2016 NYC Gaia Sprint

final wrap-up session

Acknowledgements

- This project was developed in part at the *2016 NYC Gaia Sprint*, hosted by the Center for Computational Astrophysics at the Simons Foundation in New York City.

- This work has made use of data from the European Space Agency (ESA) mission Gaia (http://www.cosmos.esa.int/gaia), processed by the Gaia Data Processing and Analysis Consortium (DPAC, http://www.cosmos.esa.int/web/gaia/dpac/consortium). Funding for the DPAC has been provided by national institutions, in particular the institutions participating in the Gaia Multilateral Agreement.

    - Details:
      http://gaia.esac.esa.int/documentation/GDR1/Miscellaneous/sec_credit_and_citation_instructions.html

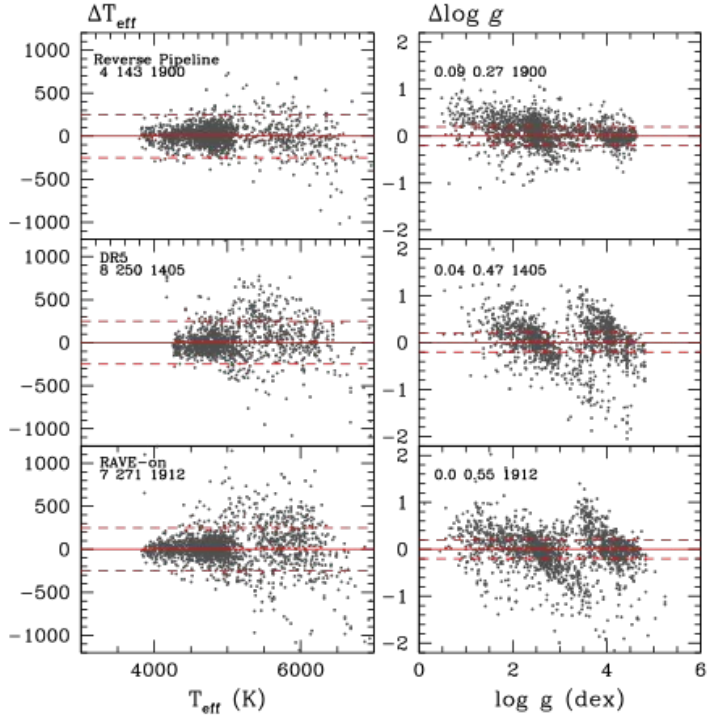
Future Gaia Sprints

- 2017 Heidelberg Gaia Sprint
  - tentative dates: 2017 July 17-21
  - tentative location: MPIA / Haus der Astronomie
- 2018 Gaia Sprint
  - summer 2018 (for after *DR2*)
  - conceivably Leiden or back to Heidelberg

morning wrap-up

Using Gaia parallaxes to break degeneracies in RAVE spectra

Andrea Kunder, Leibniz Institut für Astrophysik Potsdam (AIP)



RAVE using Gaia distances vs external

RAVE DR5 vs external

RAVE-on vs external

external = RAVE stars with High-Res spectra

Strong gravitational lens quasars in Gaia DR1

Leonidas A. Moustakas, JPL/Caltech

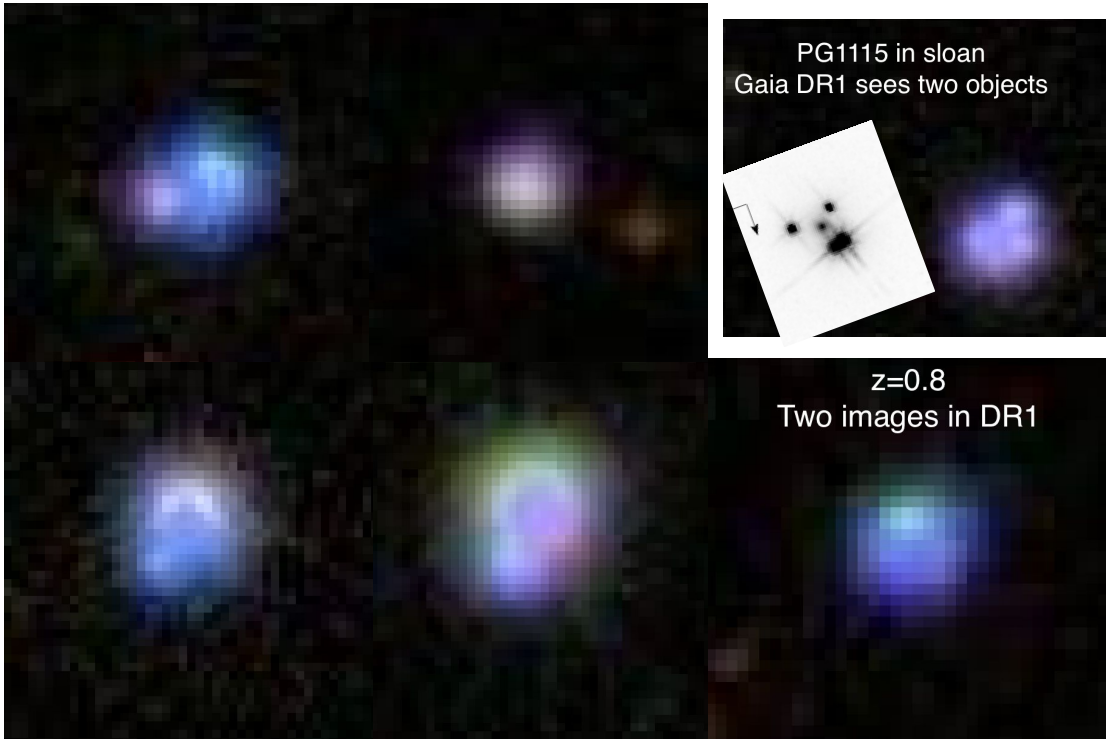
Topcat and the Gaia Archive are incredible.

Searching for the 60-ish anticipated four-image quasars in DR1 is promising.

Global AGN-candidate catalogs have a small but important number of stellar sources that Gaia can help identify.

There are 26 stars with parallax putting them <10pc and no proper motion.

There are tons of quasars behind globular clusters, it'll be fun to predict microlensing events.



The Gaia Archive

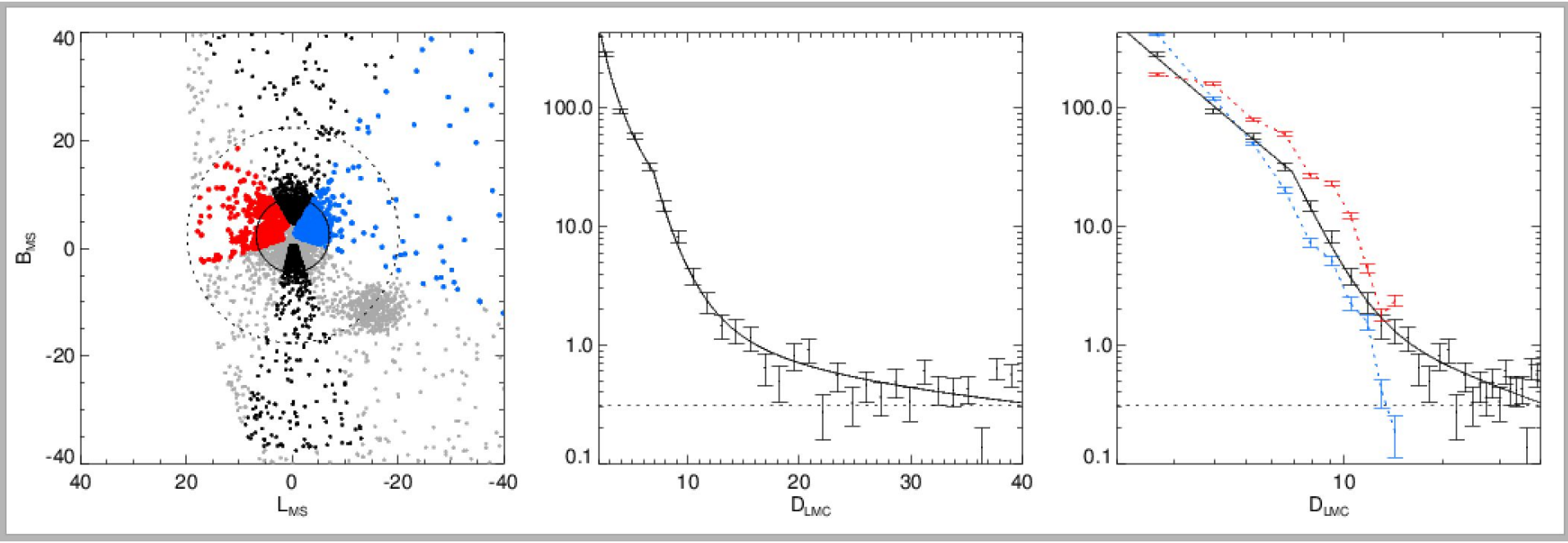
Alcione Mora, ESA-ESAC Gaia SOC

Location: http://gea.esac.esa.int/archive/. Helpdesk https://support.cosmos.esa.int/gaia/

- **Data**: Gaia main table, TGAS, variables, QSO,, Xmatch, external catalogues
- **Functionality**: TAP+ (data base, user space, sharing), cross-match
- Bring **code to the data**: select and refine (ADQL, user tables), then download
- **Prepare for DR2** (1+ billion sources). Archive might be the only way forward
- Add **ADQL queries** to your papers (Brown et al. 2016) ⇒ **Reproducibility**
- **Use it**. User demand is a key driver for future developments
- **Ask us**. Via Helpdesk, if additional support is needed. Suggestions welcome

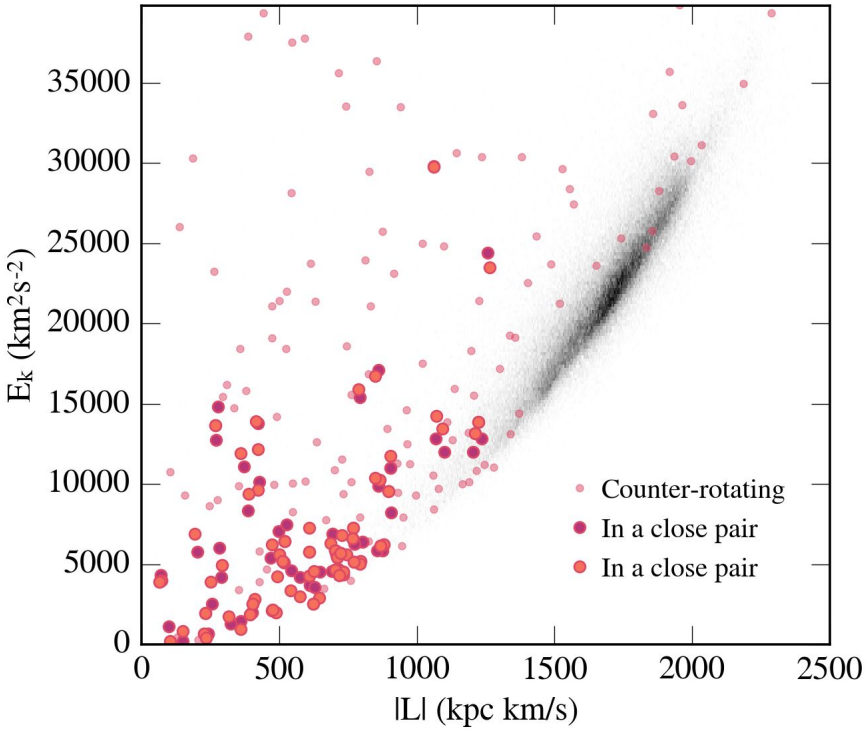
LMC stellar “halo” with Gaia RR Lyrae

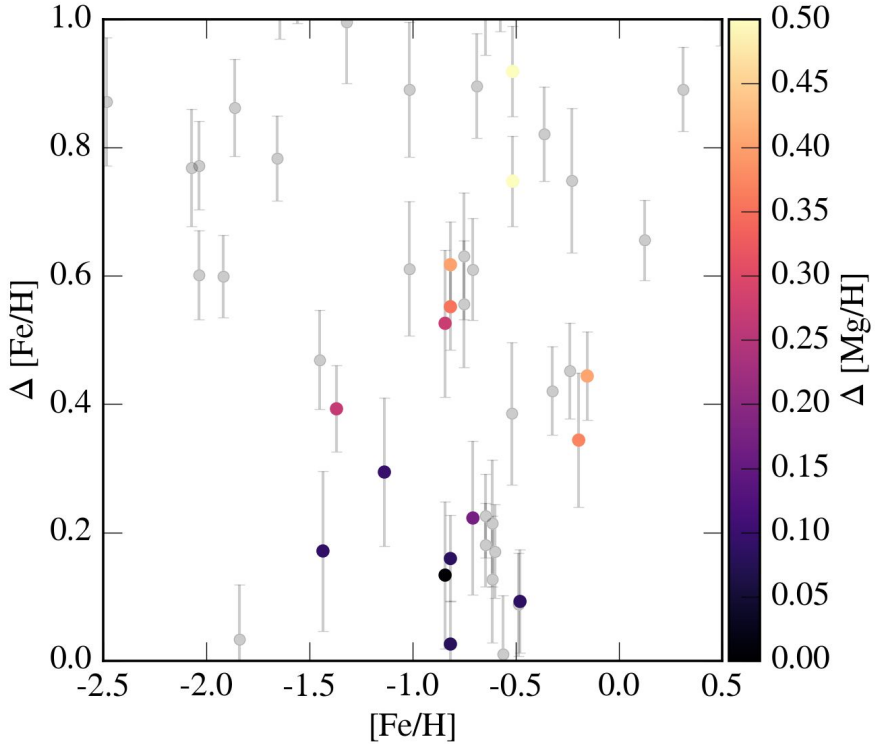
Vasily Belokurov



Peculiarities of counter-rotating RAVE-on stars

Ana Bonaca / Harvard





Python tools for 3-D dust map

Gregory Green (via Doug Finkbeiner)

Brand new for Gaia: **`dustmaps`** product available via pip install.

Contains 3-D Bayestar, Planck, SFD, BH, etc. See

`http://dustmaps.readthedocs.io/en/latest/installation.html`

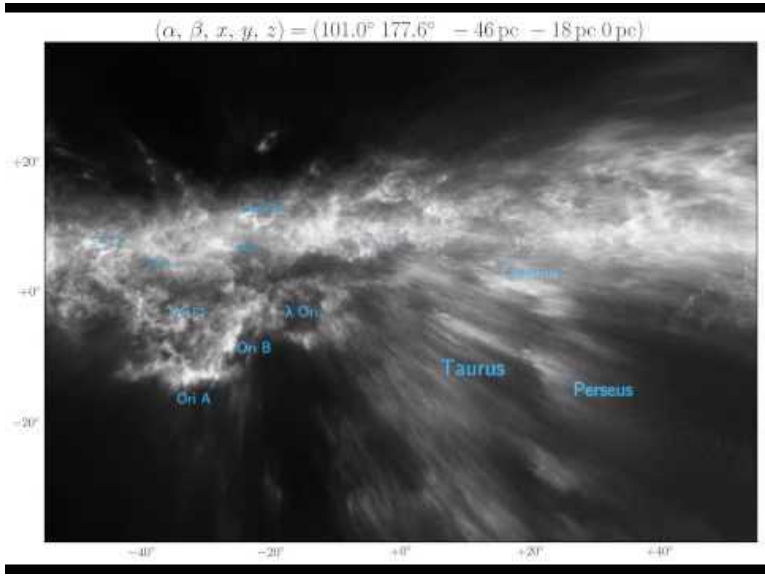
Interactive tool at

`http://argonaut.skymaps.info`

Note that all values are "SFD" E(B-V), and must be converted to

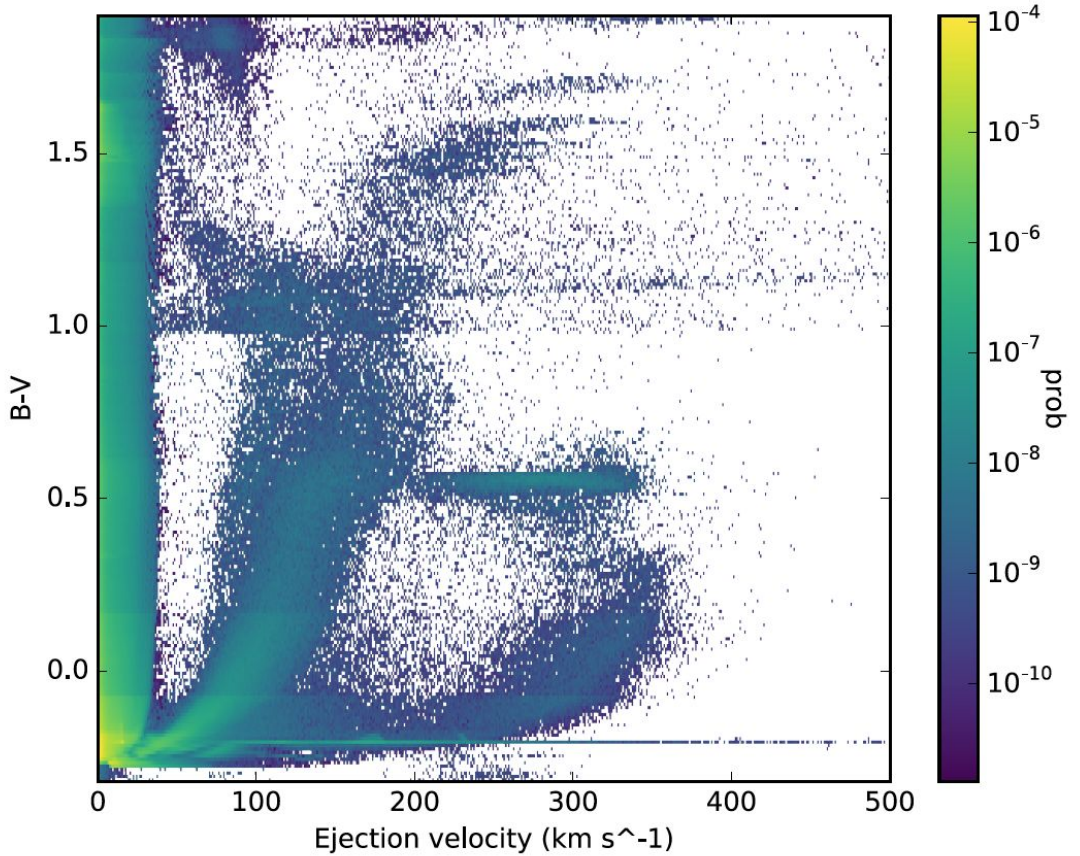
Various bands with this table:

Schlafly & Finkbeiner (2011)



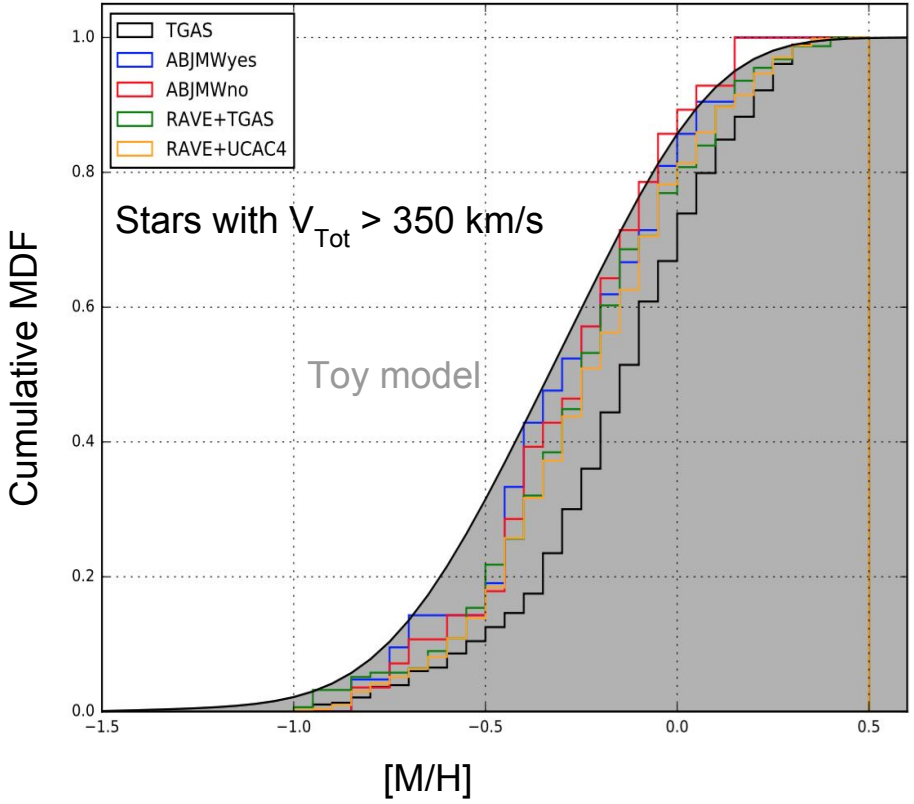
The Supernovae Tongues

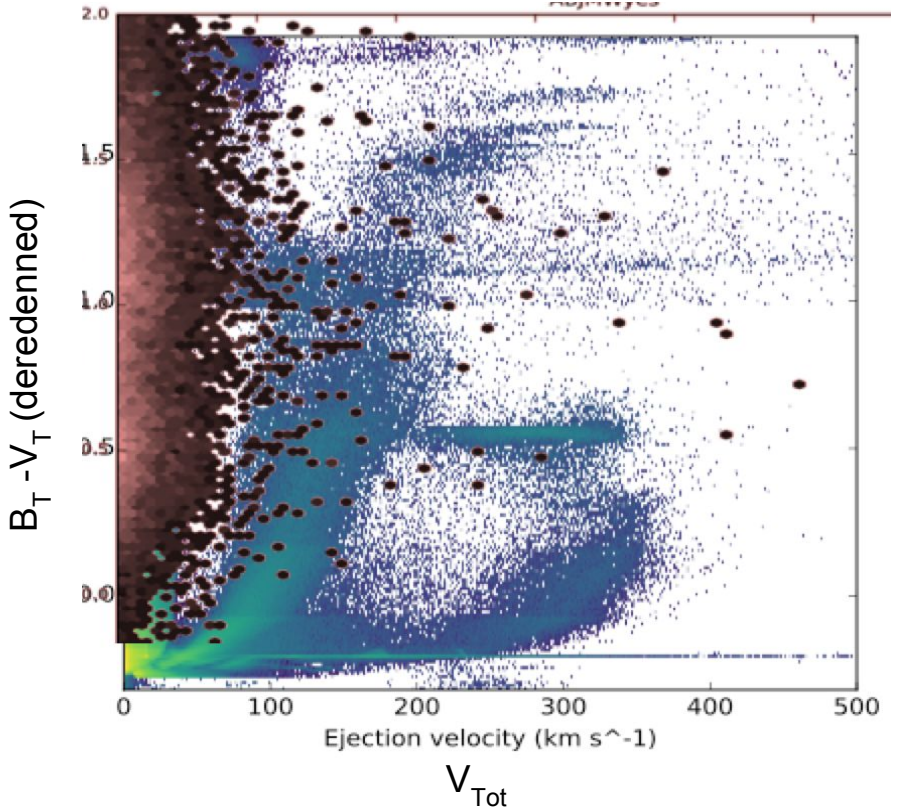
(Wyn Evans with Georges Kordopatis, Douglas Boubert)



High-Velocity stars in RAVE-TGAS

Georges Kordopatis / Leibniz Institut fur Astrophysik, Potsdam, + Wyn Evans + Keith Hawkins + Nathan Leigh+ Andrea Kunder

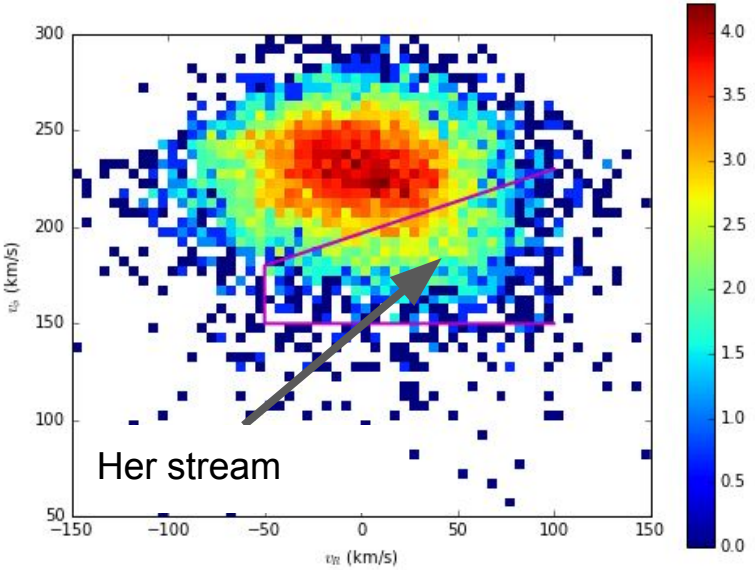


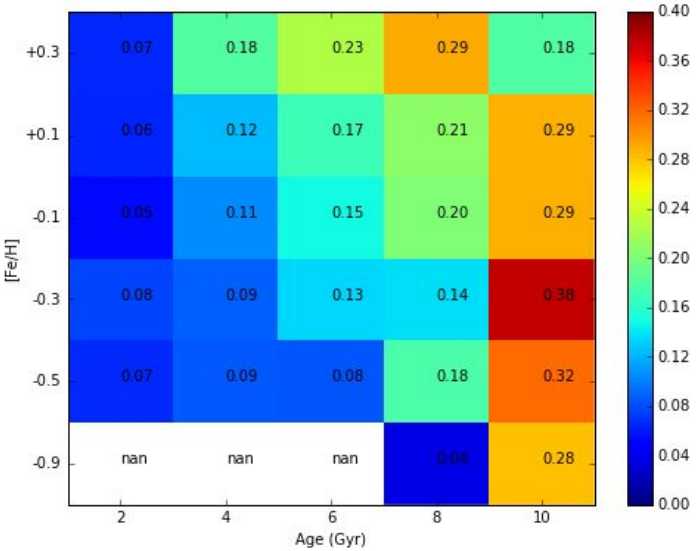


Hercules stream may not be a resonance feature

Chao Liu/NAOC, China

The Her stream are mostly comprise of the metal-rich or old stars, implying that they may together formed in high SFR region, unlike the local-born stars. Therefore, the Her stream seems not a resonance feature induced by the bar!





Fraction of the Her stream members in Age-Metallicity plane

afternoon wrap-up

David Spergel CCA

Job opportunities at CCA:
Postdocs
Associate Research Scholar
Joint ARS/AP with Columbia
Joint Group Leader/Tenured Prof. with SBU
Group Leader
Sabbatical

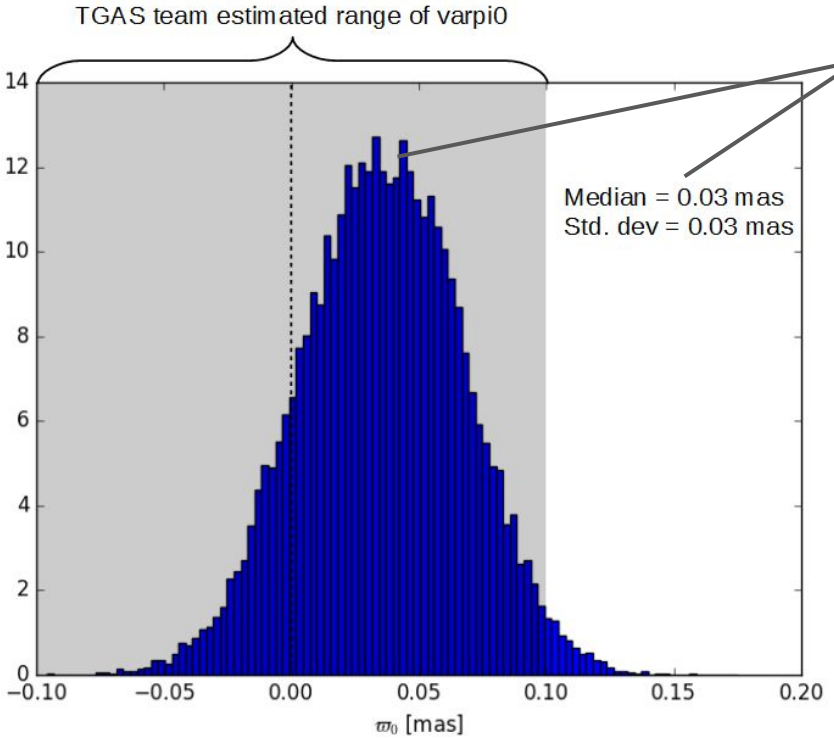
Lectureship (Assistant Professorship) in Astrostatistics at Cambridge

http://www.ast.cam.ac.uk/vacancies

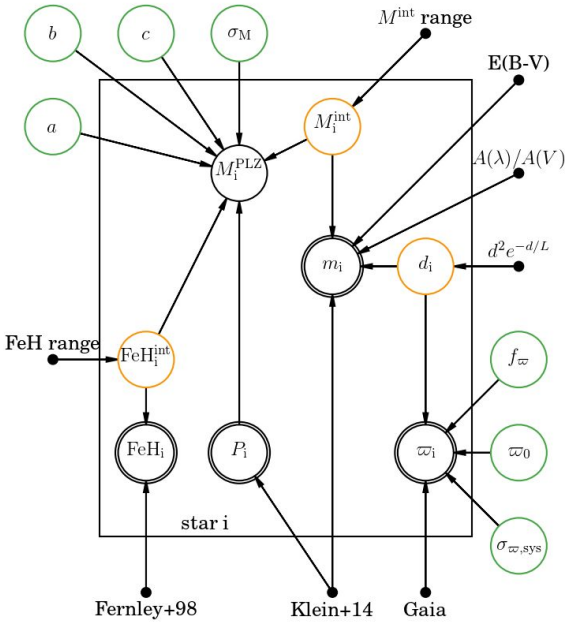
Also, November AAS webpage.

A Probabilistic Approach to Fitting Period-Luminosity Relations and Validation of Gaia Parallaxes

Branimir Sesar, Max Planck Institute for Astronomy



No significant global offset in TGAS parallaxes



“Homework for Dynamicists” inspired by *Gaia*

Kathryn V Johnston, Columbia University

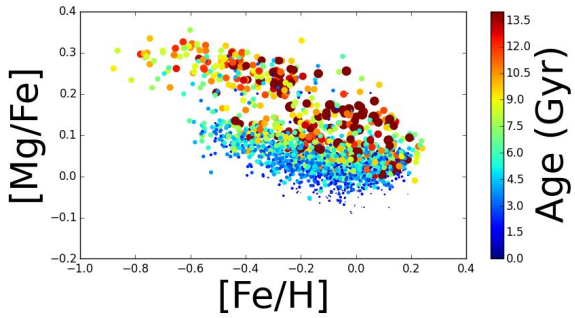
“My” homework - study partners welcome:

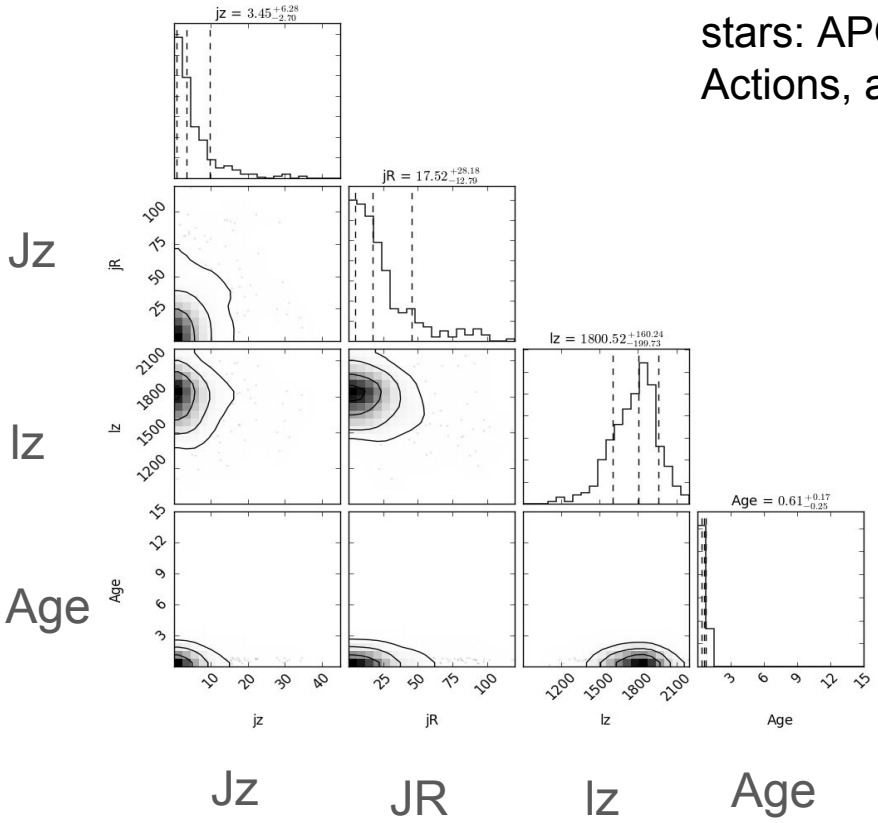
- Understanding outside of equilibria: signatures of chaos and regularity apparent over short timescales and as function of phase.
- Tools - modeling: perturbations from integrability in space and time; numerical integrations.
- Tools - model-data comparison: machine learning tuned to expected physical signatures?
- Homework to understand the etiquette of assigning homework

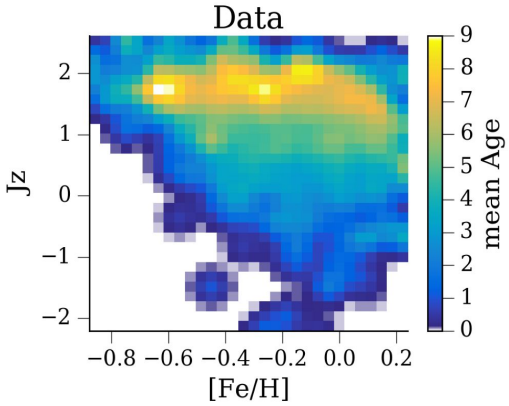
Predicting actions from stellar ages & metallicity

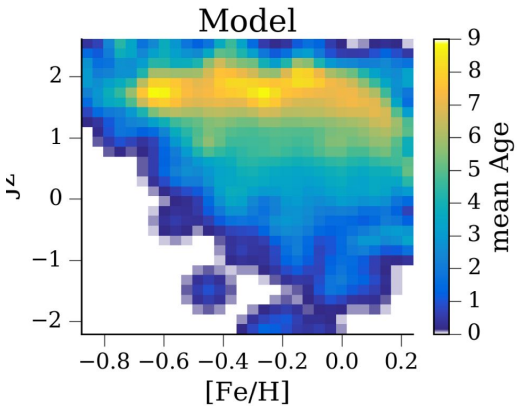
Melissa Ness, MPIA

Data: 2000 red clump stars: APOGEE-TGAS
Actions, abundances, ages









Model made to data by Morgan Fouesneau (MPIA)

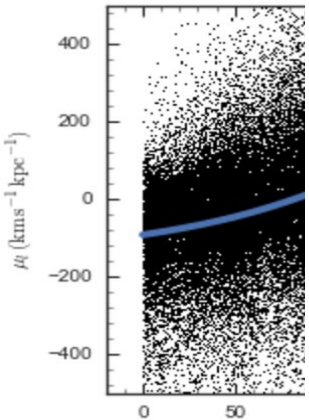
Oort constants from TGAS

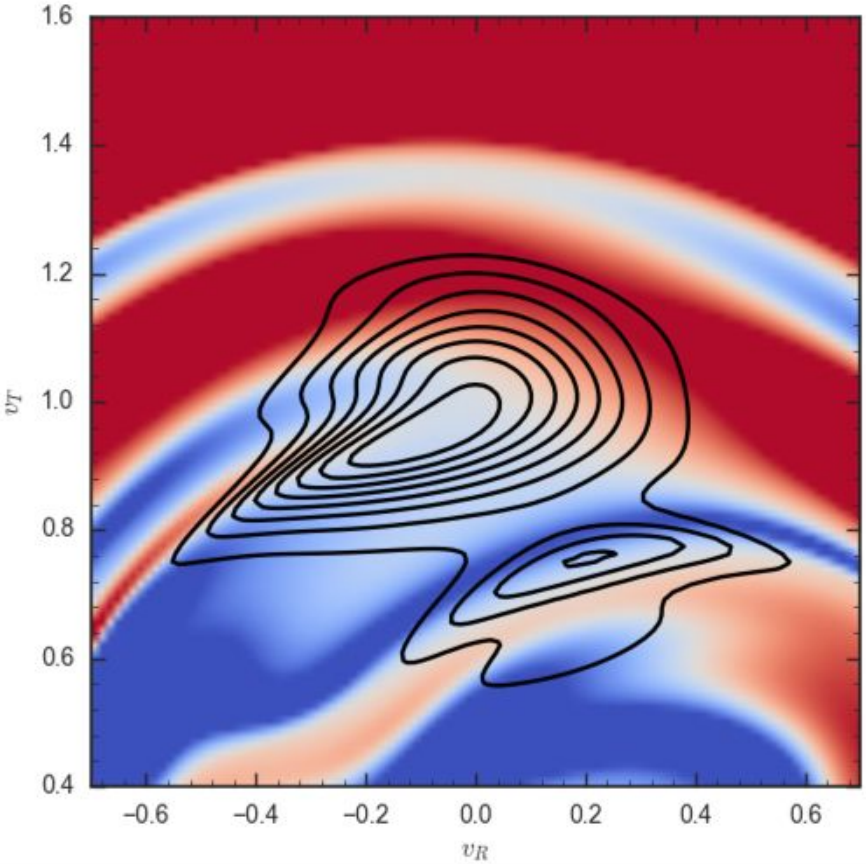
Jo Bovy

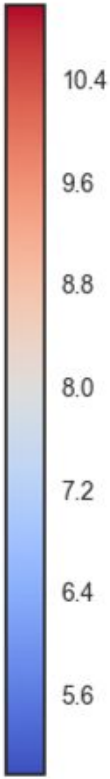
$\mu_b(l) = -(A$ + scatter,

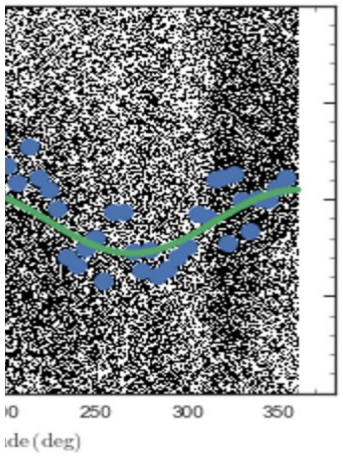
$b - w_0/d \cos b$ + scatter,

7,







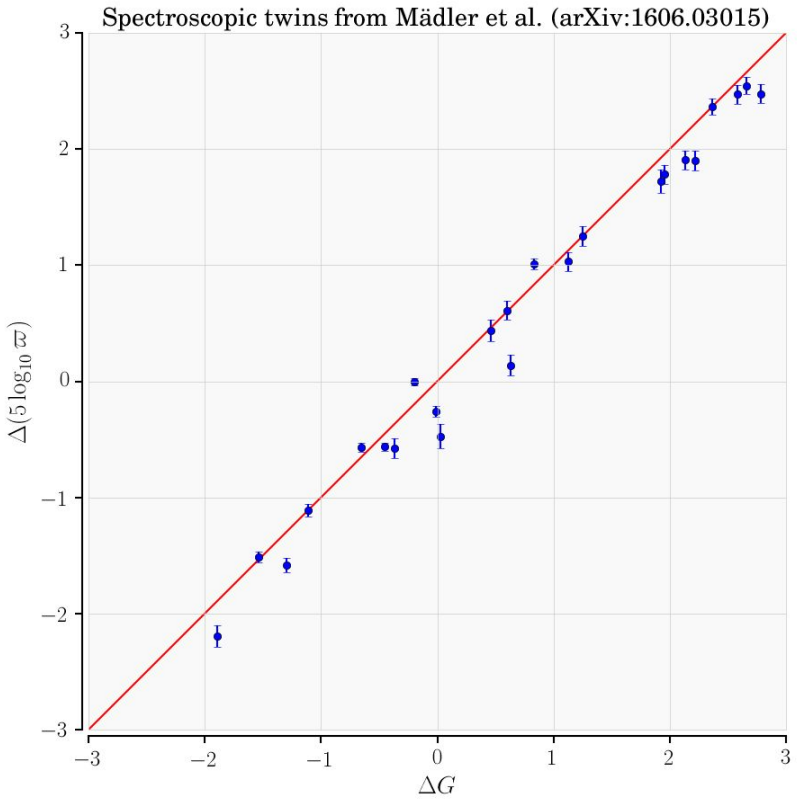


To do: Measure v_asy and h_sigma to correct A and B

Gaia DR1: the beauty of a limited data release

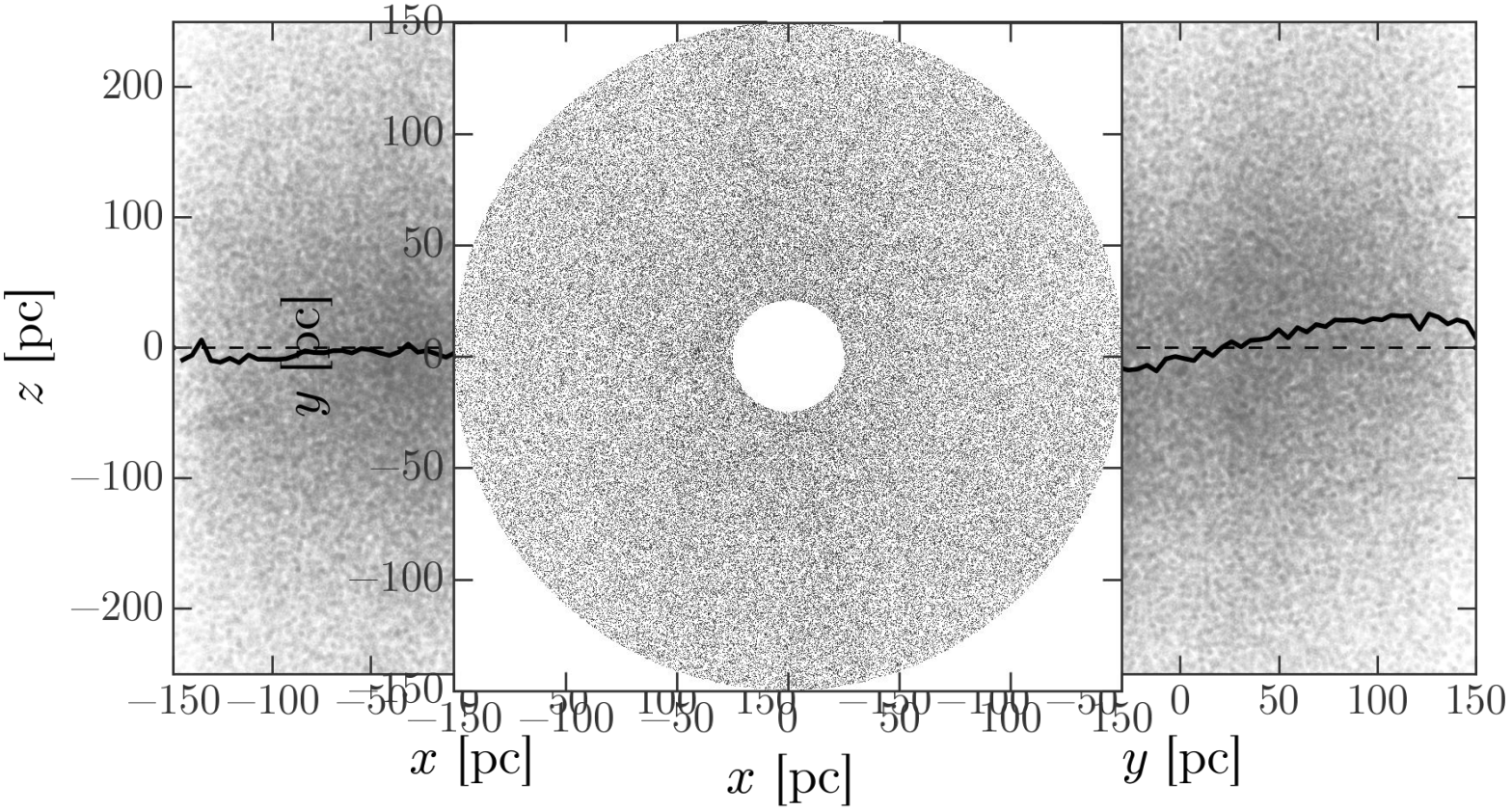
Anthony G A Brown, Leiden University

- Stimulates creativity!
- Great feedback for DPAC
  - Constructive feedback greatly appreciated
  - Get in touch if you have questions on the data and/or its interpretation
  - Also let your DPAC colleagues know you are happy with their work

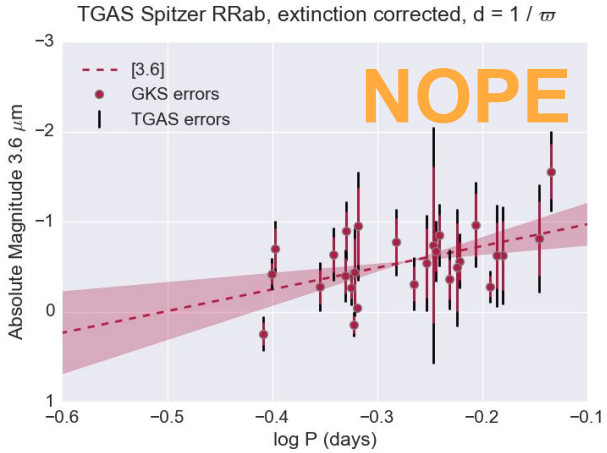


Adrian M. Price-Whelan

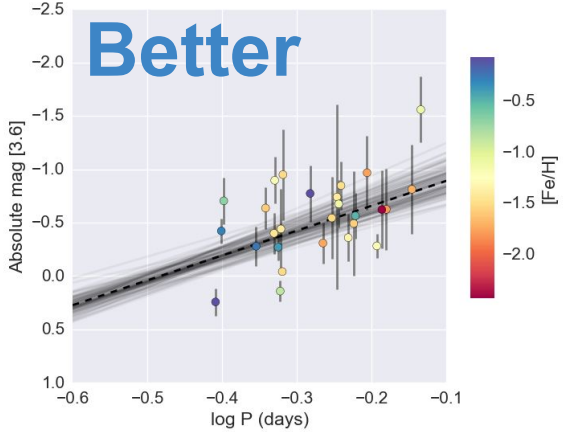
Princeton University



Fitting Variable Star Period-Luminosity Relations ‘Properly’



Until now: regular least squares fit
$M = a \log P + b[Fe/H] + c + \sigma_{internal}$



Bayesian (ish), d=1/parallax

Full analysis of PL relation done properly!

$$P(\varpi|r,\sigma_\varpi) = \frac{1}{\sqrt{2\pi}\sigma_\varpi}\exp\left[-\frac{1}{2\sigma_\varpi^2}\left(\varpi - \frac{1}{r}\right)^2\right] \text{ where } \sigma_\varpi \geq 0$$

$$P(Z \mid Z_0, \sigma_Z, S) = \frac{1}{\sqrt{2\pi(\sigma_Z^2 + S^2)}}\exp\left[-\frac{(Z-Z_0)^2}{2(\sigma_Z^2+S^2)}\right]$$

$$P(A_\lambda \mid A_0) = \frac{1}{\sqrt{2\pi}A_\lambda}\exp\left[-\frac{(A_\lambda - A_0)^2}{2A_\lambda^2}\right]$$

$$P(m_\lambda \mid m_0) = \frac{1}{\sqrt{2\pi}\sigma_m}\exp\left[-\frac{(m_\lambda - m_0)^2}{2\sigma_m^2}\right]$$

$$P(Z) = \frac{1}{\sqrt{2\pi}}\exp\left[-\frac{1}{2}(Z-\mu))^2\right]$$

$$P(A_\lambda) = \frac{1}{\sqrt{2\pi}\mu}\exp\left[-\frac{1}{2}\left(\frac{A_\lambda - \mu}{\mu}\right)^2\right]$$

$$P(M \mid \Delta, a, b, c, \log P, Z) = \frac{1}{\Delta} \quad \text{where } |M - (a\log P + bZ + c)| < \Delta$$
$$= 0 \quad \text{otherwise}$$

$$P(m_0 \mid M, r, A_0) = \delta\left[m_0 - (M + A_0 - 5 + 5\log r)\right]$$

$$P_{usd}(r) = \frac{3}{r_{lim}^3}r^2 \quad \text{for } 0 < r \leq r_{lim}$$
$$= 0 \quad \text{otherwise}$$

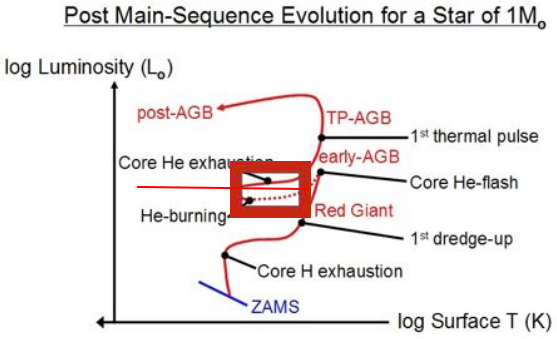
$$P(\theta \mid \{Y\}_N) = \frac{P(\varpi|r,\sigma_\varpi)P(Z \mid Z_0,\sigma_Z,S)P(A \mid A_0)P(m \mid m_0)P(M \mid \Delta,a,b,c,\log P,Z)P(m \mid M,r,A_0)P_{usd}(r)P(Z_0)P(A_0)}{\int\int\int\int\int P(\varpi|r,\sigma_\varpi)P(Z \mid Z_0,\sigma_Z,S)P(A \mid A_0)P(m \mid m_0)P(M \mid \Delta,a,b,c,\log P,Z)P(m \mid M,r,A_0)P_{usd}(r)P(Z_0)P(A_0)drdA_0dm_0dMdZ_0}$$

Victoria Scowcroft, University of Bath

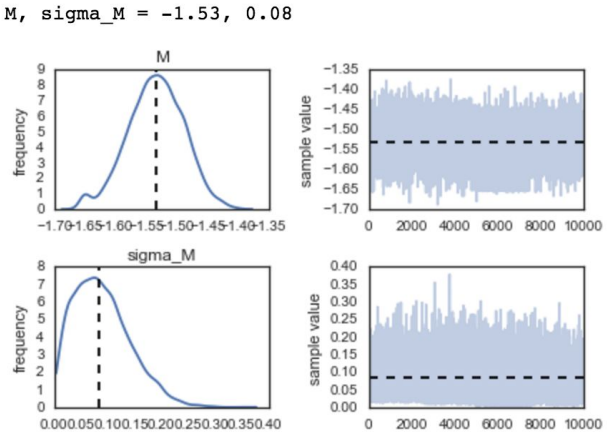
Now questioning my life choices

Are Red Clump Stars Standard Candles? … with TGAS

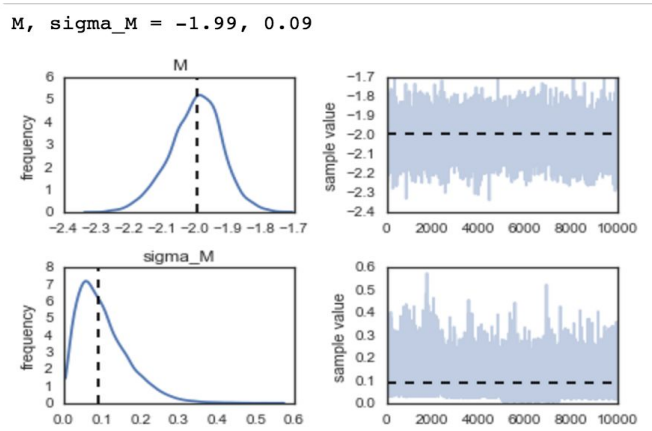
Keith Hawkins (simons fellow) Columbia University; with Leistedt; Hogg; Coronado



Model RC as a constant absolute magnitude with some dispersion



(*APOGEE RC sample* ~250 stars)
Mk = -1.72 +/- 0.03
Sigma_Mk = 0.07 (+0.05, - 0.04)

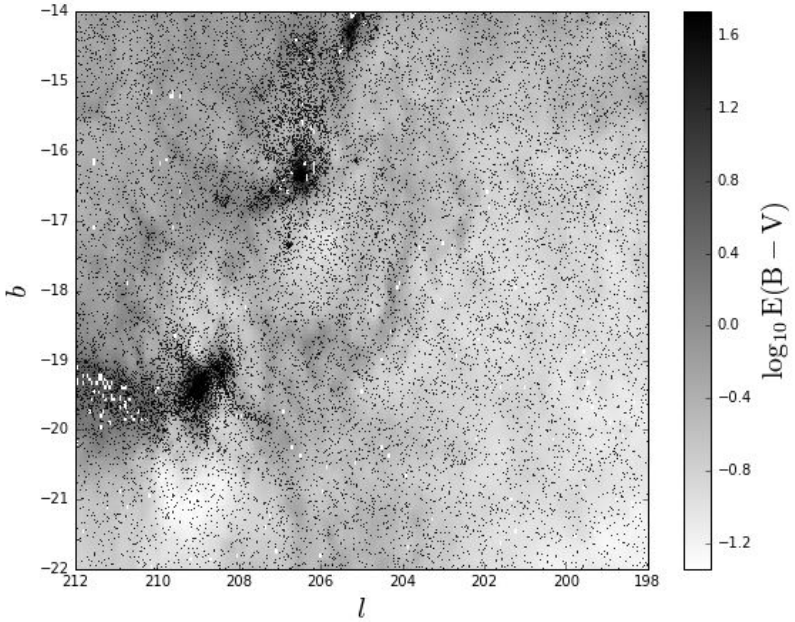


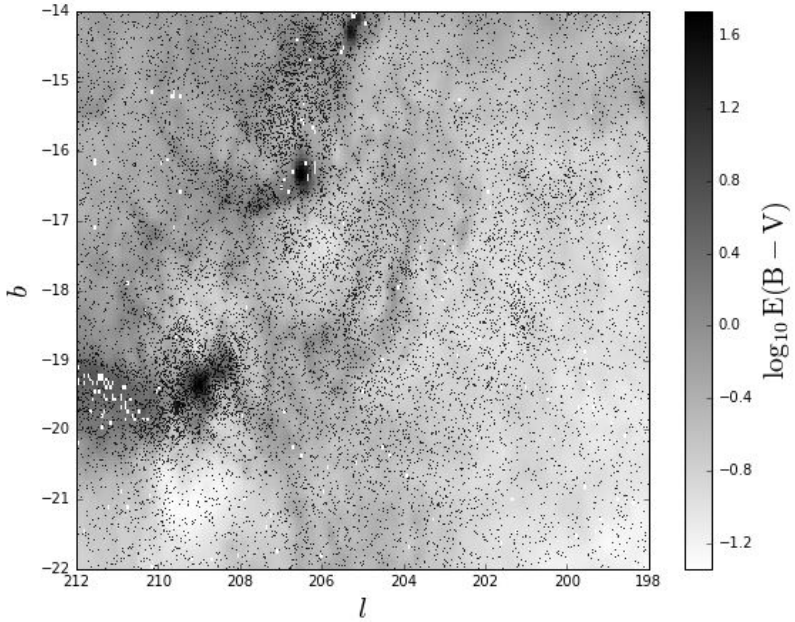
(***APOKASC*** *RC sample* ~30 stars)
Mk = **-1.99 +/- 0.08**
Sigma_Mk = 0.09 (+ 0.08,-0.05)

Laney et al. (2012) found Mk = -1.61 +/- 0.02 ; 0.06 +/- 0.03

Stars and dust in Orion

Eleonora Zari, Leiden Observatory





The Galah survey & actions

https://
Galah-survey
.org

GALAH+TGAS 6D information:

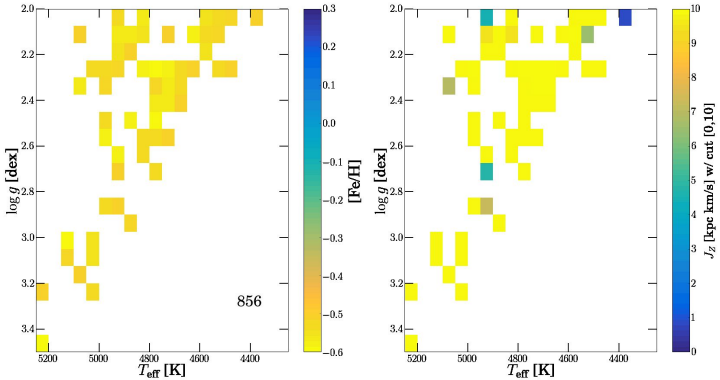
RA, Dec, pmRA, pmDec from Gaia DR1 TGAS
(e.g. Michalik et al. 2016)

\+ D (‘r50’) with MW prior (Astraatmadja et al. 2016)

\+ Galah radial velocities (Martell et al. 2016)

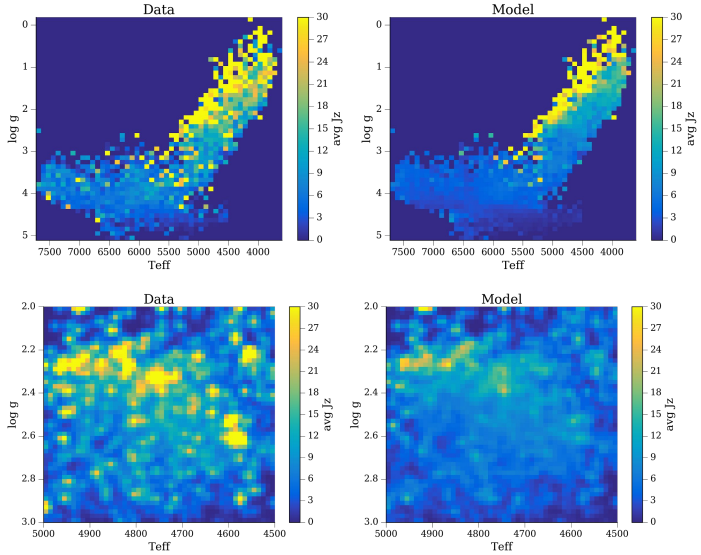
\+ Galpy by J. Bovy with tutorial by W. Trick

→ Actions for Galah-TGAS

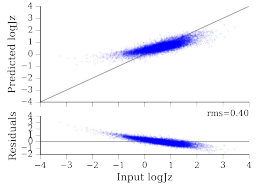


Gradient for HRD vs. vertical action J_Z?
$f(J_Z \mid T_{\rm eff}, \log(g), [\mathrm{Fe/H}])$?

Extra tree model with M. Fouesneau
trying to predict $f(J_Z \mid T_{\rm eff}, \log(g), [\mathrm{Fe/H}])$



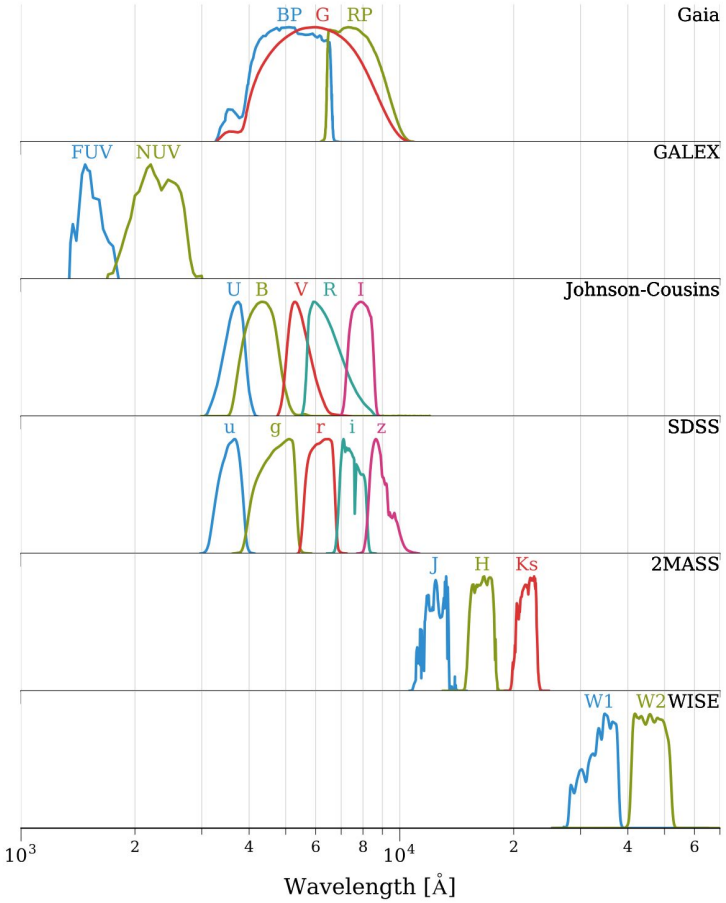
How biased are we by the
GALAH+TGAS selection?
Trend in RMS!
→ To be found out until next sprint?!

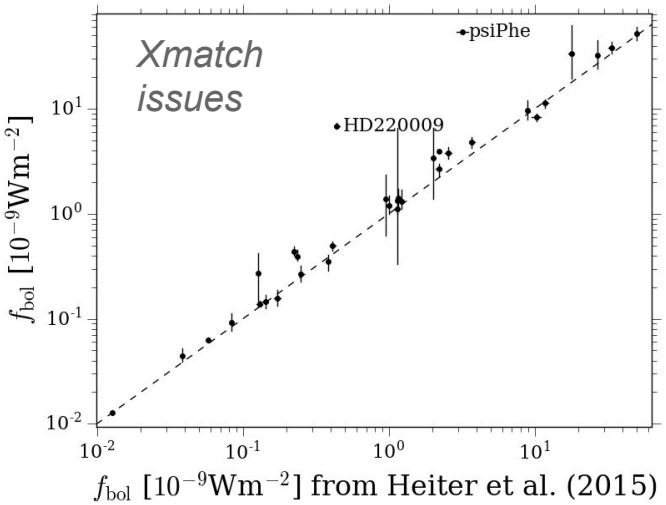


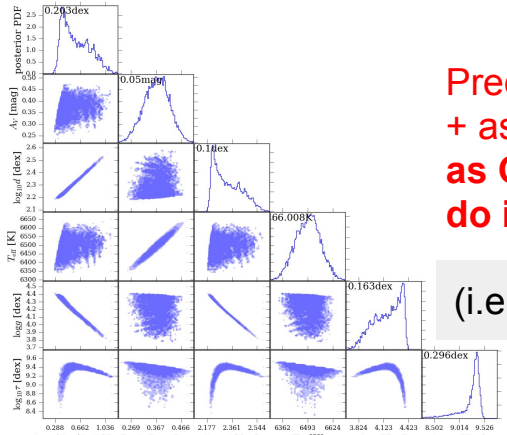
Sven Buder (MPIA) & The Galah team

Gaia Hybrid Catalogs

M. Fouesneau, *R. Andrae, C. A. L. Bailer-Jones, (MPIA, Gaia Team)*
H.W. Rix (MPIA) & ***D.W. Hogg*** *(NYU, CCA, MPIA)*







Produced Tools
(my homework)

- Pystellib
- Pyphot
- Pyextinction

See github

w/ contributions of Tim Morton & Dan Foreman-Mackey

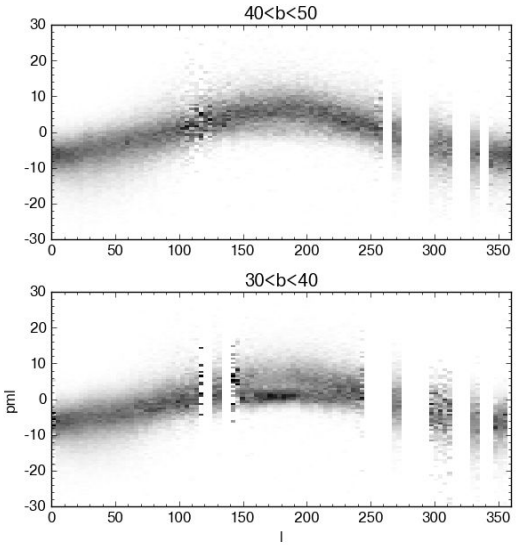
Predicting **fbol**
+ astrophysical parameters
as Gaia/CU8 will do in DR3

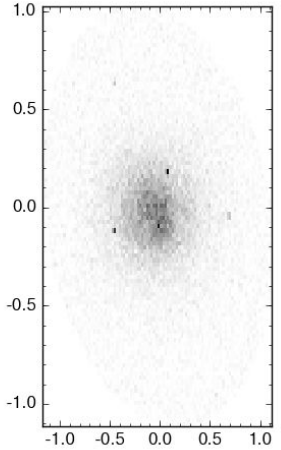
(i.e., MCMC samples)

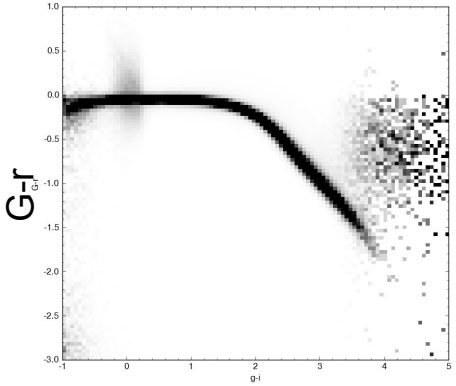
Exploring Gaia Data

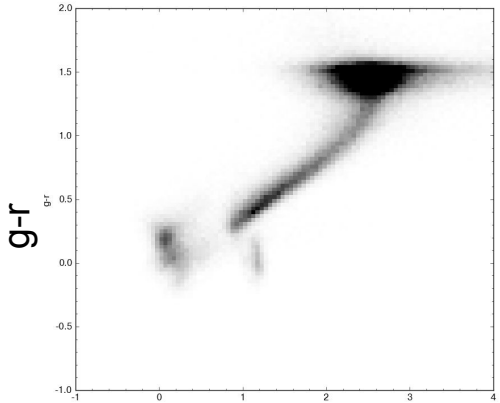
Sergey Koposov (Uni of Cambridge)

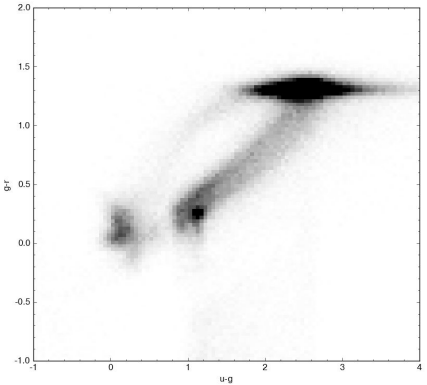
- Proper motions
- 3D structure of dwarfs
- Photometry outliers

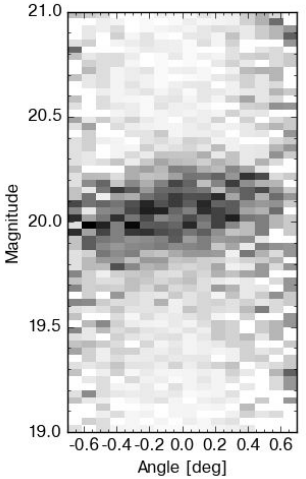










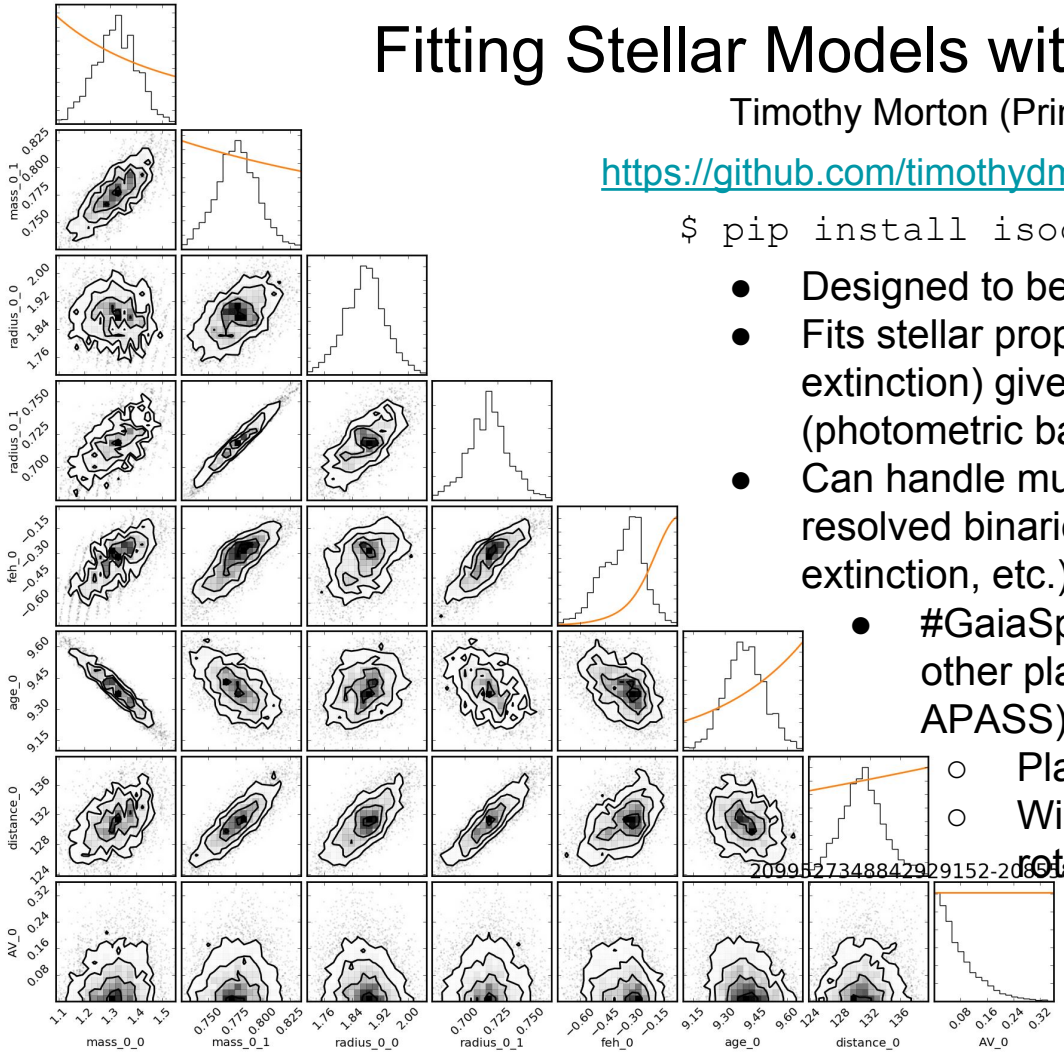


Fitting Stellar Models with `isochrones`

Timothy Morton (Princeton)

https://github.com/timothydmorton/isochrones

```
$ pip install isochrones
```



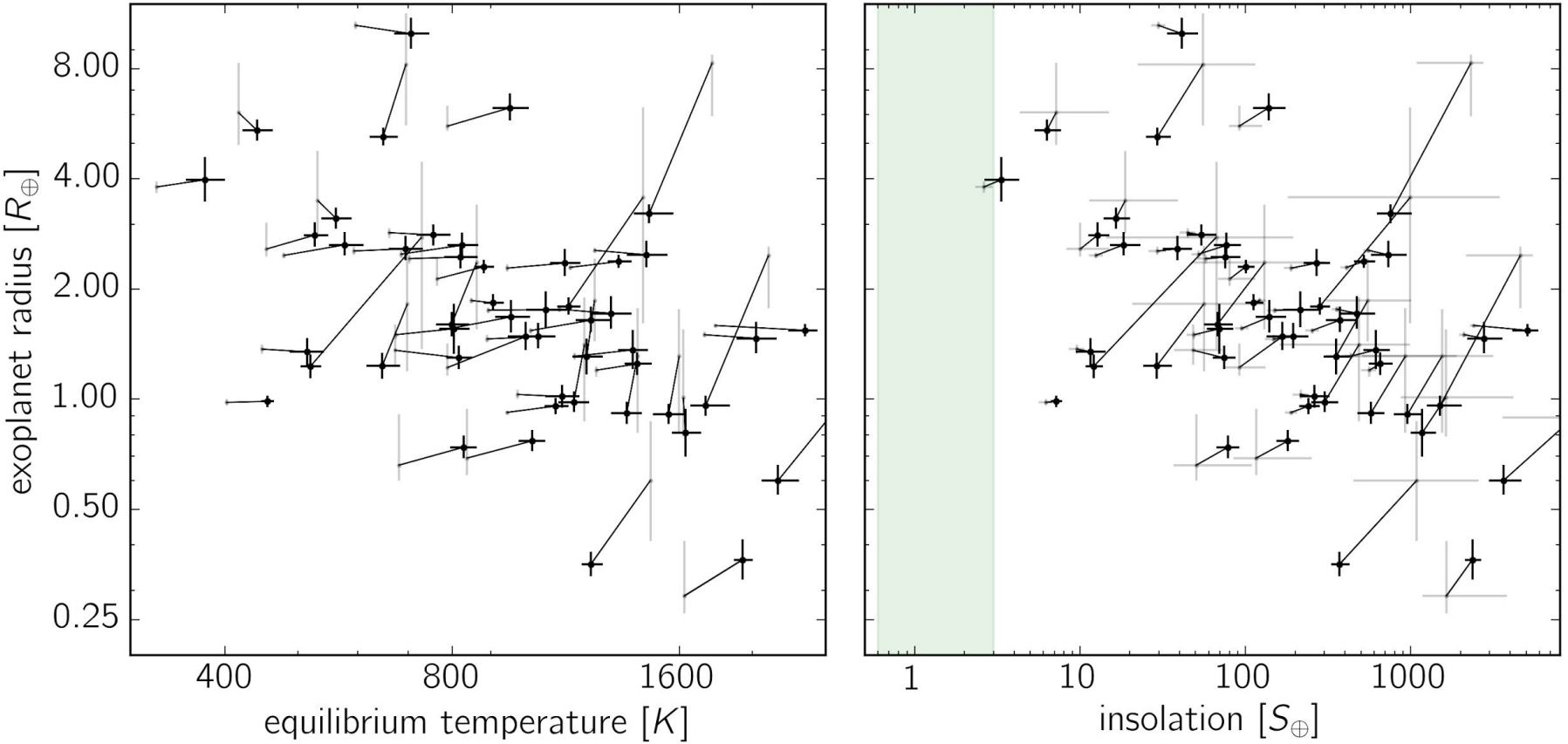
- Designed to be easy to use for star-fitting newbies
- Fits stellar properties (mass, age, [Fe/H], distance, extinction) given arbitrary observed quantities (photometric bands, spectroscopic params, parallax…)
- Can handle multiple stars (e.g. can fit blended and/or resolved binaries at the same age, feh, distance, extinction, etc.)
  - #GaiaSprint: applied to a sample of Kepler stars & other planet hosts (TGAS plax + 2MASS + WISE + APASS)
    - Planet hosts & non-hosts
    - Wide binary candidates with measured rotation periods

2099527348842929152-208[illegible]

Contact Tim (tdm@astro.princeton) with any usage questions!

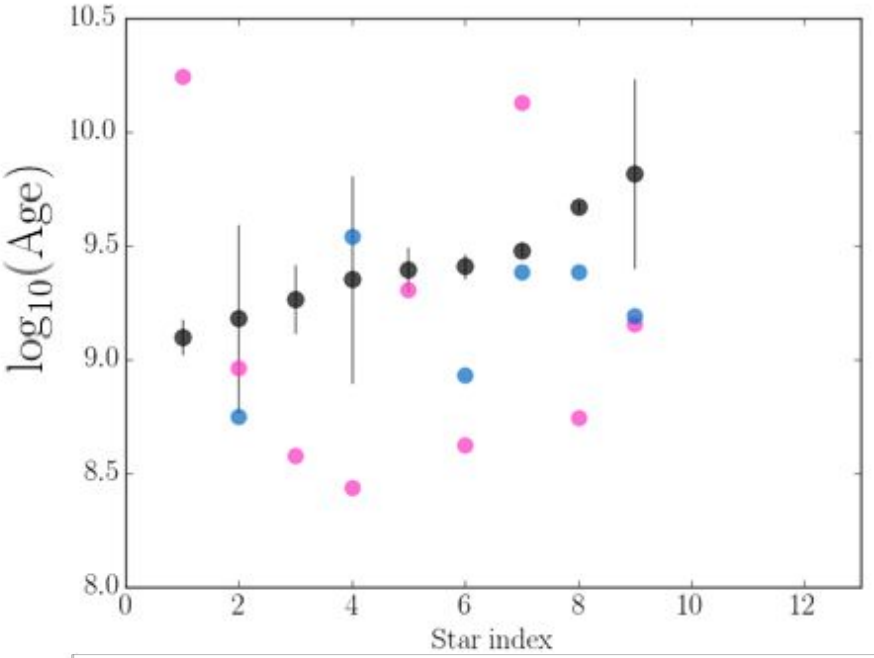
Dan Foreman-Mackey
Sagan Fellow | University of Washington | dfm.io | @exoplaneteer | github.com/dfm

github.com/dfm/gaia-kepler

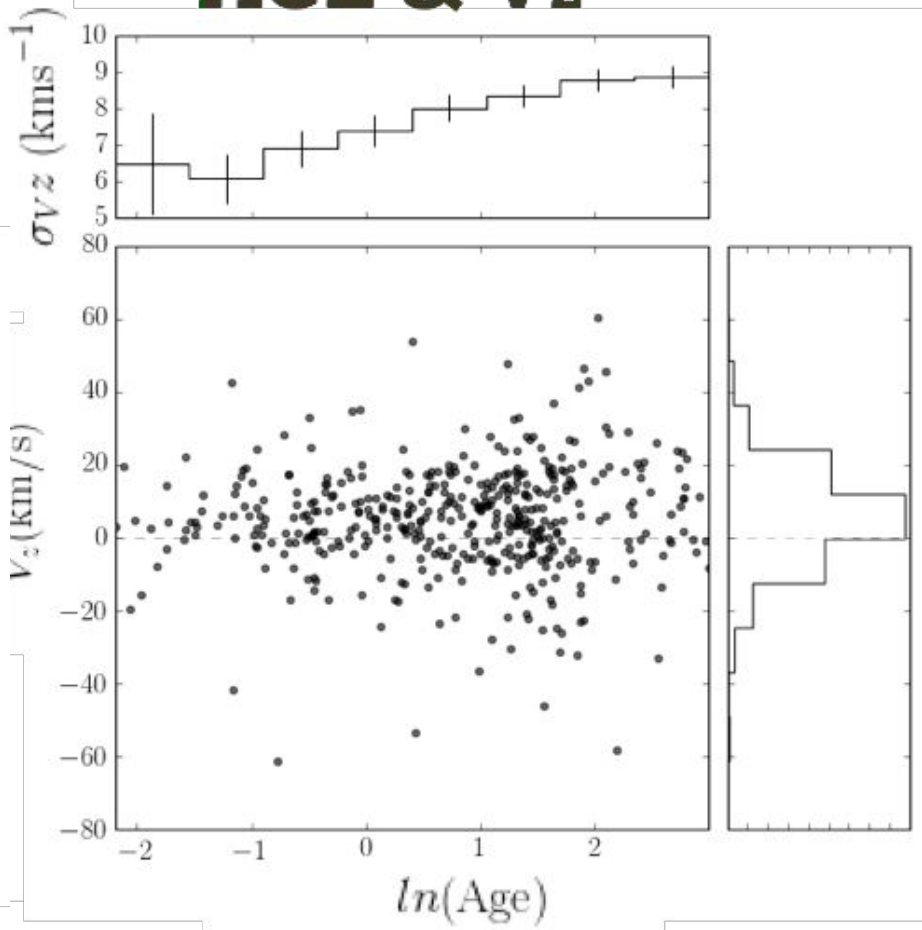


RUTH ANGUS
SEMYEONG OH | DAN F-M
TIM MORTON | JOHN LURIE
MELISSA NESS | WILMA TRICK

COMOVING PAIR AGES



AGE & Vz



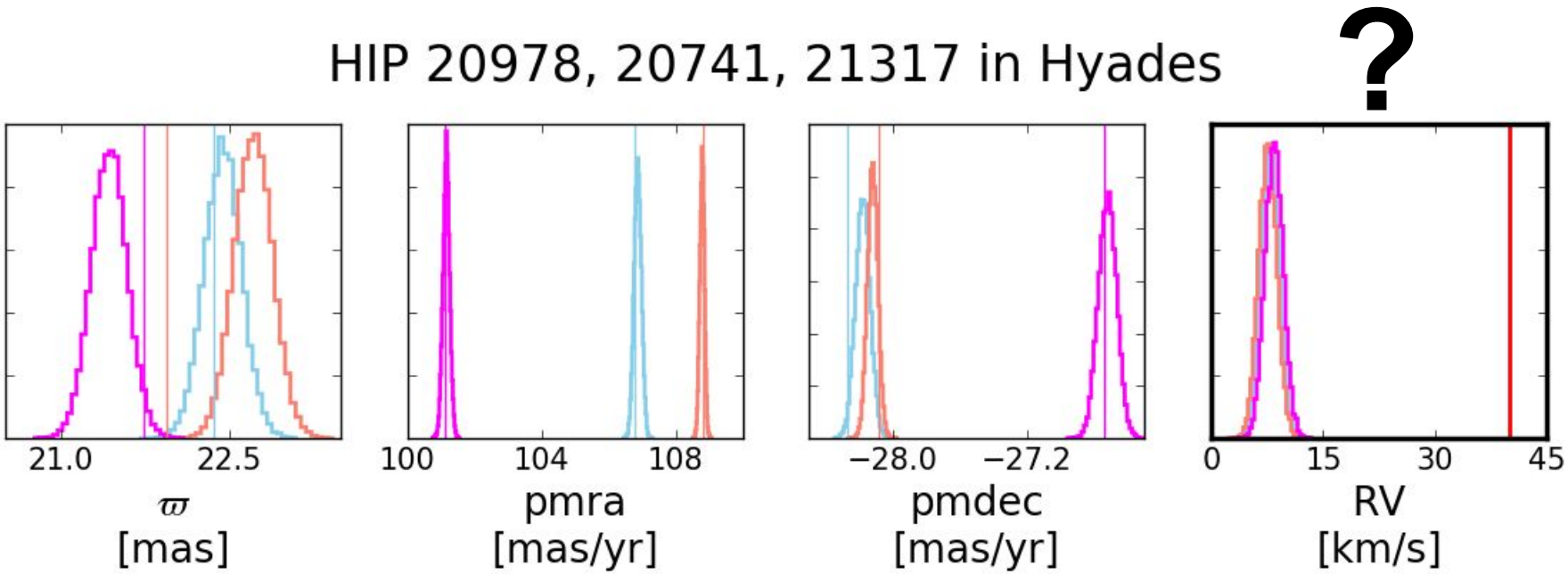
My week

David W. Hogg (NYU) (MPIA) (SCDA) (CCA)

- Run a hack week called the **Gaia Sprint**.
- Build a data-driven model of the CMD; de-noise parallaxes (with Leistedt).
  - requires a challenging Gibbs sampling
- Measure the mid-plane of the disk, tilt and curvature (with Price-Whelan).
  - requires a selection function for *TGAS*
- Determine *causal relations* among age, [Fe/H], and actions (with Bird, Ness).
  - looks like there are differences between low-alpha and high-alpha populations
- “Low-hanging” == “Doesn’t require the selection function”
  - **We need a selection function!**
  - *input:* RA, Dec, G
  - *output:* probability of being in *TGAS*, and pdf over parallax errors

Attempt at astrometric radial velocity

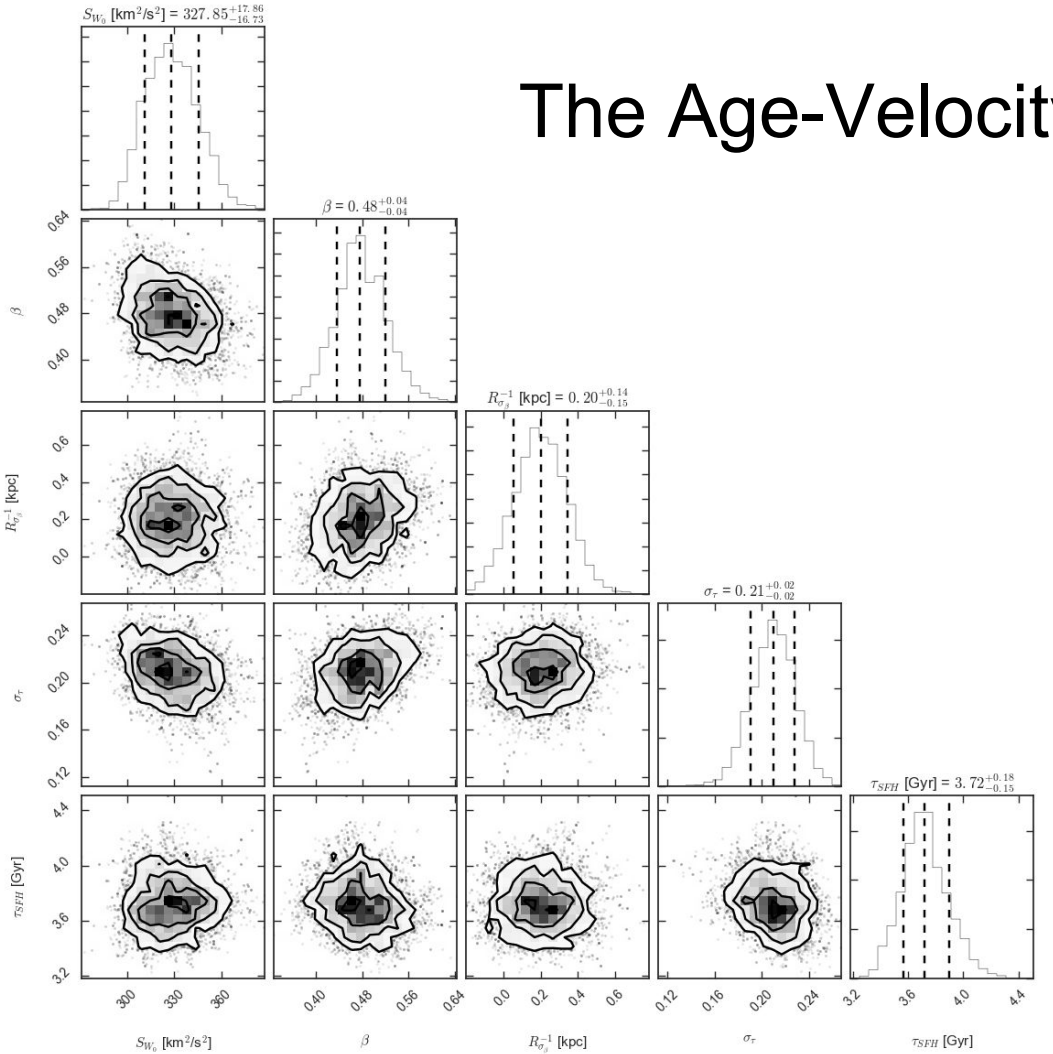
Semyeong Oh, Princeton University



Assumed zero intrinsic velocity dispersion

The Age-Velocity Dispersion Relationship for APOGEE RC Stars

Jonathan Bird
Vanderbilt University



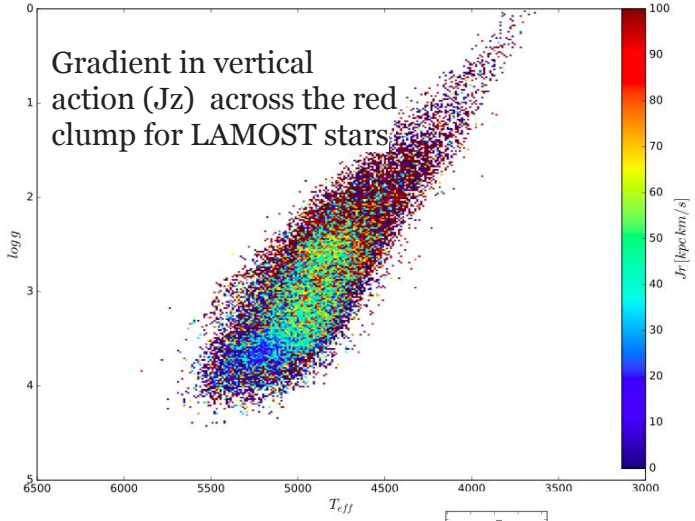
Data: ~1300 RC stars from APOGEE overlapping with TGAS. Thanks to Ness, Bovy, Gaia.

Using generative model for both velocities **and** ages.

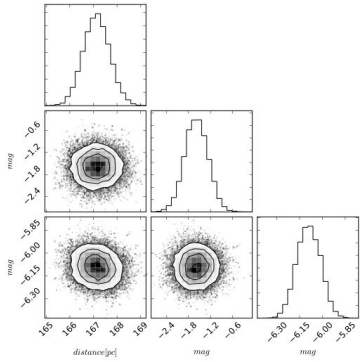
Many Thanks: Bovy, Ness, Hogg, Price-Whelan, Sanders; EVERYONE! What a groovy week.

TGAS + RAVE for actions

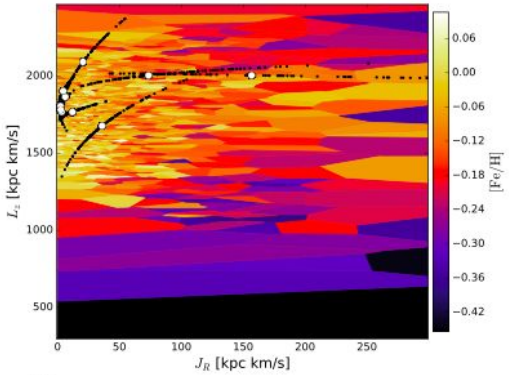
Johanna Coronado, MPIA

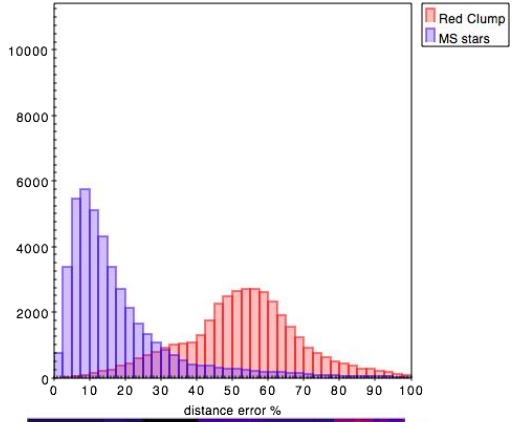


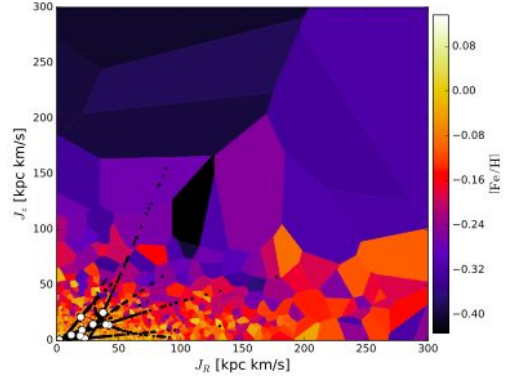
Work in progress:
222 stars with
APOGEE labels in
TGAS to obtain
photometric
distances

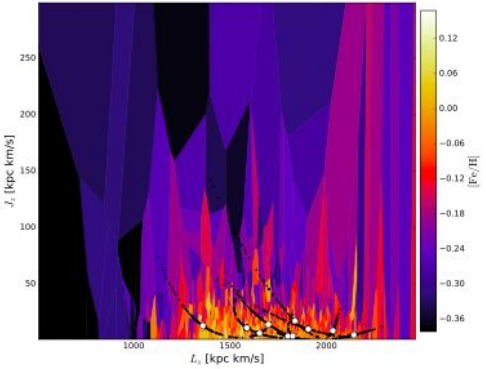


Current picture for error samples in action space for the distances of RC stars in TGAS + RAVE:





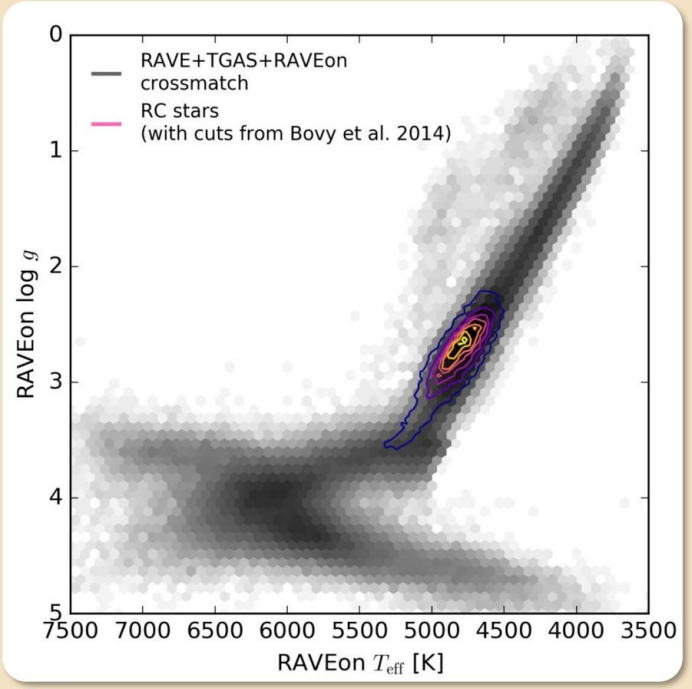




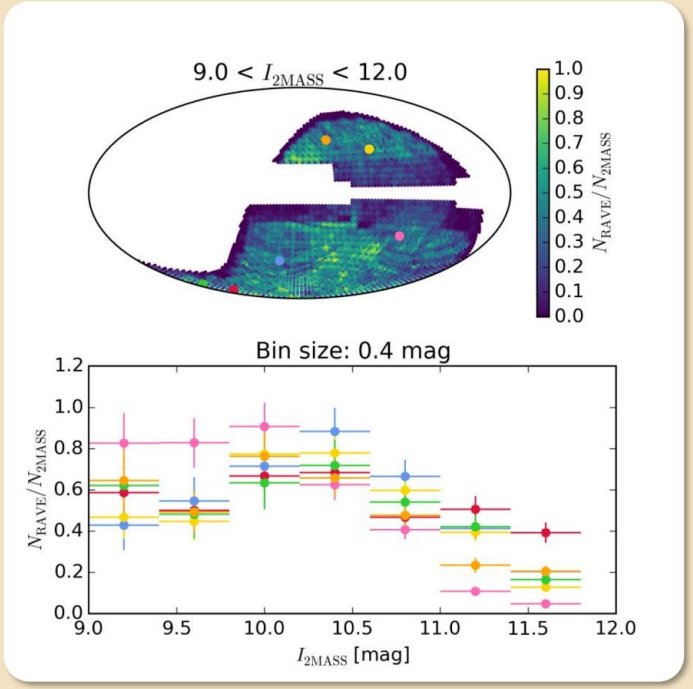
Preparing for Modeling TGAS+RAVE with RoadMapping

. . . to recover the Milky Way's gravitational potential

a) Selecting tracers



b) Setting up the Selection Function



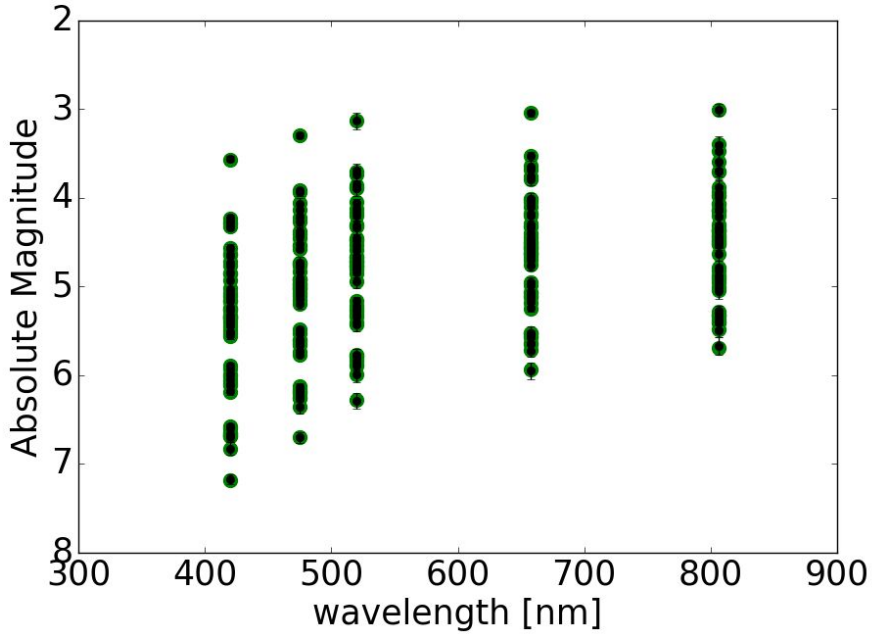
Thanks to: Jo Bovy, Georges Kordopatis, Jennifer Wojno

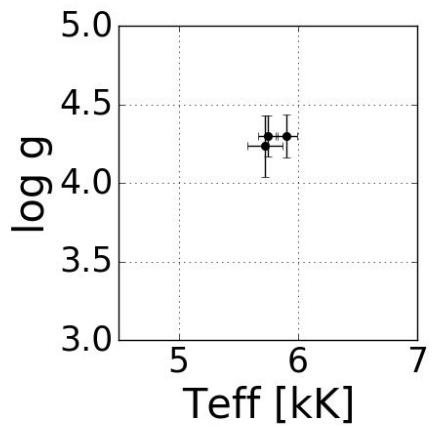
Want to dive into working with actions?
➡ Quick start tutorial:
github.com/wilmatrick/GaiaSprint

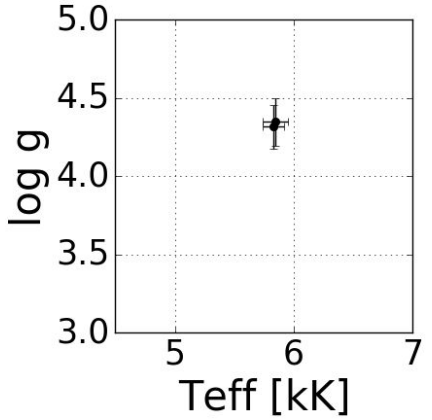
Wilma Trick

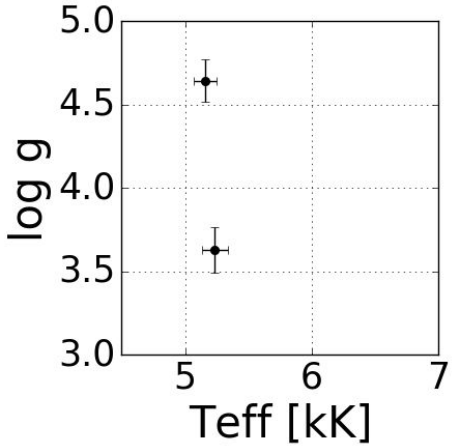
MPIA, Heidelberg

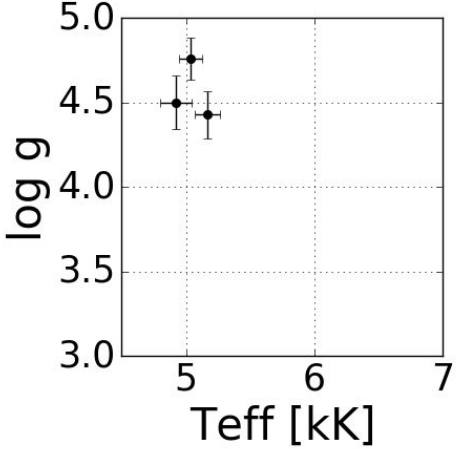
Photometric Twins in **GAIA** using **APASS**
Xmatched with **RAVE** for stellar parameters









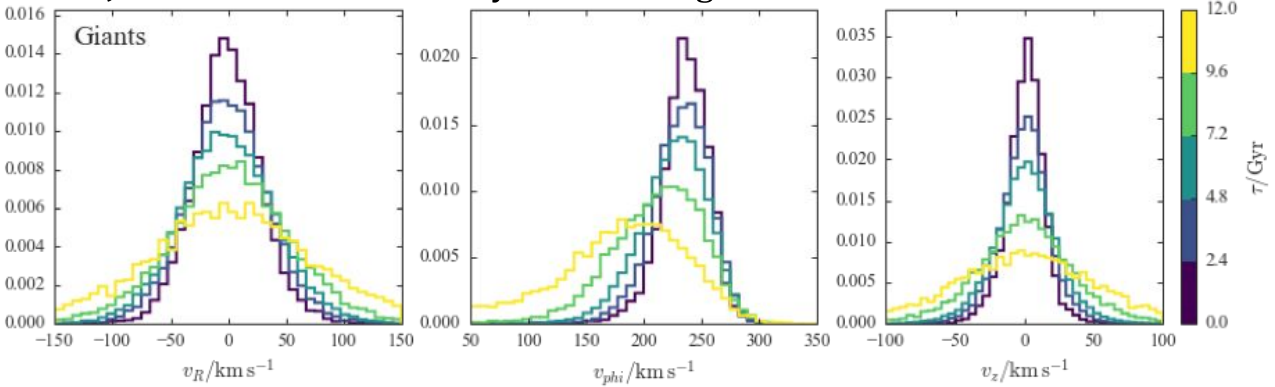


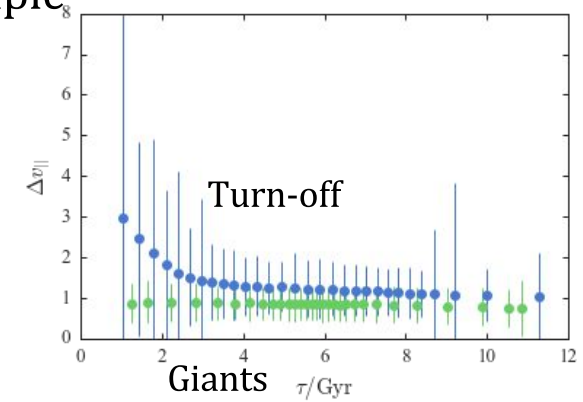
Lauren Anderson Flatiron Fellow, CCA
landerson@simonsfoundation.org
SIMONS FOUNDATION

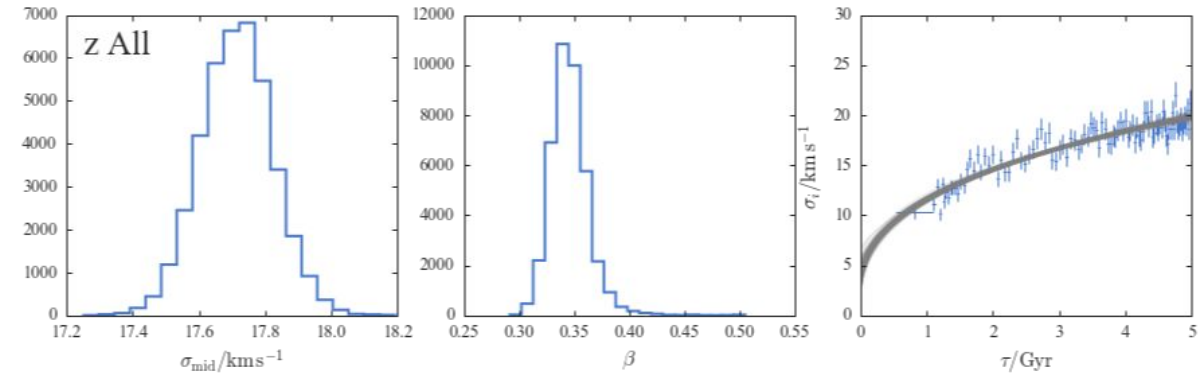
TGAS+RAVE-on age-velocity dispersion relation

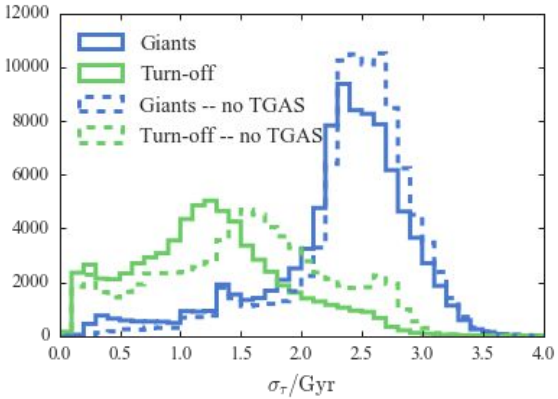
Age estimates from isochrones for giants and turn-off sample

Jason Sanders, University of Cambridge





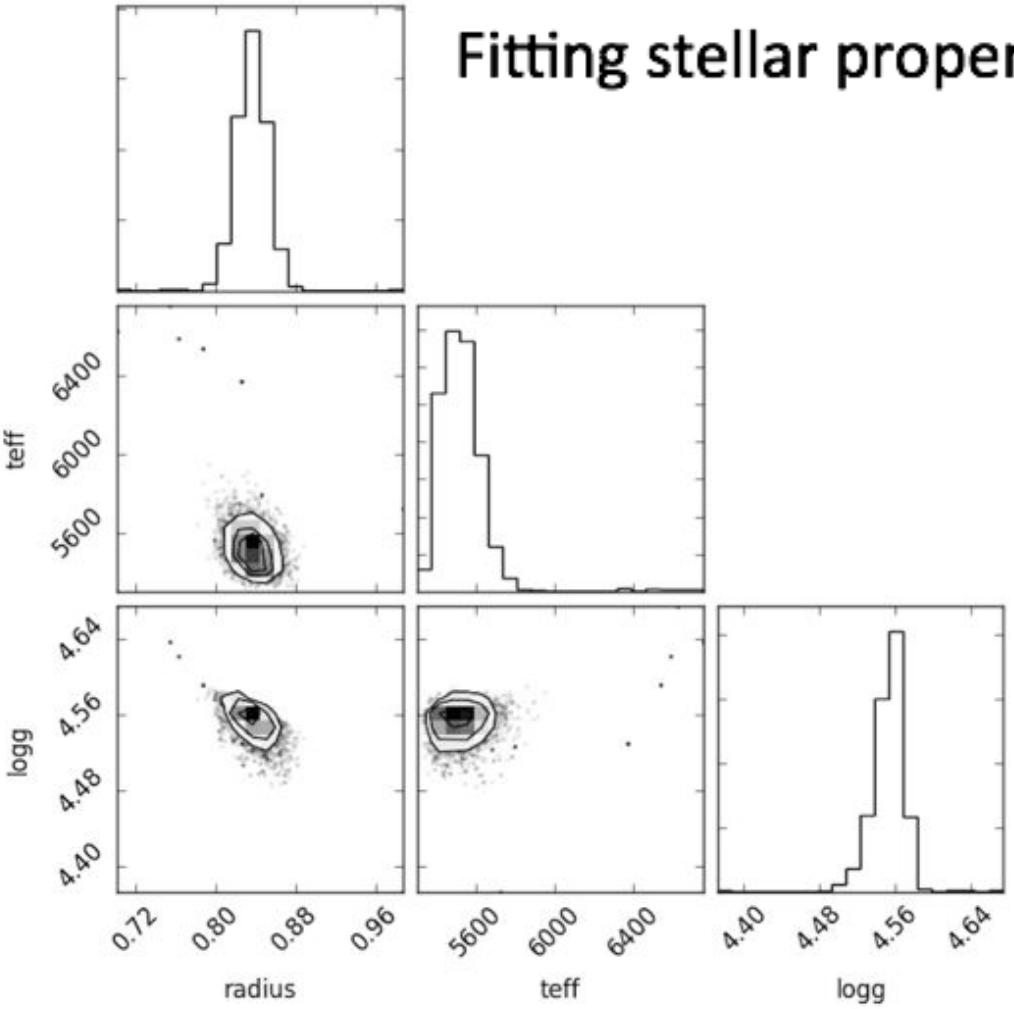




To do: more careful error modelling, remove OB stars that are flagged by RAVE for binarity etc.

Fitting stellar properties for exoplanet host stars

Sophia Sánchez-Maes
Yale / JPL ExEP



- Only known exoplanet host stars from Kepler with photometries and known met, teff, and logg information were fitted
- Informing isochrone model using LAMOST, TGAS, and photometry to fit for stellar properties
- Better estimates of metallicity, effective temperature, and logg, as well as distance

Thanks to Timothy Morton, Dan Foreman-Mackey, Miguel de Val-Borro and the Gaia Sprint!

Milky Way model with TGAS-APOGEE

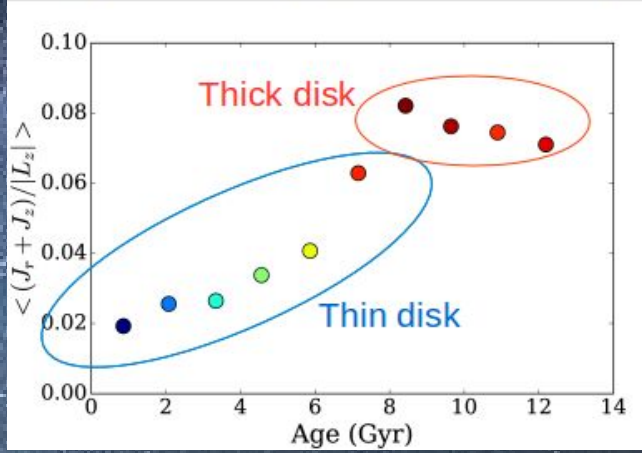
Dust model Isochrone model	Milky Way model f(***J***,[Fe/H],[α/Fe]) Distance model *d*(ω)

2-MASS (*J, H, K*)
Apogee (T_{eff},log*g*,[Fe/H],[α/Fe])
Cannon (*m*)
TGAS (Ra, Dec, ω, μ_{Ra}, μ_{Dec})
SDSS-TGAS (Ra, Dec, μ_{Ra}, μ_{Dec})

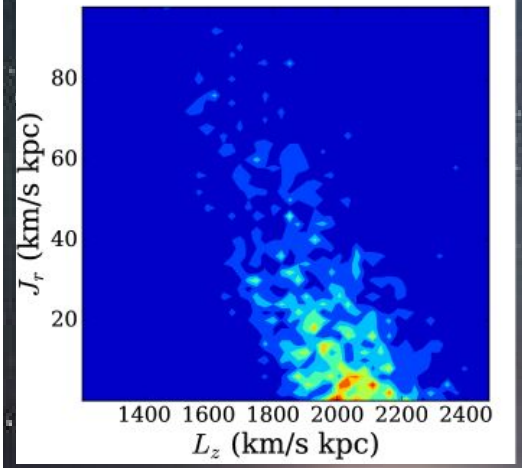
Payel Das

UNIVERSITY OF OXFORD

Age-eccentricity (TGAS-APOGEE)



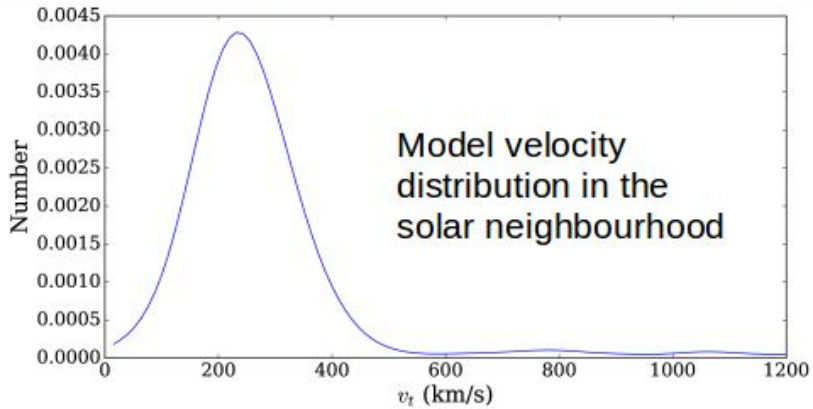
Resonances (TGAS-APOGEE)



Code

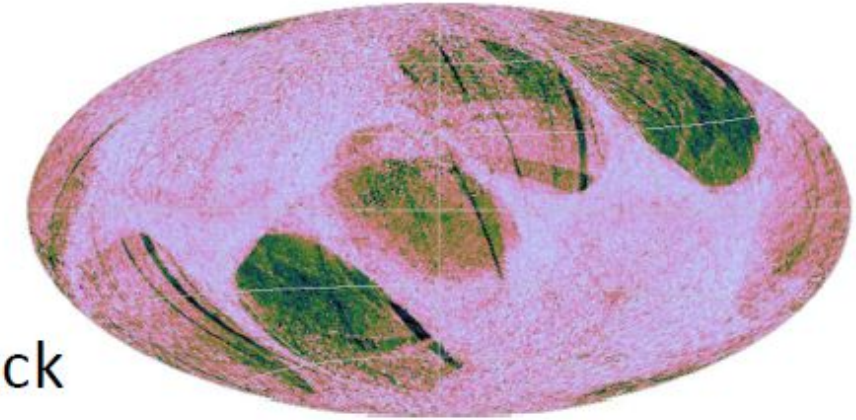
https://github.com/GalacticDynamics-Oxford/Agama
https://github.com/payeldas/FitGalaxyModels

Isolating hypervelocity stars with *f*(J)



TGAS *S*election function

$$S = S(\vec{x}, \vec{p}, \mu) = S(\vec{x})S(\vec{p})S(\mu)$$



What's next:

- Clean the hack
- Write the paper
- Make it usable
- Continue the calaboration

by Ronald Drimmel
INAF – Osservatorio Astrofisico di Torino

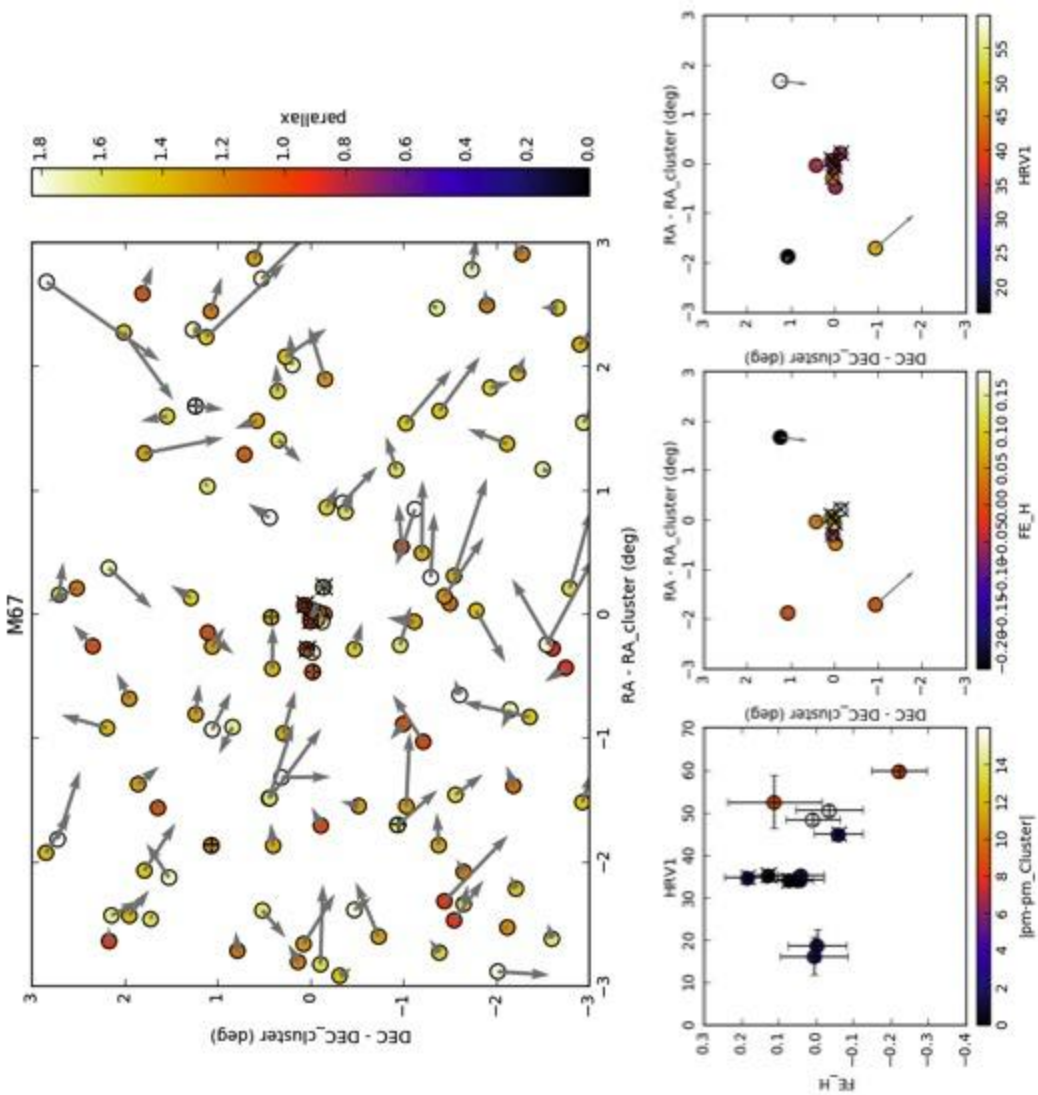
Escaping stars from known clusters

Tjitske Starkenburg

Center for Computational Astrophysics, Simons Foundation

with:

Keith Hawkins, Nathan Leigh, Lauren Anderson, Georges Kordopatis



Galactic escape speed & axis ratio

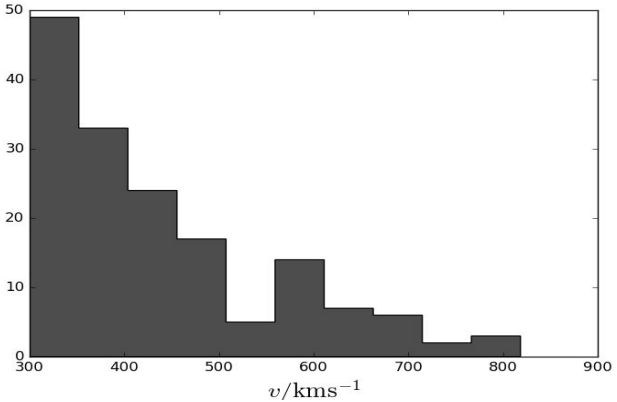
Gus Williams, Vasily Belokurov, Andy Casey

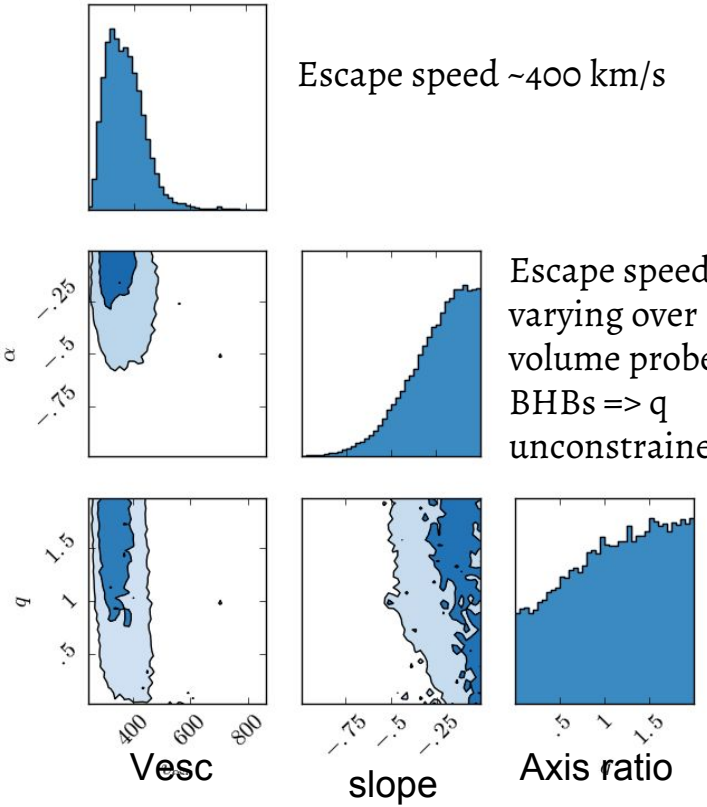
Model tail of velocity distribution:

p(V) = (Vesc - V)^k (Leonard & Tremaine 1990)

Allow Vesc to vary as a function of position => constrain change in Vesc with radius and the axis ratio of the potential

Constrain with BHBs from SDSS with radial velocities and Sergey Koposov's revised proper motions...





Use photometric BHBs and marginalise over radial velocity (with prior on anisotropy) => factor of 10 more objects so better constraints.

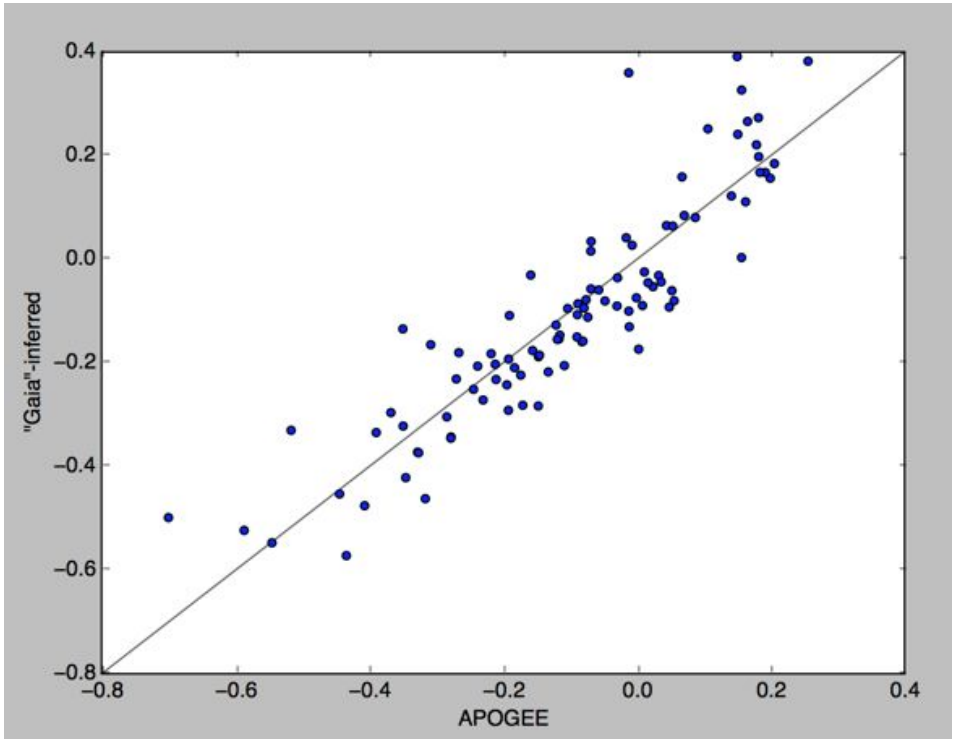
A first (bad) attempt at a semi-analytic model for stellar spectra

Andy Casey

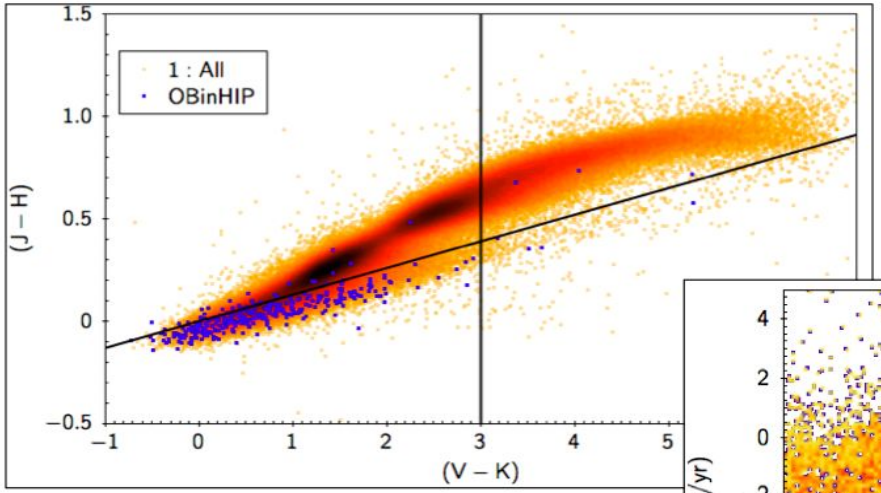
- APOGEE spectra
- Colors give priors on temperature
- Gaia gives prior on absolute magnitude
- Assume that a linear model is the true model for flux, and use a noise model (not shown):

$$y \approx \theta_0 + \theta_1 T_{\rm eff} + \theta_2 M_G + \theta_3 [{\rm Fe/H}]$$

- Require [Fe/H] coefficient to be negative (more MR = deeper lines)
- ~50,000 model parameters that need sampling

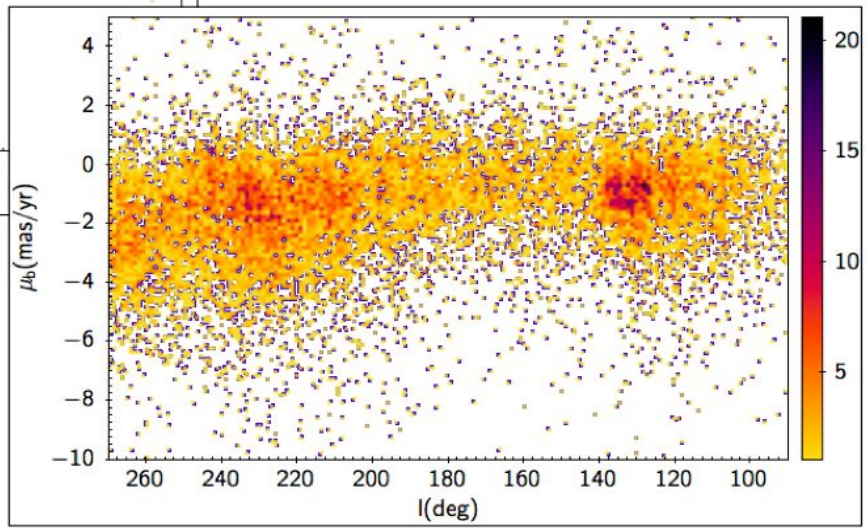


Search for kinematic warp signature in TGAS OB stars



1) OB stars selection + parallax cut

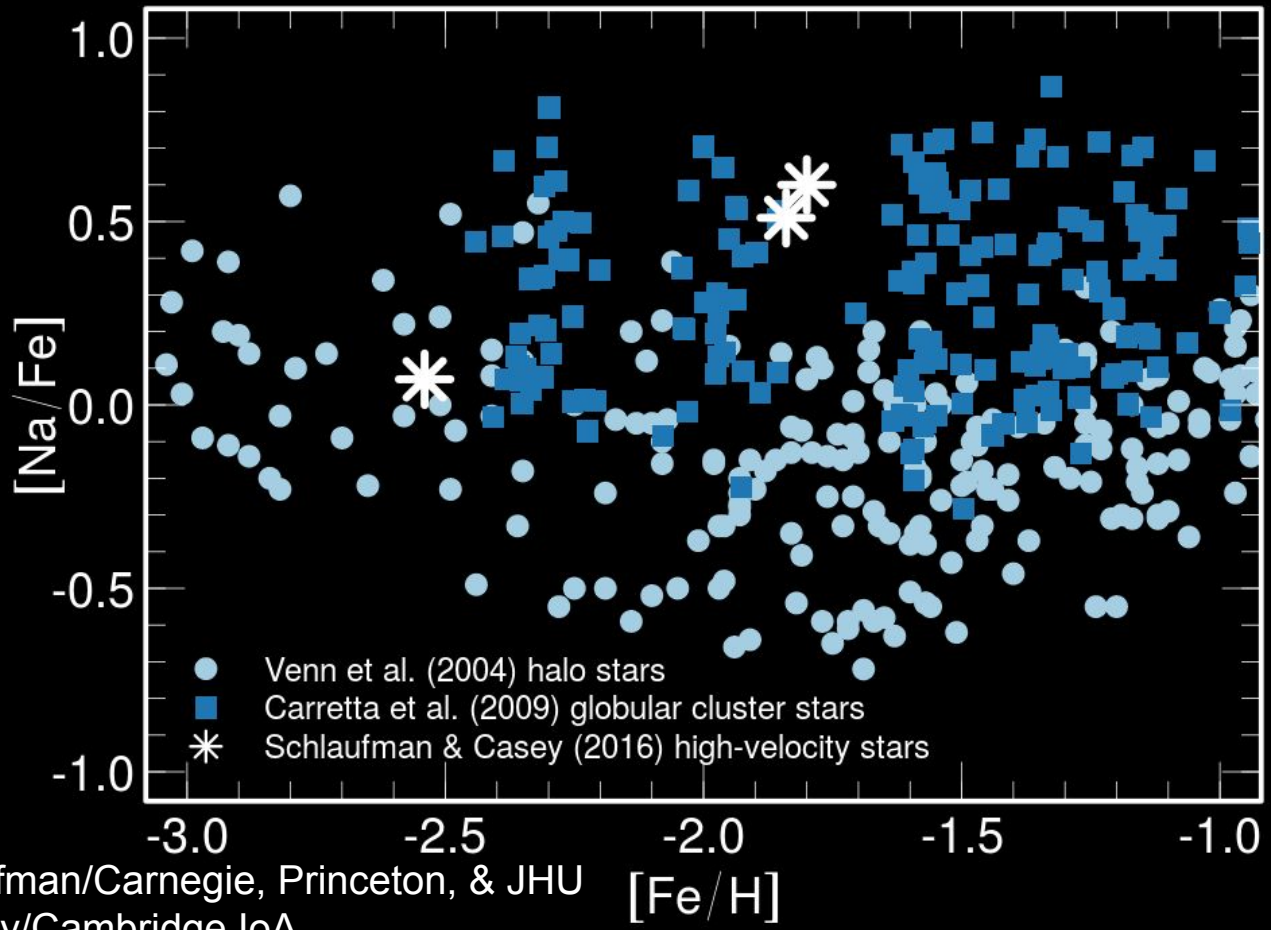
2) Explore $\mu_b(l)$



Eloisa Poggio

INAF — Osservatorio Astronomico di Torino

The Origin of High-velocity Stars



Kevin C. Schlaufman/Carnegie, Princeton, & JHU
Andrew R. Casey/Cambridge IoA

Kinematics-Chemistry-Age / Binaries + Neural Network

Yuan-Sen Ting, Harvard University