PLATO Complementary Science

website: fys.kuleuven.be/ster/Projects/plato-cs/home

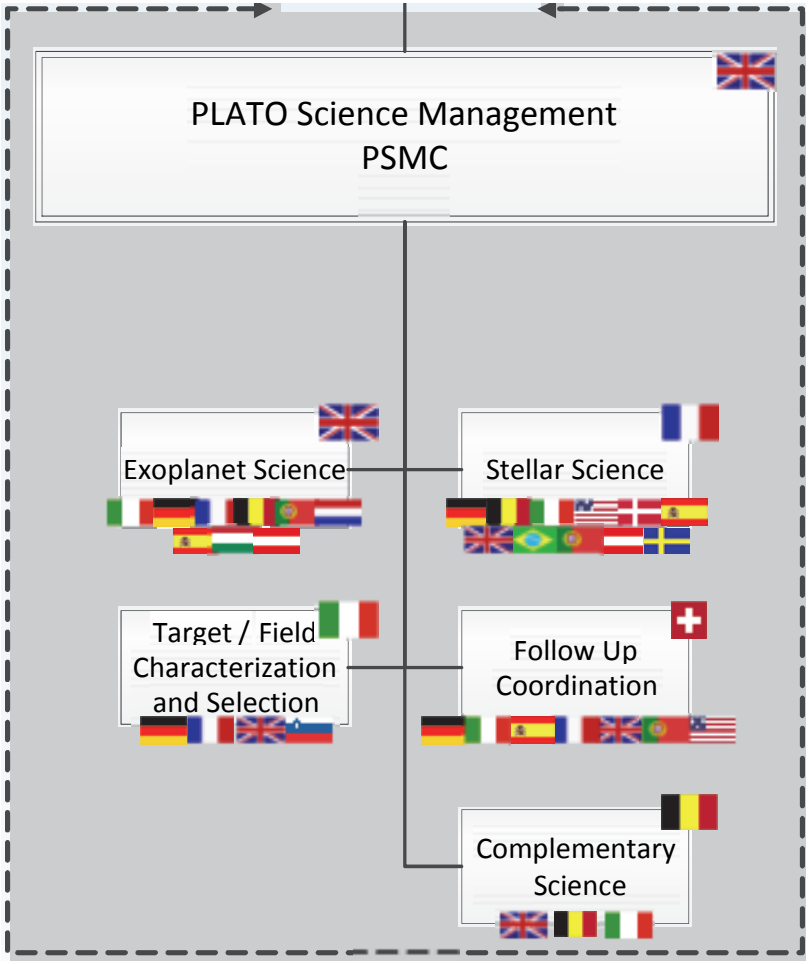
Leuven University, Belgium

Conny Aerts, Andrew Tkachenko, Joris De Ridder, Pierre Royer, Rik Huygen, Bart Vandenbussche

Work Package (WP) leaders

John Southworth (UK), Coralie Neiner (France), Manuel Güdel (Austria), Peter Jonker (Nederlands), Conny Aerts (Belgium), Sergio Simón-Díaz (Spain), Saskia Hekker (Germany), Samaya Nissanke (Nederlands), Ennio Poretti (Italy)

Place within PSM & model philosophy



- Scientific programmes distinct from the Core Science
- Makes sure community is ready for **optimal GO proposal** submission
- **Not a main driver of mission design** (advisory role: fine-tune target/field selection, optimize integration times, etc.)
- **No impact on mission costs** (funding at national/local level)
- **Variability catalogue & data products** through dedicated website

How? PLATO Guest Observer program

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Telemetry for GO: 8% open time

Baseline

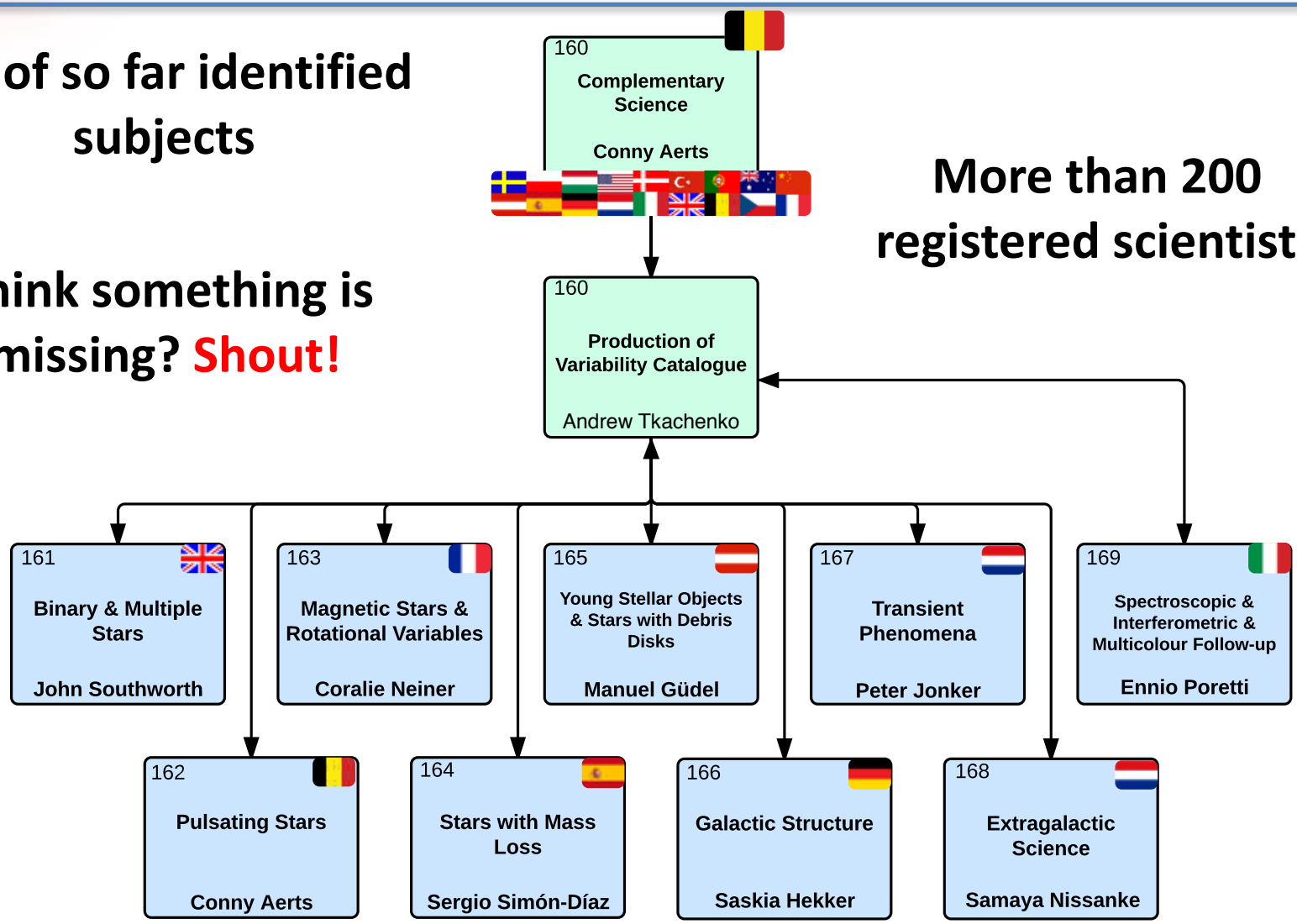
1. ±40 targets/pointing for Fast Cam, observed in 2 colours with cadence 2.5 sec cadence and downloading imagettes
2. ±800 targets/pointing for Norm Cam, observed with cadence 25 sec cadence and downloading imagettes
3. ±39,200 targets/pointing for Norm Cam, observed with cadence 50 sec cadence and downloading onboard processed light curves
4. Target of Opportunity (ToO): no onboard detection but limited to the ”known” sources

PLATO-CS: scientific content

List of so far identified subjects

Think something is missing? Shout!

More than 200 registered scientists



PLATO-CS: scientific content

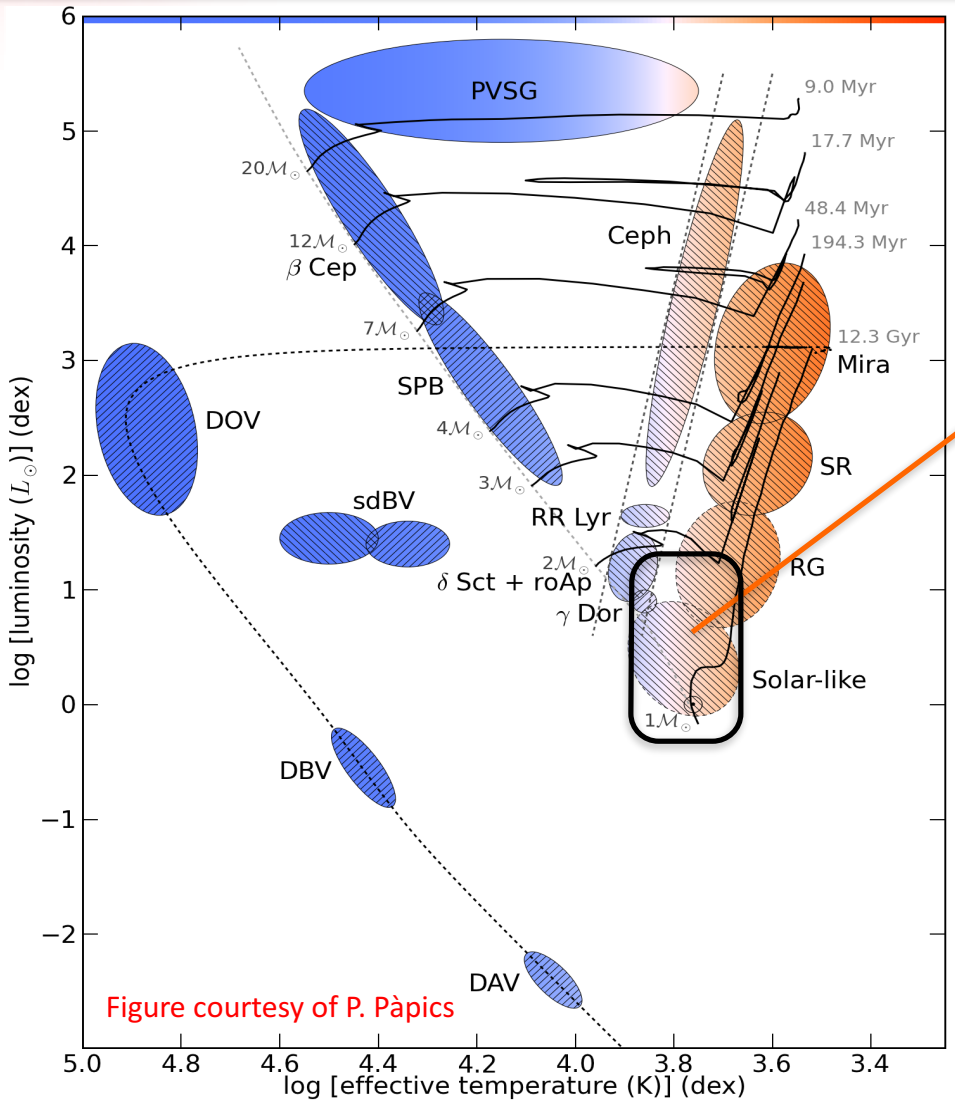


Figure courtesy of P. Pàpics

Core Science only considers asteroseismology of K7-F5 stars

CS treats asteroseismology + magnetism/activity + binarity/tides + rotation + distance scales + galactic archeology from all other classes, including single + binary + cluster stars

Classification

the what and *the* why

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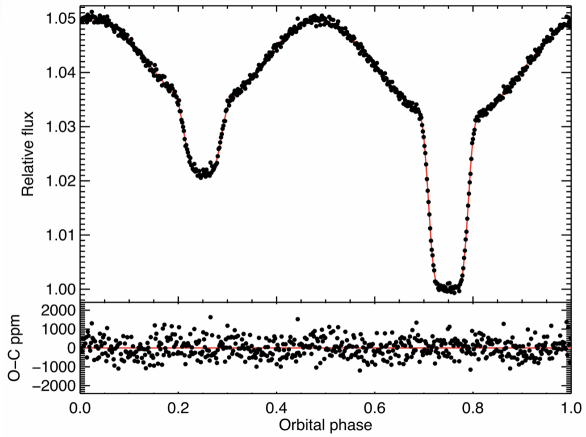
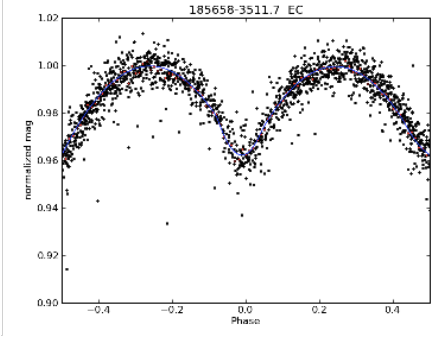
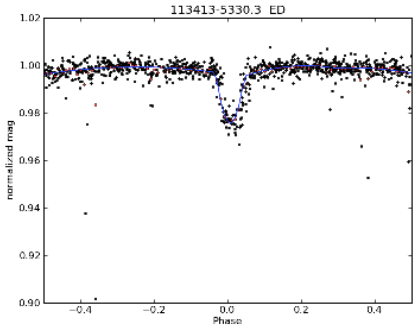
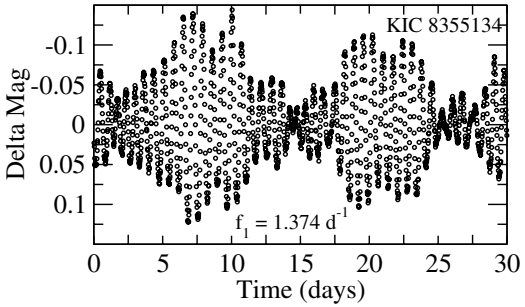
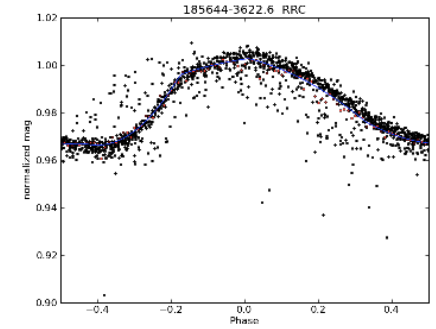
160
Production of Variability Catalogue
Andrew Tkachenko

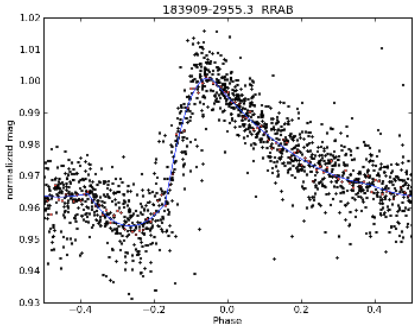


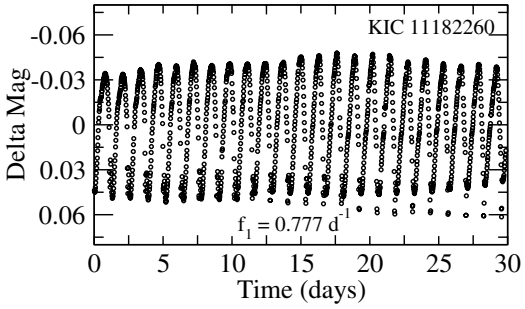


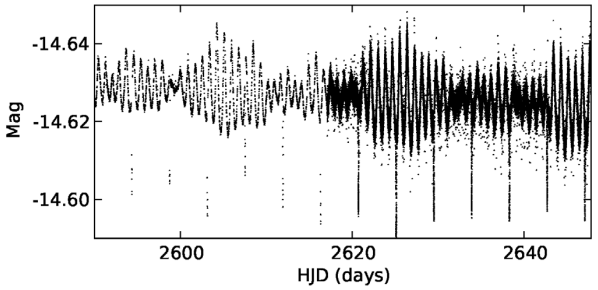


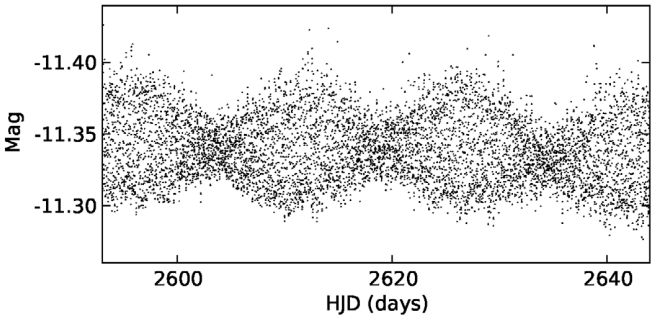






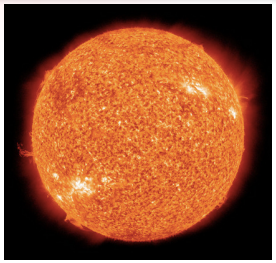


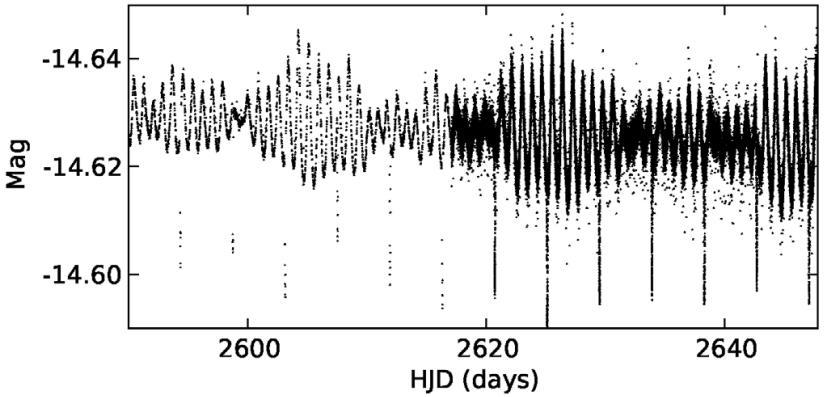




Classification

the how - attributes





ASTROPHYSICAL PARAMETERS:

- Temperature
- Surface gravity
- …

MORPHOLOGY:

- Frequencies & harmonics
- Amplitudes
- Skewness
- …

Classification

supervised vs. unsupervised

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160 Production of Variability Catalogue Andrew Tkachenko

	Supervised (pre-defined set of variability types)	**Unsupervised** (clustering)
Requires **training** set	✓	✗
A priori knowledge available	✓	✗
New variability types can be discovered	✗	✓

Classification
towards a Meta-Classifier

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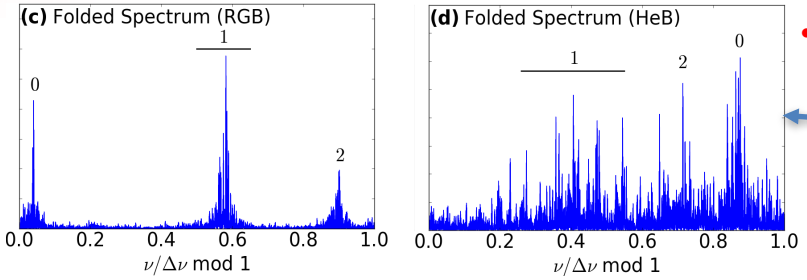
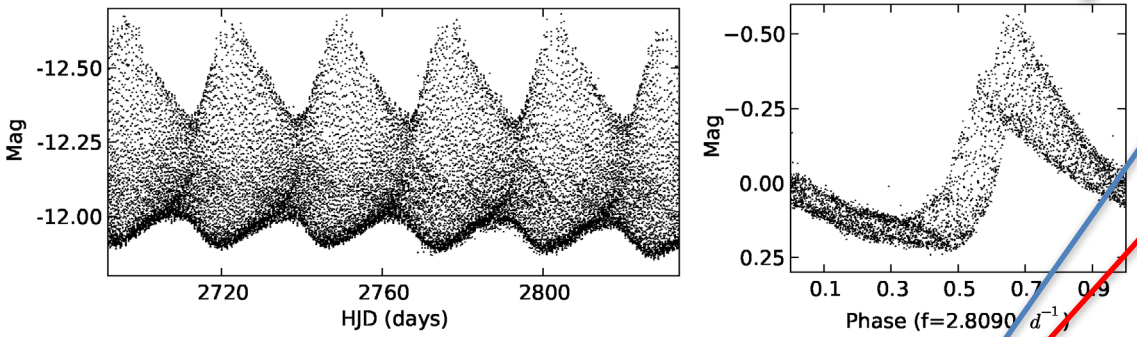
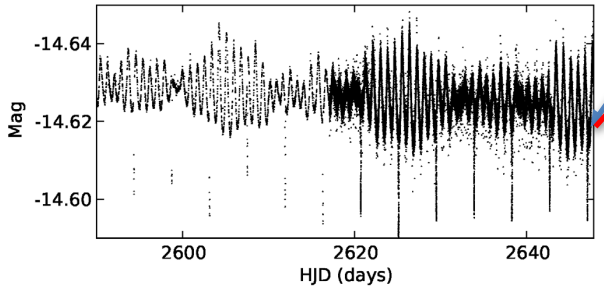
Solar-like pulators



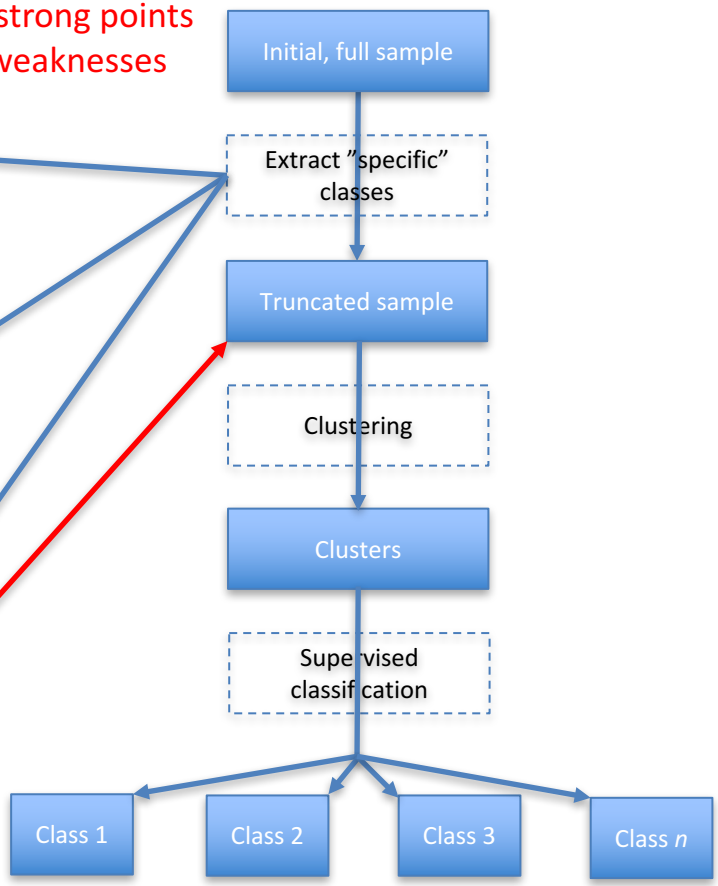
Classical pulators



(pulsators in) binaries

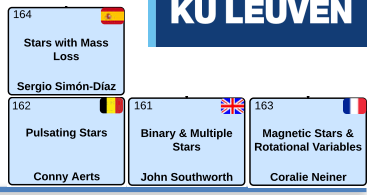


- Combine the strong points
- Mitigate the weaknesses



See also talk on binary classification by B. Debski (Thursday)

Magnetism: fossil fields



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Origin of fossil fields

Magnetized molecular cloud
(remnant of the Galactic magnetic field)

- Young Herbig Ae/Be stars do show magnetic fields ✓
- Occurrence is 7-10 % both on the MS and pre-MS. Why? ✗
- Only 1 binary with both components hosting MF ✗
- 1.5 % of binary systems with magnetic detection ✓

Binary interactions
(mergers and/or mass transfer)

- Population synthesis: 7-10 % are mergers ✓
- Strong differential rotation generates fields ✓
- Blue stragglers: mergers but only 6 % are magnetic ✗
- Magnetic stars in close binaries: survive merging? ✗

Relaxed fields
(dynamo fields during star formation)

- Theory: fields are shaped during early evolution ✓
- Theory: about 7 % of cases gain stability to survive ✓
- Close to 100 % of IMTTS in convective region hold magnetic fields ✓
- About 6 % detection in the radiative region ✓

PLATO-CS: young stars (rotation, seismology), massive stars (rotational modulation, activity, seismology), binary stars (common-envelope, mass-transfer, seismology)

Binary stars
test of stellar evolution

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163 Magnetic Stars & Rotational Variables — Coralie Neiner
162 Pulsating Stars — Conny Aerts
161 Binary & Multiple Stars — John Southworth

THE MASS-RADIUS RELATION OF YOUNG STARS, I: USCOCTIO 5, AN M4.5 ECLIPSING BINARY IN UPPER SCORPIUS OBSERVED BY K2

Adam L. Kraus[1], Ann Marie Cody[2], Kevin R. Covey[3], Aaron C. Rizzuto[1], Andrew W. Mann[1,4], Michael J. Ireland[5]

New Pleiades Eclipsing Binaries and a Hyades Transiting System Identified by K2

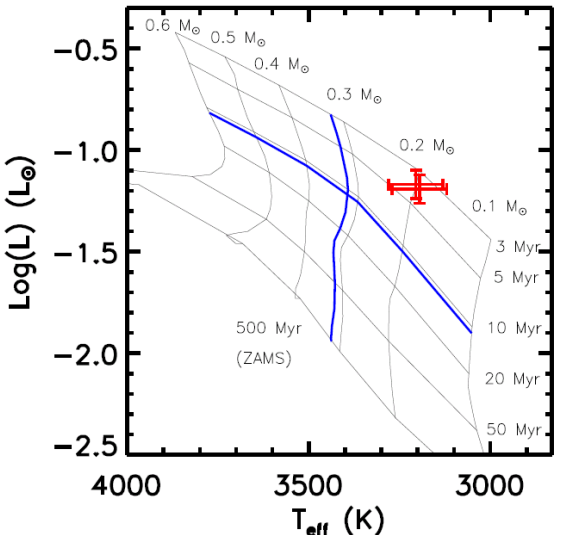
Trevor J. David[1,2], Kyle E. Conroy[3], Lynne A. Hillenbrand[1], Keivan G. Stassun[3,4], John Stauffer[5], Luisa M. Rebull[5], Ann Marie Cody[6], Howard Isaacson[7], Andrew W. Howard[8], Suzanne Aigrain[9]

K2 DISCOVERY OF YOUNG ECLIPSING BINARIES IN UPPER SCORPIUS: DIRECT MASS AND RADIUS DETERMINATIONS FOR THE LOWEST MASS STARS AND INITIAL CHARACTERIZATION OF AN ECLIPSING BROWN DWARF BINARY

Trevor J. David [1,2], Lynne A. Hillenbrand [1], Ann Marie Cody [3], John M. Carpenter [1], Andrew W. Howard [4]

DYNAMICAL MASSES OF YOUNG STARS. I. DISCORDANT MODEL AGES OF UPPER SCORPIUS

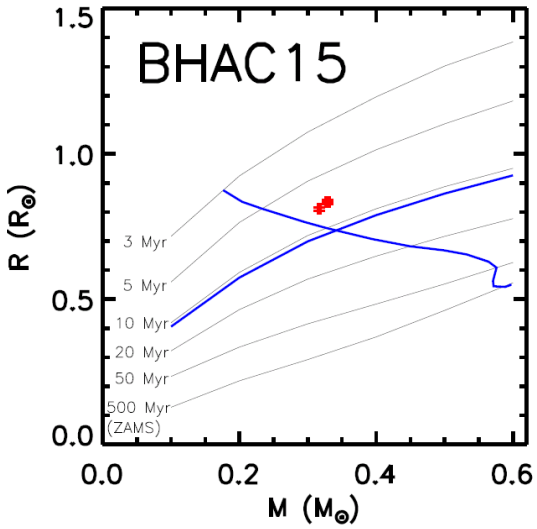
Aaron C. Rizzuto[1], Michael J. Ireland[2], Trent J. Dupuy[1], and Adam L. Kraus[1]



Models of stellar evolution

- Inconsistent (inflated) radii
- Are inter (and intra) inconsistent
- Agreement with the models can be forced but ages differ by up to 50%
- Magnetic fields come at rescue?

PLATO will provide observational test!



Binary stars
test of tidal evolution

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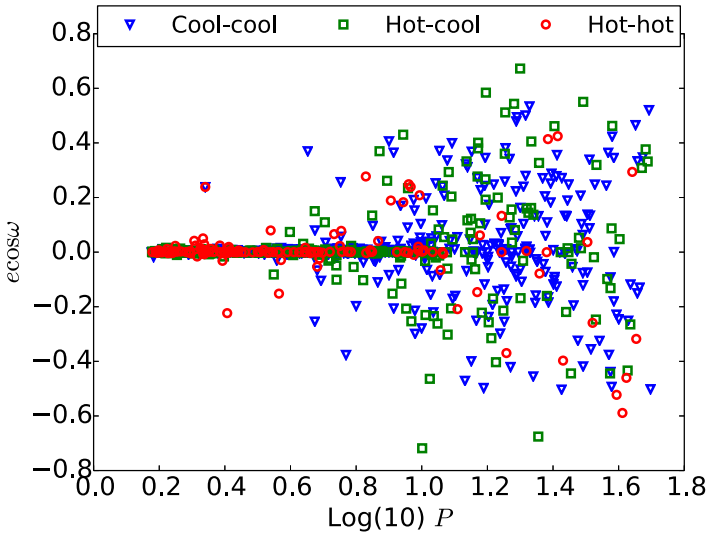
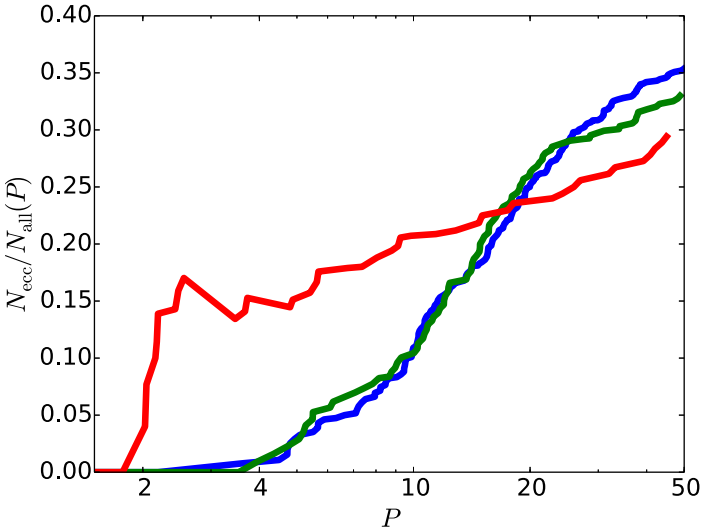
161 Binary & Multiple Stars John Southworth

ORBITAL CIRCULARIZATION OF HOT AND COOL *KEPLER* ECLIPSING BINARIES

VINCENT VAN EYLEN[1,2], JOSHUA N. WINN[2,3], AND SIMON ALBRECHT[1]





Sample

- MS stars (assumed)
- Boundary at 6250 K; stars with Teff < 10 000 K
- No ages, masses, evolutionary states

Conclusions

- Theory performs OK, at least for stars with cooler components
- Stars with(out) cool component: tidal dissipation (age) dominates

See also talk on binaries from K2 by P. Maxted (later today)

Asteroseismology

The era of space missions

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CoRoT

Separate seismo & exo detectors

5 months/FoV

Seismo: 100 stars with mag = 5 to 9 @ cadence of 32sec

Exo: 175000 stars with mag = 11 to 16 @cadence of 15 min

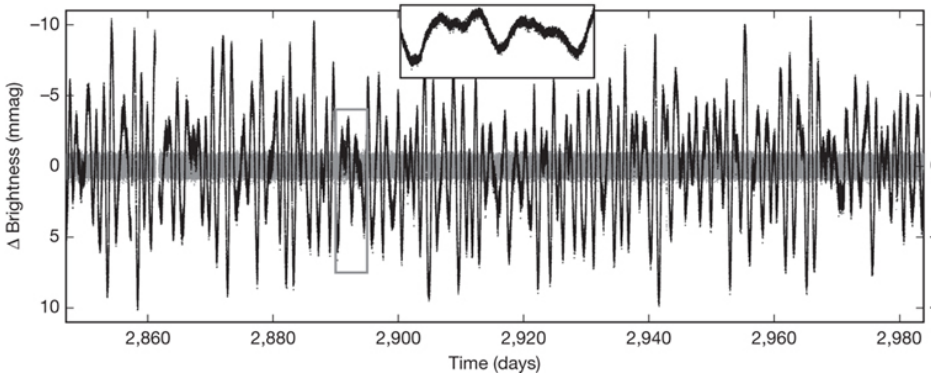
Kepler

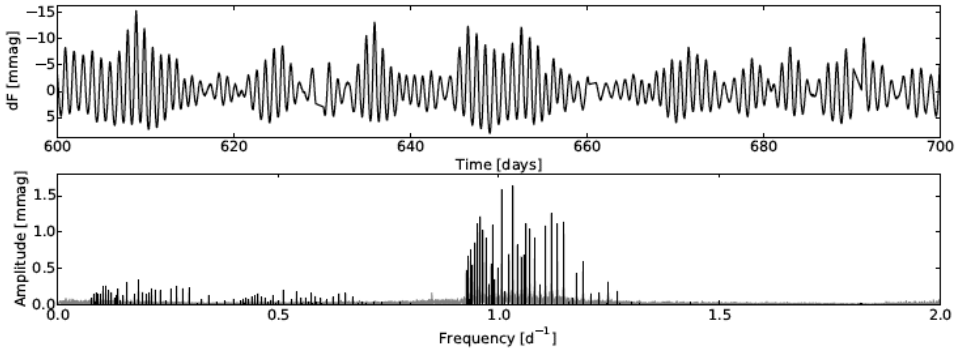
Seismo & exo on same detectors

4 years/1 FoV

150,000 stars with mag = 6 to 17

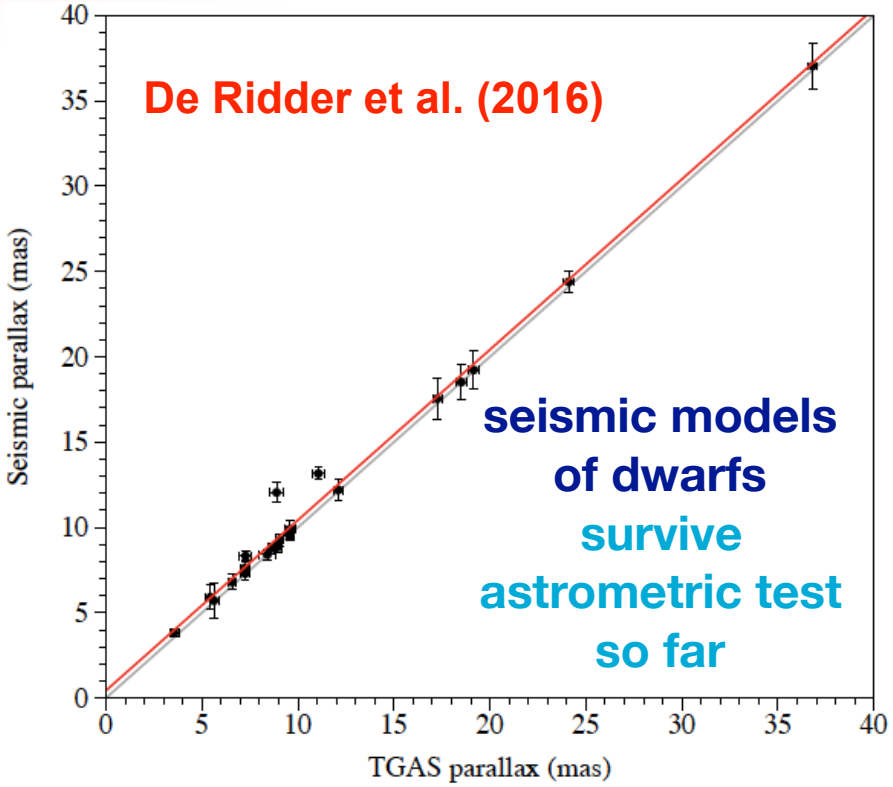
cadence of 1 (500) or 30min (all others)

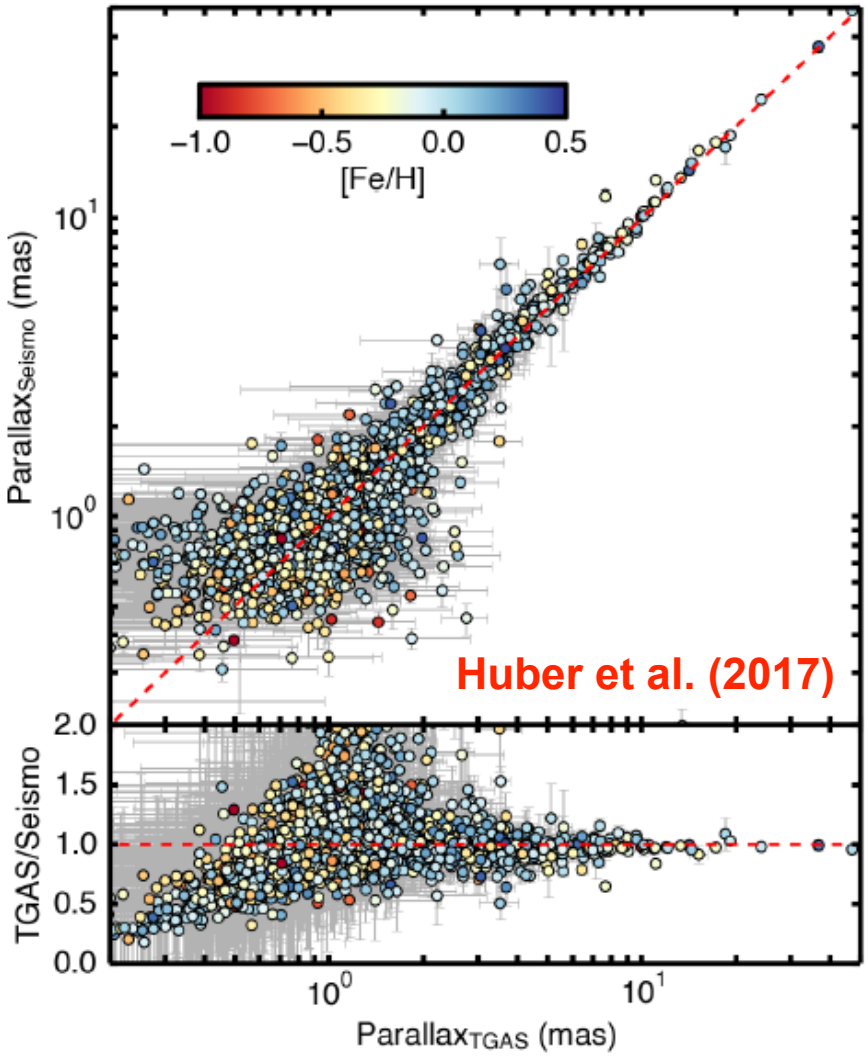




Solar-like pulsators

Asteroseismic vs. Gaia parallaxes





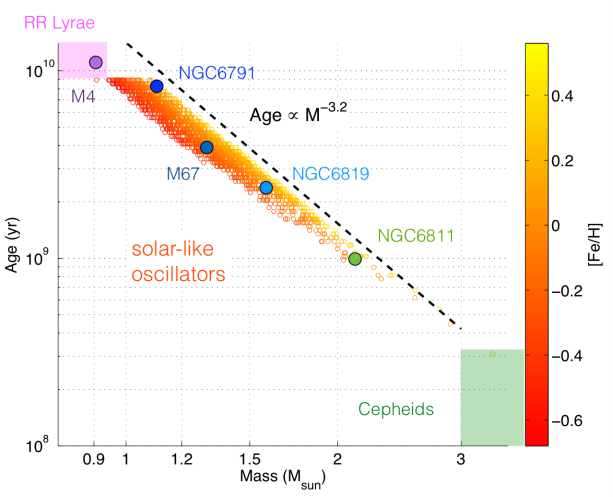
Seismic parallaxes currently better than TGAS parallaxes for distant red giants (up to 8 kpc for CoRoT)

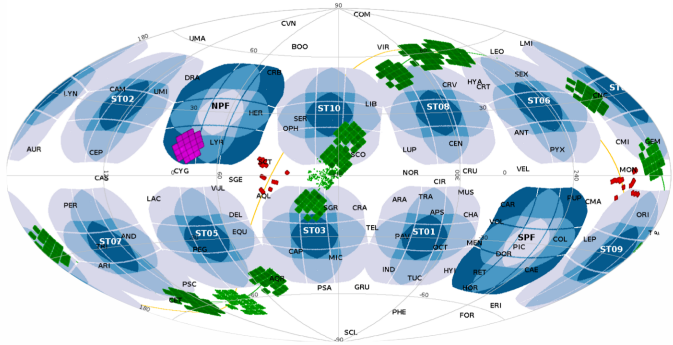
Galactic Archaeology/Structure

See talk on Galactic Archaeology by A. Miglio (later today)

Galactic archeology with PLATO

complementing Gaia's view of the Milky Way
with precise and accurate ages

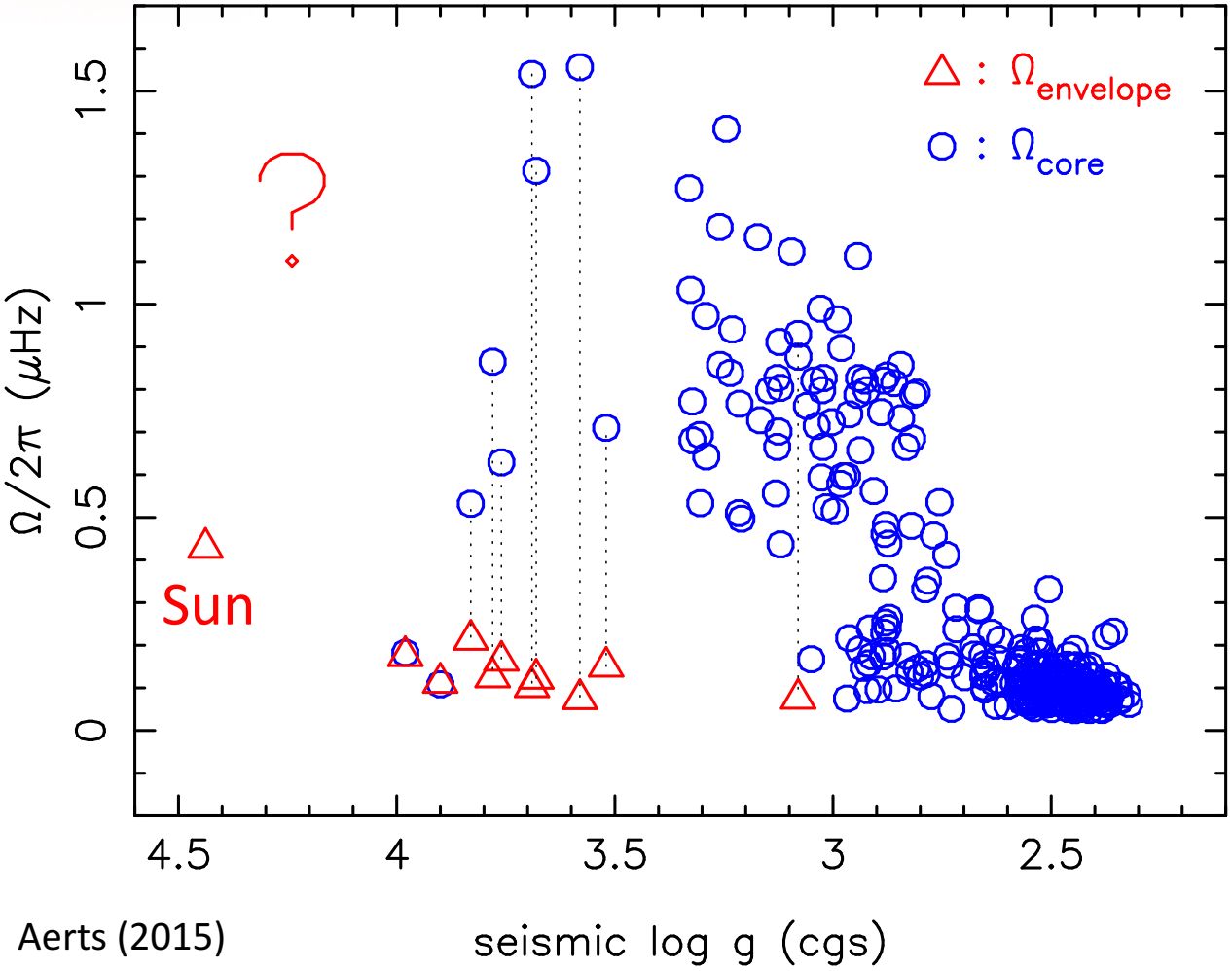




PLATO-UPD-SCI-TN-001 - "PLATO preliminary field selection",
Nascimbeni, Piotto, Granata, University of Padova

Solar-like pulsators

Interior rotation from *Kepler*



Aerts (2015)

$0.7\ M_\odot < M < 3.0\ M_\odot$

Models of stellar evolution fail

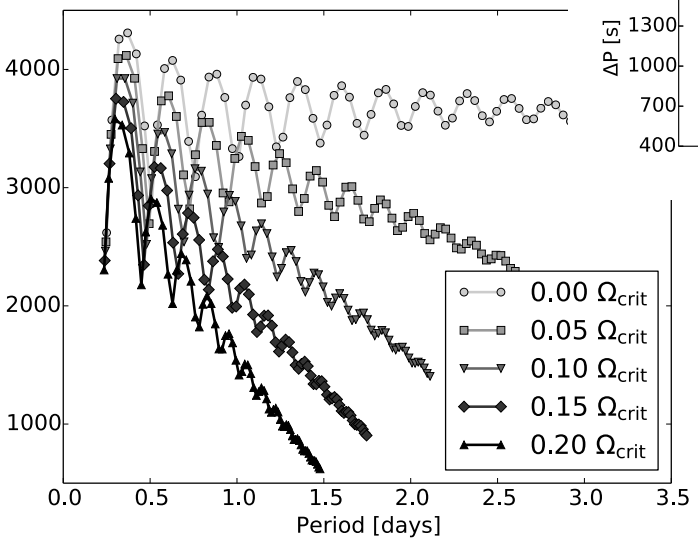
2 orders of magnitude discrepancy

Beck et al.
Mosser et al.
Deheuvels et al.
(2012 ->2017)

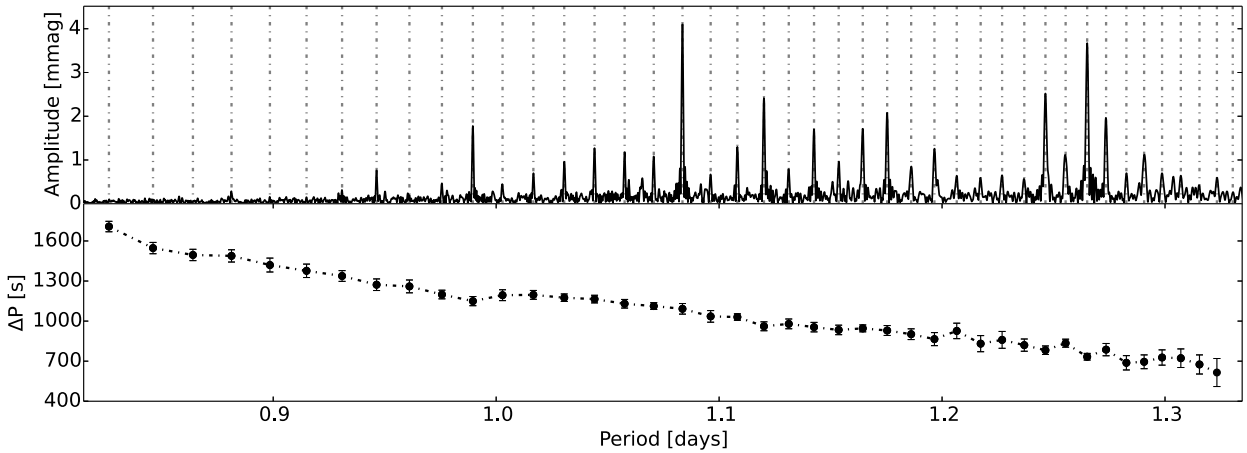
Heat-driven oscillations

g-modes = core rotation

$$\begin{cases} X_c = 0.4 \\ Z = Z_\odot \\ M = 2M_\odot \end{cases}$$



T. Van Reeth, PhD Thesis, 2017,Leuven



From mathematical modeling of detected & identified g-mode period spacings:

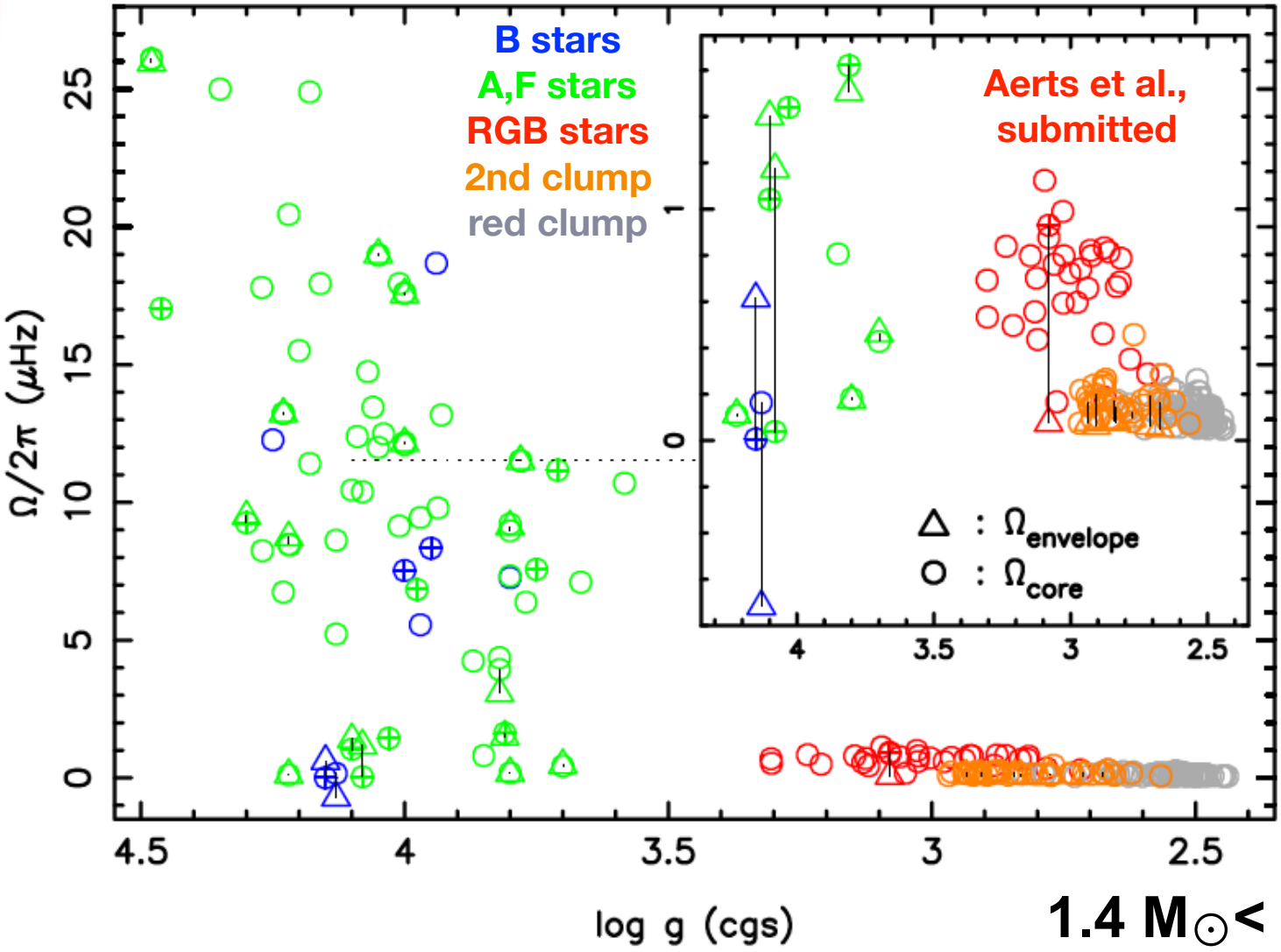
mass & near-core rotation

So far: 50-ish core H-burning stars with large range of core rotation

(Kurtz et al. 2014, Saio et al. 2015, Murphy et al.2016, Schmid & Aerts 2016,Van Reeth et al.2016, Quazzani et al. 2017, Pápics et al. 2017, Kallinger et al. 2017)

Heat-driven oscillations

Interior rotation & angular momentum



Internal Gravity Waves (IGWs) at work?

1.4 $M_\odot$ < M < 5 $M_\odot$

Ground-based follow-up

Are we fine or (will) need more?

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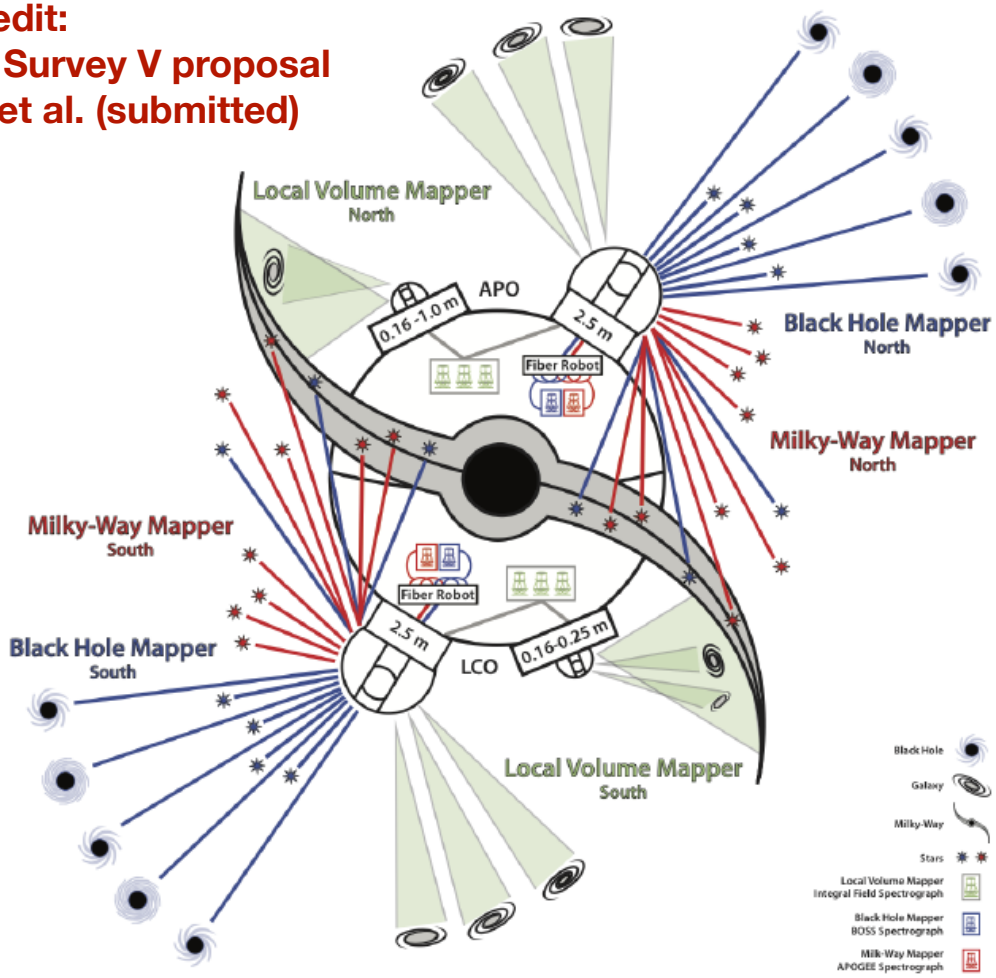
169 Spectroscopic & Interferometric & Multicolour Follow-up Ennio Poretti

Credit:
Sloan Digital Sky Survey V proposal by J. Kollmeier et al. (submitted)



AS4 = After SDSS IV

http://www.sdss.org/future/

Timeframe (SDSS V)

2020 - 2025

Data

- > 6 000 000 objects
- > 40 000 000 spectra
- Near-IR (R = 22 000) + optical (R = 5 000)

Ground-based follow-up

Are we fine or (will) need more?

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SDSS V: Project Summary

Program	Science Targets	# of Objects or Sky Area	Primary Spectral Range & Hardware	Primary Science Goal
Milky Way Mapper (MWM)	Stars across the Milky Way	>6,000,000 stars, all sky	Infra-red; APOGEE with Fiber Positioning System	Understanding the formation of the Milky Way and the physics of its stars
Black Hole Mapper (BHM)	Black holes	>400,000 black holes, all sky	Optical; BOSS with Fiber Positioning System	Understanding how black holes grow
Local VolumeMapper (LVM)	Interstellar gas in the Milky Way and nearby galaxies	>25,000,000 contiguous spectra over 3000 square degrees	Optical; new IFS (also called LVM)	Probing galaxy formation and regulation from star and black hole formation

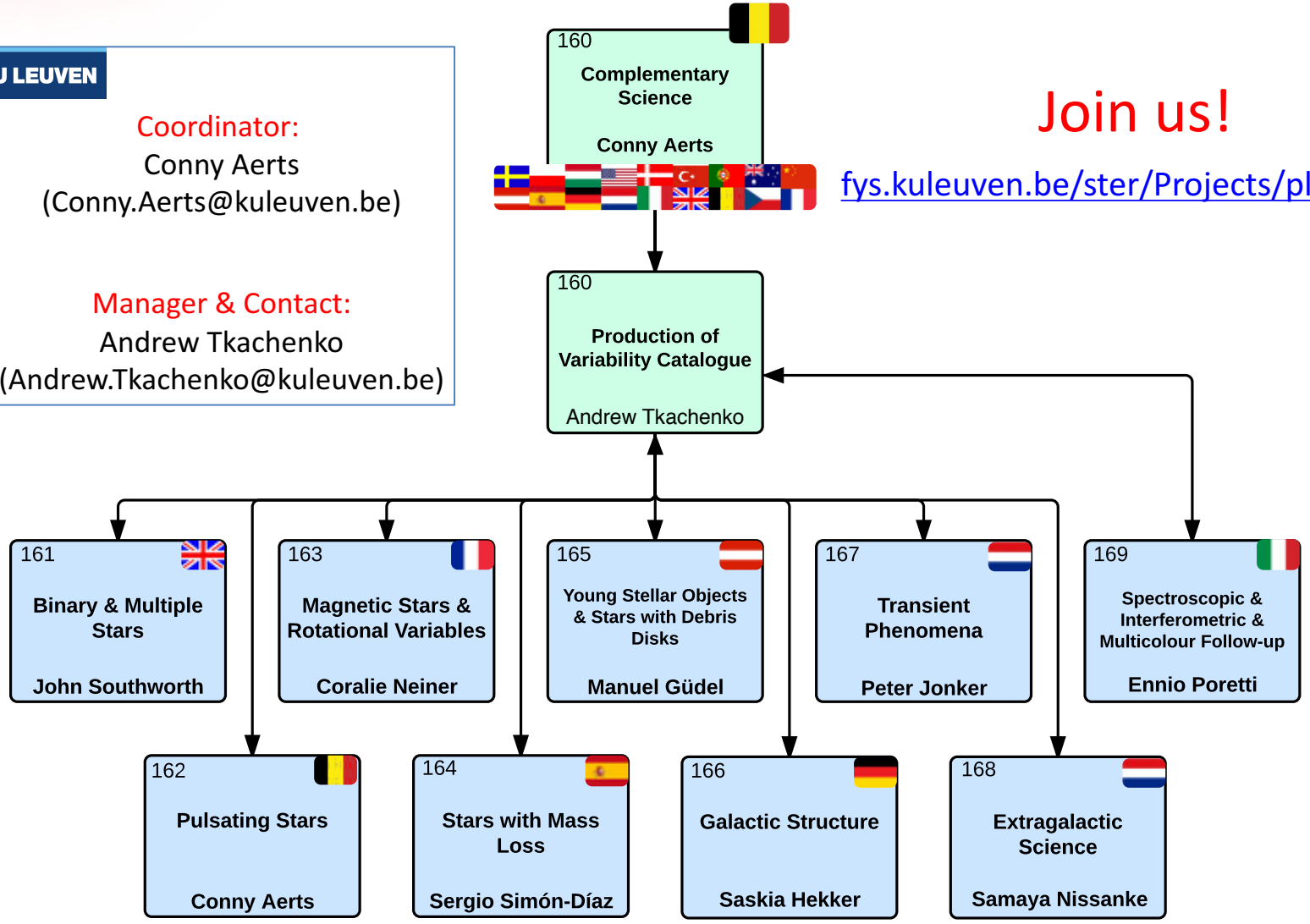
Credit: Sloan Digital Sky Survey V proposal by J. Kollmeier et al. (submitted)

PLATO Complementary Science

KU LEUVEN

Coordinator:
Conny Aerts
(Conny.Aerts@kuleuven.be)

Manager & Contact:
Andrew Tkachenko
(Andrew.Tkachenko@kuleuven.be)



Join us!

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