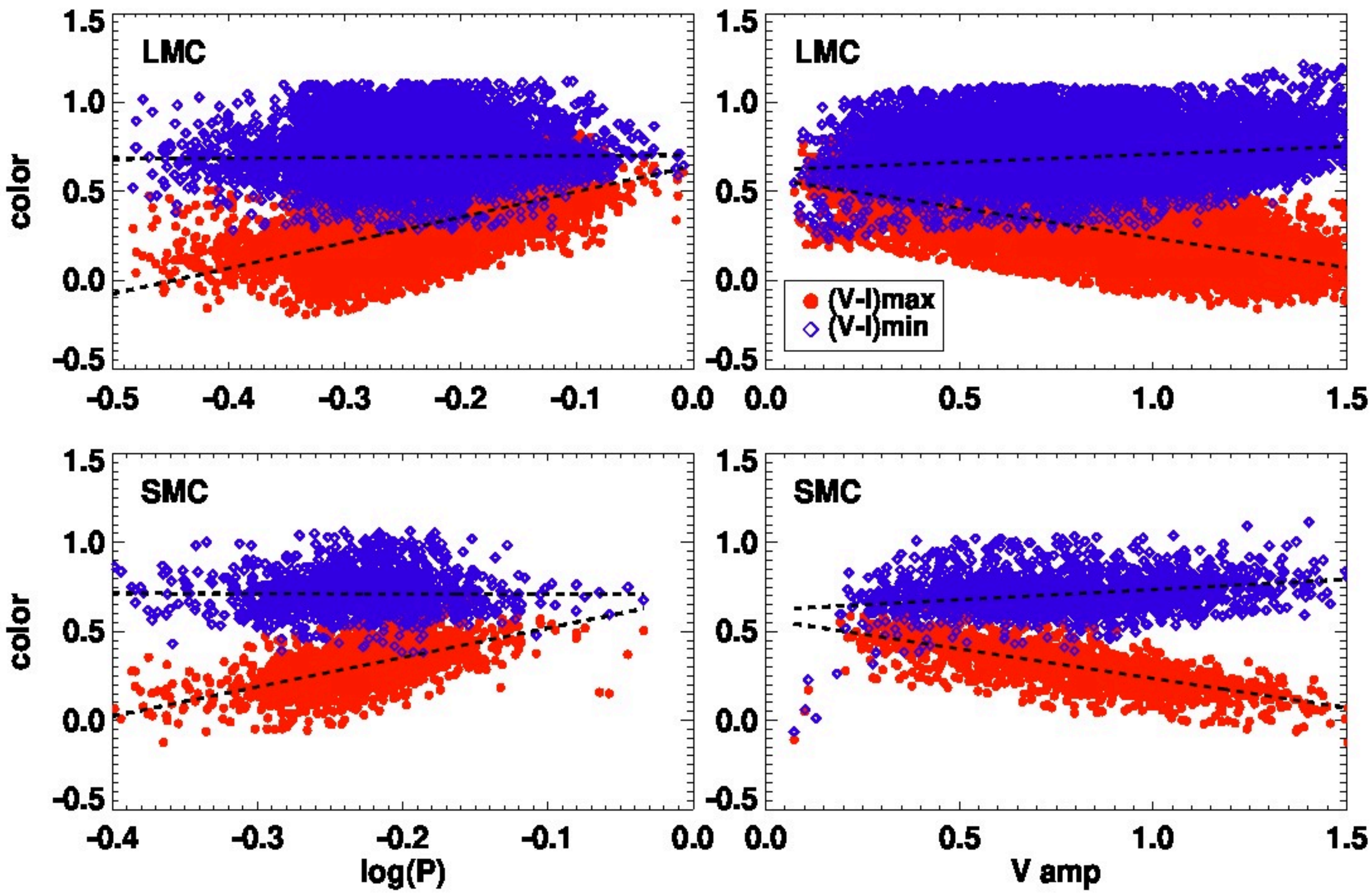
LMC Structure



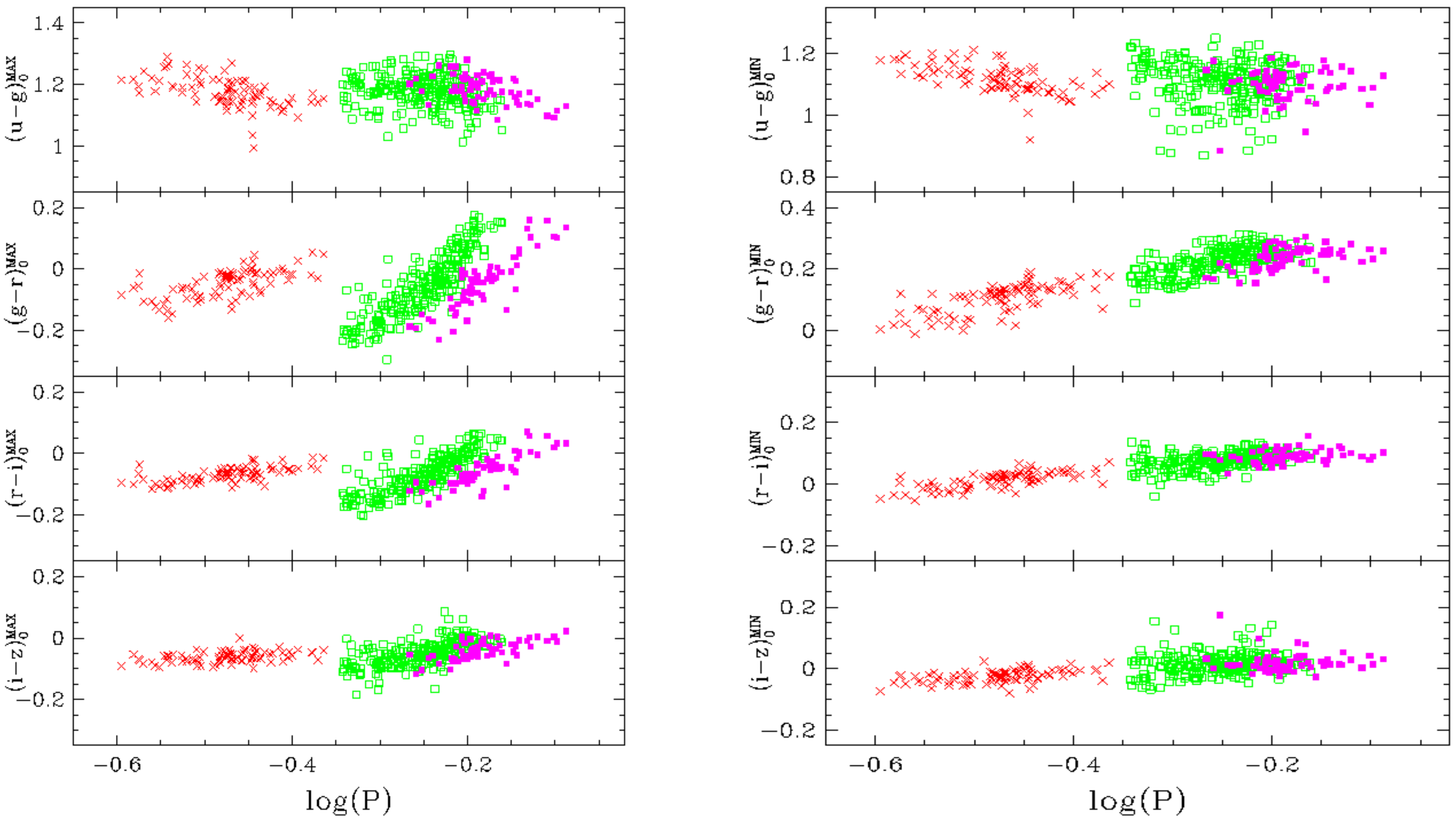
Distance Scales



PCAC Relations for RR Lyraes - Fundamental Mode



RR Lyraes in Sloan Colors



Assignment

- Science Drivers
- LSST increases no. of observation bands – more constraints.
- Observational Challenges – getting sufficient coverage to get accurate light curve structure through Fourier decomposition
- Have MAF working – will explore cadences subsequently.
- Synergy with classification and automation group?

Pulsating Variable Stars

Keaton J. Bell
University of Texas at Austin

LSST TVS Science Collaboration
Roadmap Meeting
Argonne National Laboratory
Thursday 24 March 2016

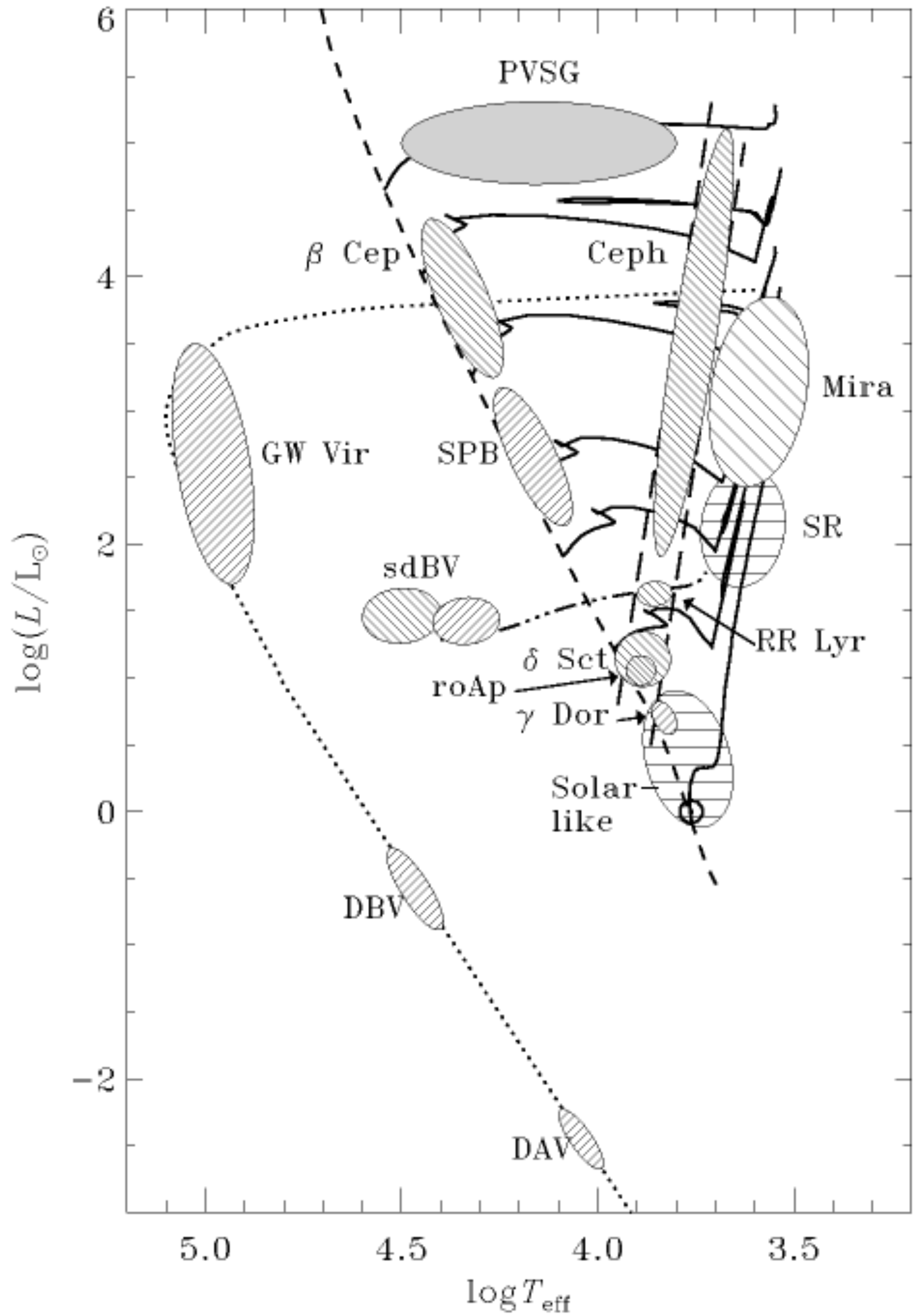
Pulsation
HR Diagram

Asteroseismology (2010)

C. Aerts

J. Christensen-Dalsgaard

D. W. Kurtz

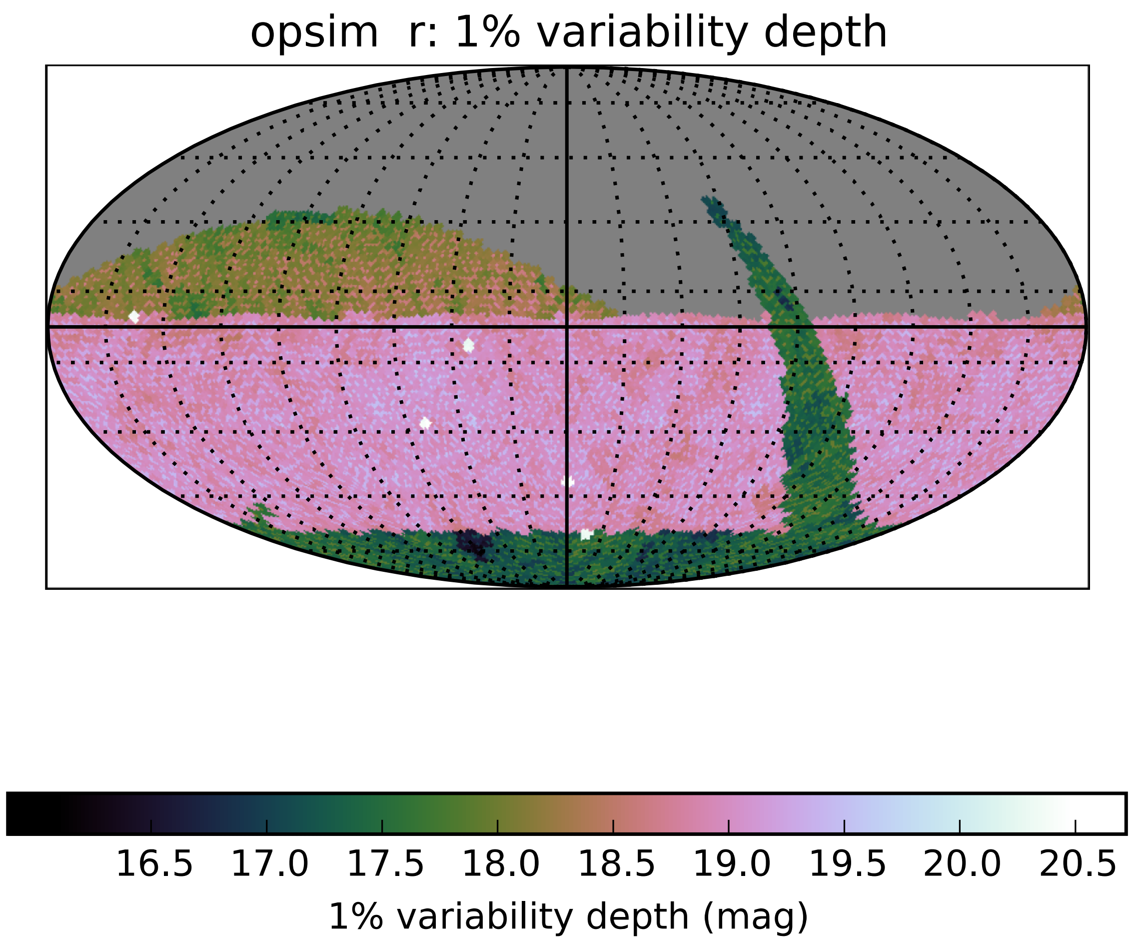


Nonradial Pulsators

- Typically multi-periodic with shorter periods and smaller amplitudes.
- Fourier Transforms of light curves reveal eigenfrequencies of stars as physical systems.
- High duty cycle typically the key to asteroseismology.
  - LSST will *not* have a high duty cycle.
- LSST *will* be a discovery machine.
- Statistical methods must be employed for astrophysics.
  - Understanding of noise characteristics critical.

Recovering low-amplitude variables

- 1% RMS intrinsic variability
- 95% completeness
- 5% False Alarm Rate
- 10-year survey
- r-band *only*

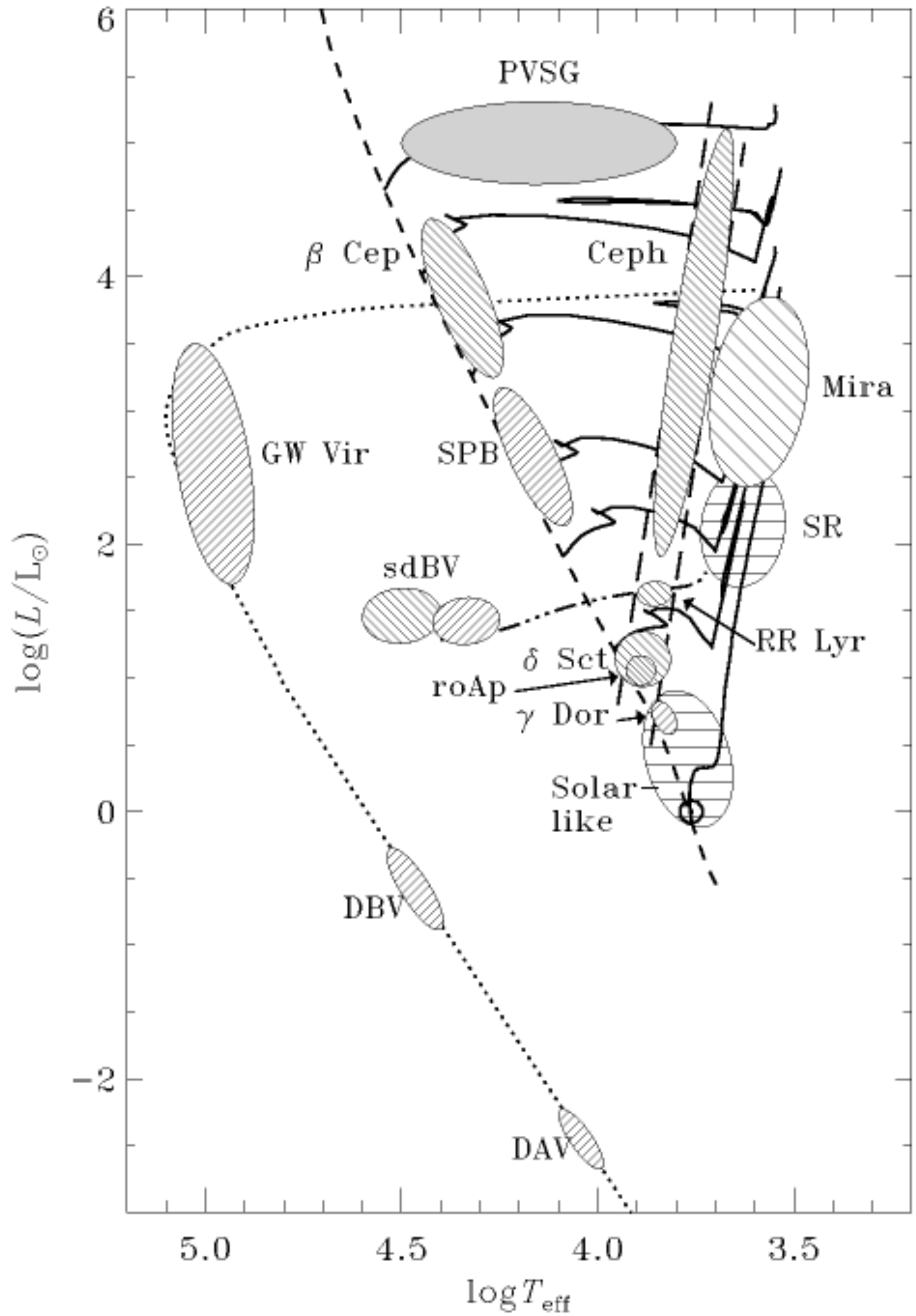


https://github.com/keatonb/sims_maf_contrib/blob/master/science/variabilityDepth/variabilityDepth.ipynb

Pulsation HR Diagram

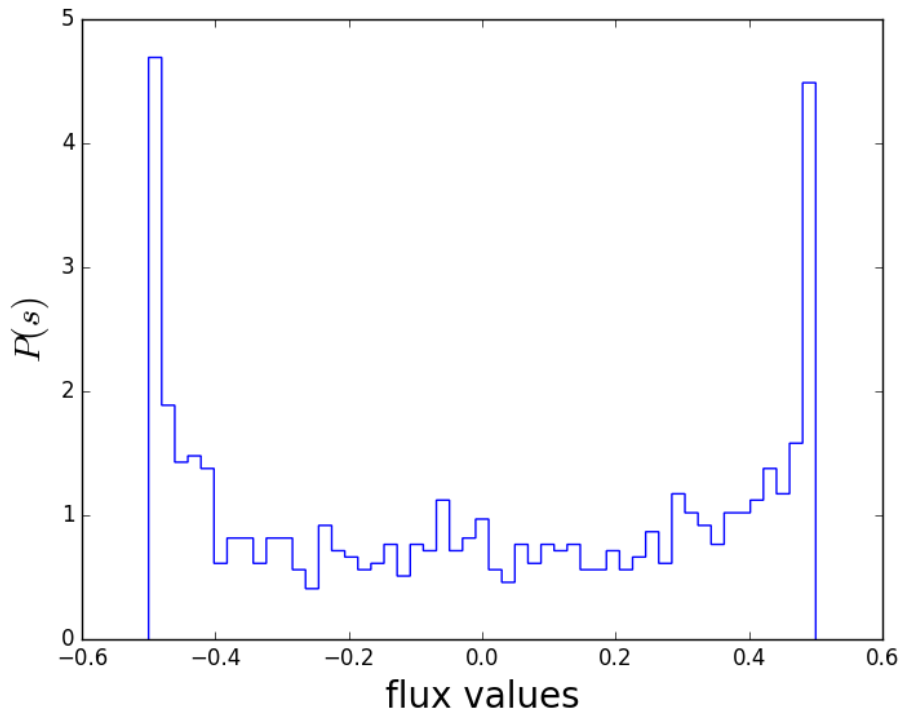
LSST will reproduce this diagram in 6-filter parameter space.

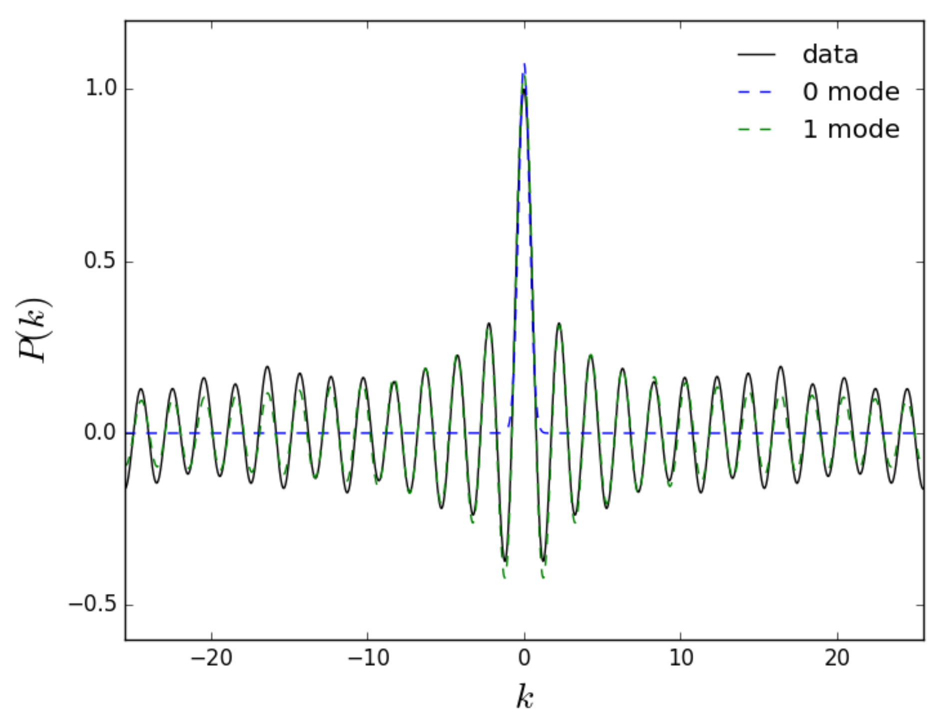
Will yield an extensive catalog of pulsating stars.



Mathematical Tricks

Flux distribution measured randomly in phase Fourier Transforms to product of Bessel functions that gives mode amplitudes.

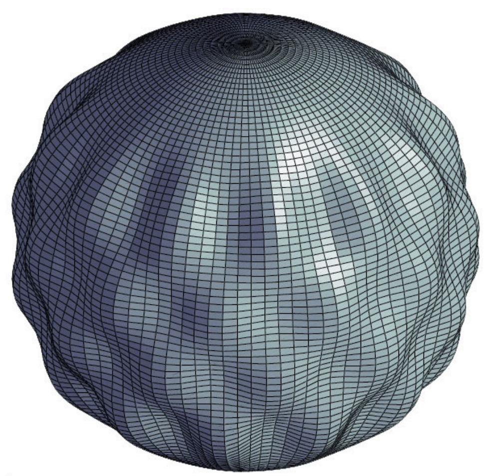




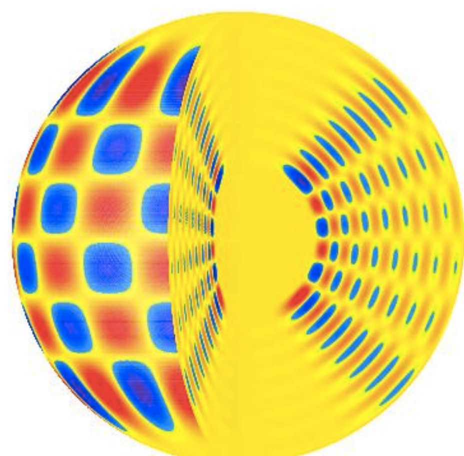
Bell and Montgomery, in prep.

Color Dependence

- Wavelength-dependent limb darkening causes different measured amplitudes in different filters.
- pressure-modes cause greater geometric distortion than gravity-modes.
- LSST *may* be able to determine relative proportions of p- vs. g-modes and different spherical degree (ℓ) pulsations in an ensemble sense.



p-modes



g-modes

Kepler Data as Training Set

- *Kepler* was ideal for pulsating variable stars, but for a limited sample.
- Resampling *Kepler* data at the LSST cadence will inform how well we can recover *Kepler*-quality results with LSST data.