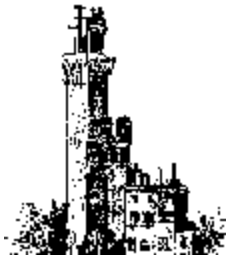
gaia



Gaia DPAC
Data Processing & Analysis Consortium

Astrophysical Parameters: Classification and Stellar Evolution

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+PD stellar evolution group

INAF, Padova, Catania, Torino

Overview

- Classification principles, goals
- Classification performances
- The Italian Contribution
- Stellar evolution verifications

CU8: Classification Principles

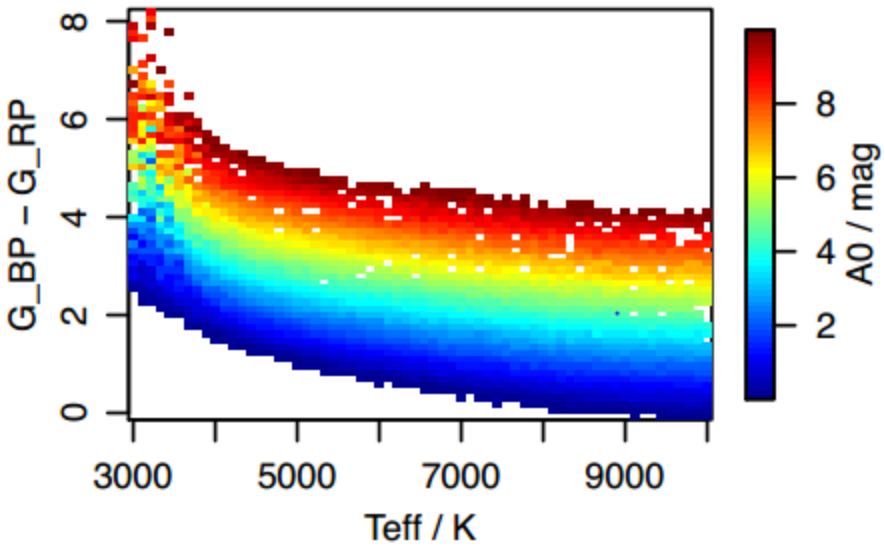
Goal : Object classification (photometry, spectroscopy, parallaxes)

- Discrete classification of objects: (single stars, QSOs, unresolved binaries, galaxies)
- Identification of QSOs (reference frame)
- Basic stellar parameters for single stars as input for RVS data processing: Log(g),Teff, [Fe/H], Av
- Derivation of L,R, age ,m using parallaxes (and stellar models)
- Parametrization of special sources (galaxies…)

- **Italian contribution: Training data**
  Galaxy simulation
  Cool star classification

Not involved in the commissioning, but early tests with EPC

Data release scenario

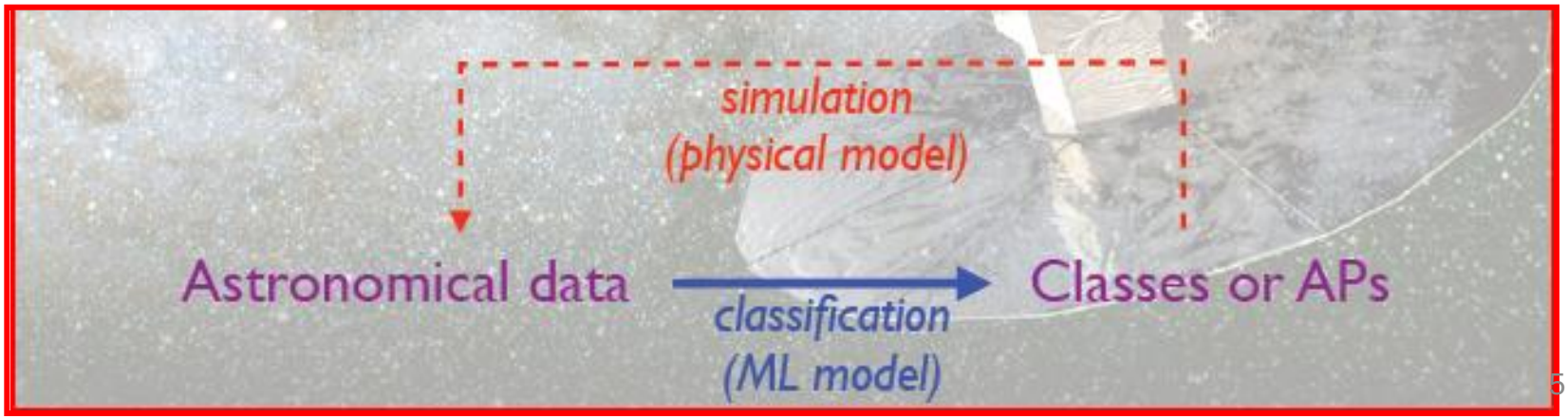


One Parameter Classification
Teff assuming Av

Second release: launch + 28 Months Feb-2016	• **Positions (α,δ), proper motions, and parallaxes** and G-mag for single stars (90% of the sky) •Integrated photometry RP/BP (some astrophysical parameters, if available) • **Mean radial velocities for stars** with non-variable radial velocity (90% of the sky)
Third release: launch + 40 Months Feb-2017	• Updates of above + • Orbital solution for period between 2 months and 75% of the observation duration • Spectrophotometry from RP/BP for sources for which astrophysical parameters are simultaneously released • **Source classification based on BP/RP and astrometry** for stars with sufficiently high quality data • Mean RVS spectra for sources where single epoch spectra are usable and APs are simultaneously released

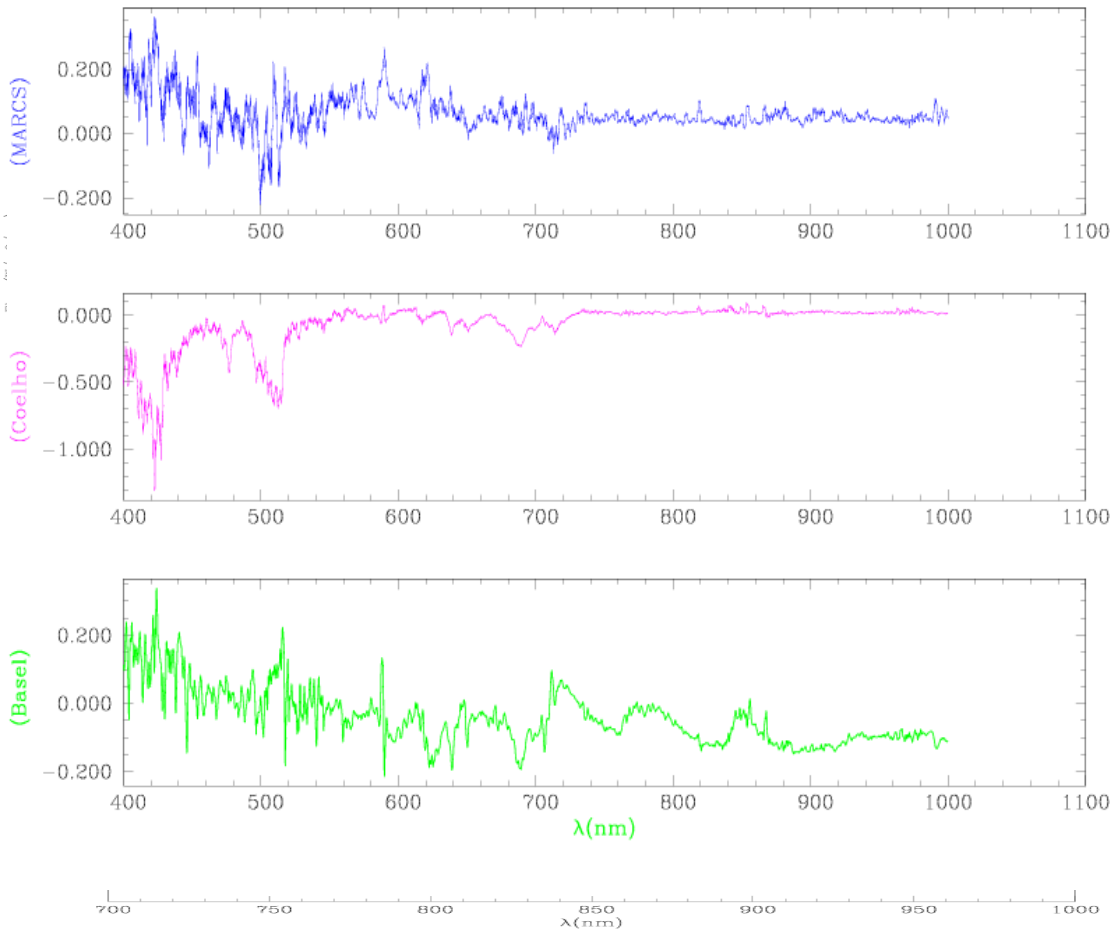
Gaia Training data

- The classification algorithms (except OCA) based on supervised models.
- These classify sources or estimate their APs source-by-source based on their similarity to a set of predefined templates.
- Training data: software engineering+ strong scientific background to ensure the requested quality to data classification



Validating Stellar libraries

- Quali
  Phoe
- BP/RI
- RVS:



- Quali
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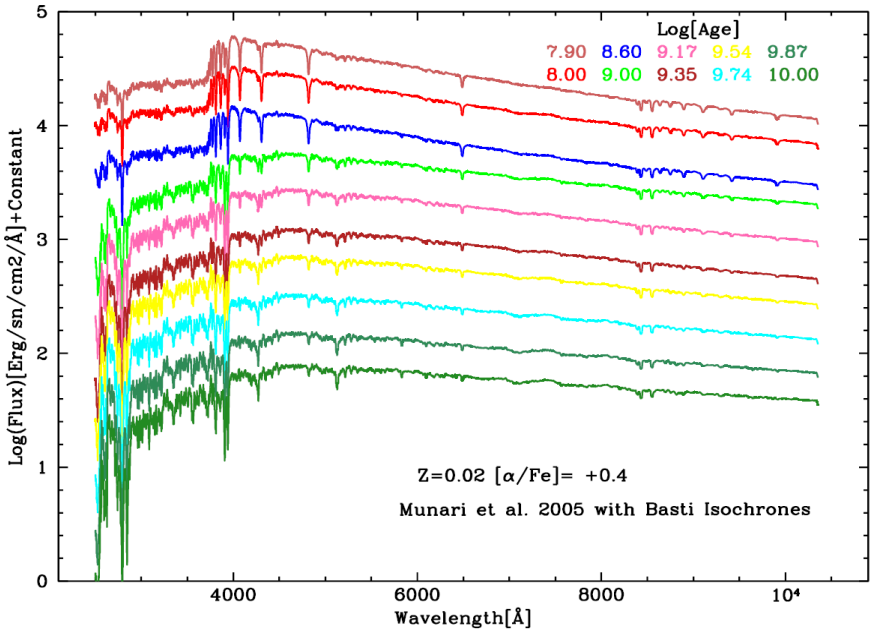
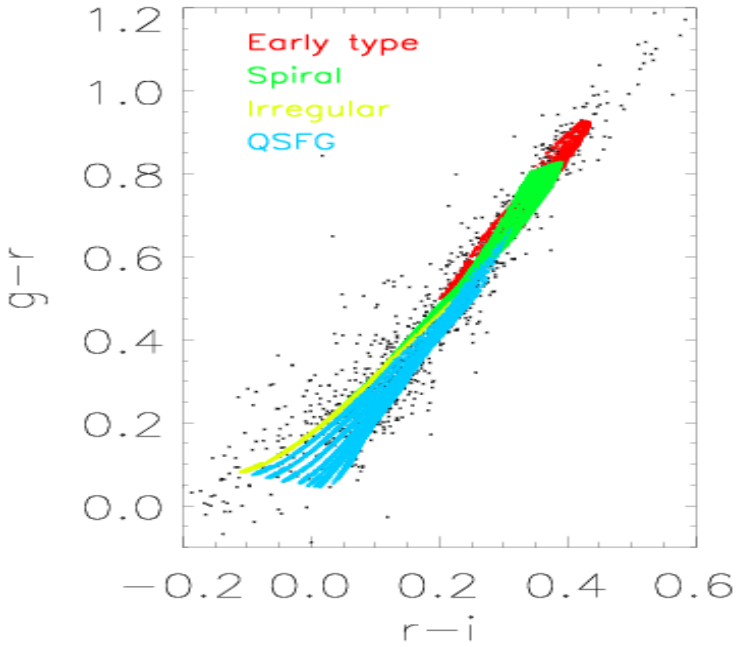
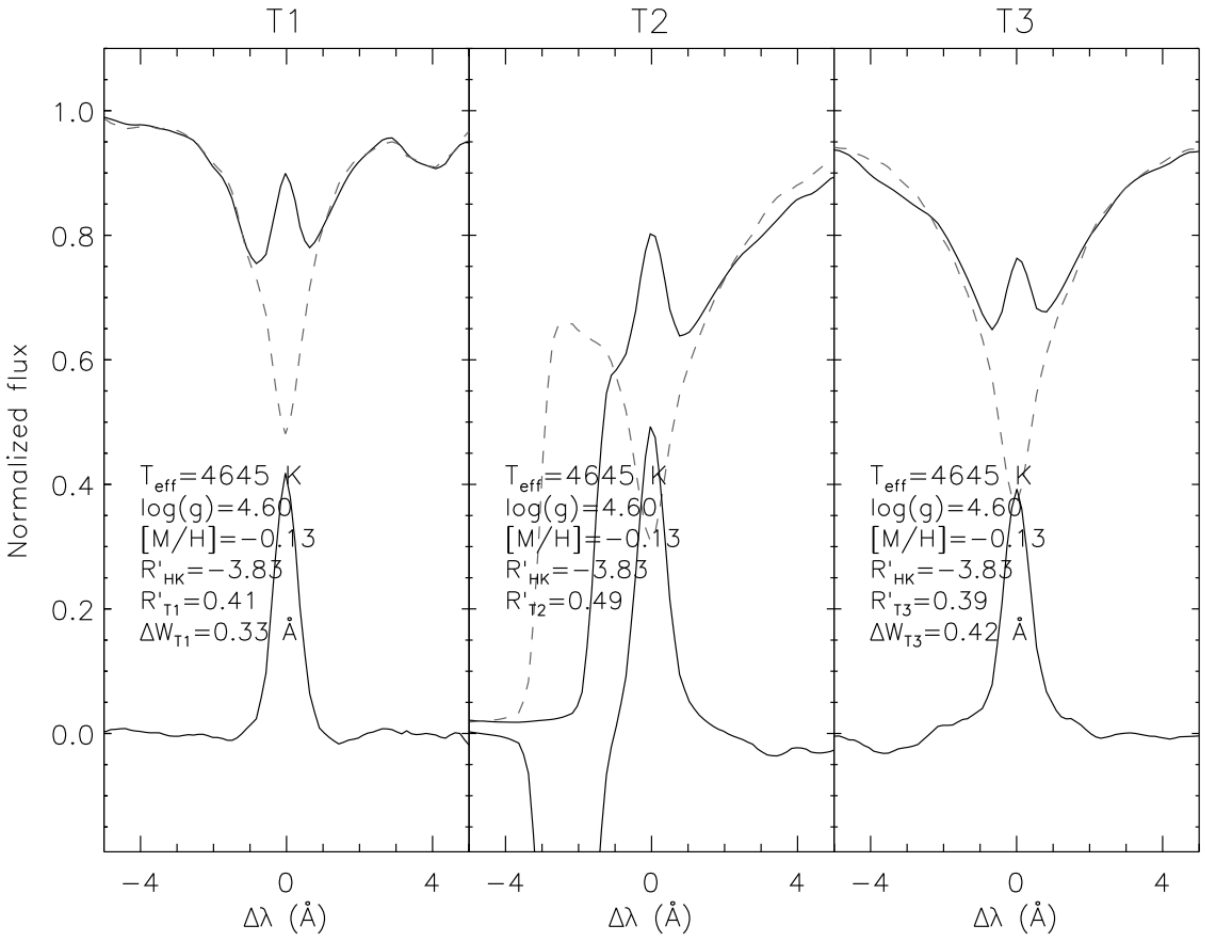
Galaxy simulations and classification





- Starting from stellar isochrones+Gaia spectral libraries→ SSP calculation→ synthetic galaxy libraries (Pegase)—10^5 galaxies (Sordo+2012,Tsalmantza+ 2006,2009,2010,2012)
- Galaxy simulations and classification → 10^6-10^7 gal. to z=0.2
- Derived: Galaxy type, z,Δz=0.007; SFR estimate (E and S)

Cool star Classification



Simulations on Ca IRT FEROS data degraded to RVS resolution

Astrophysical Parameters of active stars (young)

Gaia legacy on chromospheric activity will replace Mt.Wilson.

Training data calculation

- Training data: production of libraries of synthetic stellar spectra and simulated Gaia spectra:
  →stars, galaxies, QSOs, binaries
  →distribution of the stars in the sky following Galaxy model, stellar evolution, IMF,
  →2 Terabyte of data per cycle, several millions of spectra

- CU8-CU2 interface; CU2 simulation software verification and debugging
- Tools to calculate and manage large datasets

- *In total 3.8 FTE*
- *Simulations and classification tasks are forseen till the end of the mission*

Data Bases for Gaia Classification

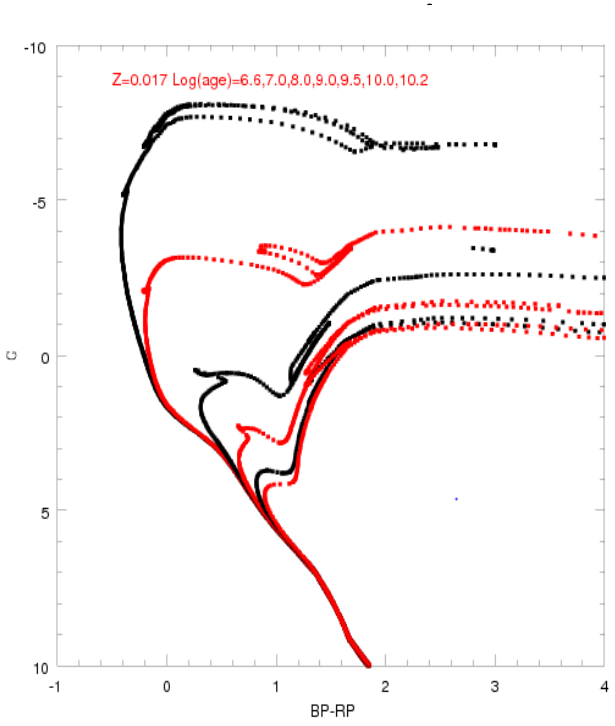
- synthetic / observational stellar spectra
  (Sordo Munari et al 2005, Sordo, Vallenari et al 2009, 2010)

- Synthetic galaxy spectra, SSPs (PD-Athens-Paris)
  Semiempirical libraries based on SDSS(v1—V3
  (Tzalmatza et al 2006, 2007; 2011; Sordo et al 2013)

- Stellar tracks and isochrones
  He content, [Fe/H]
  (Bertelli, Nasi et al 2008, Jordi..Vallenari.. 2010,
  Bressan+ 2013)

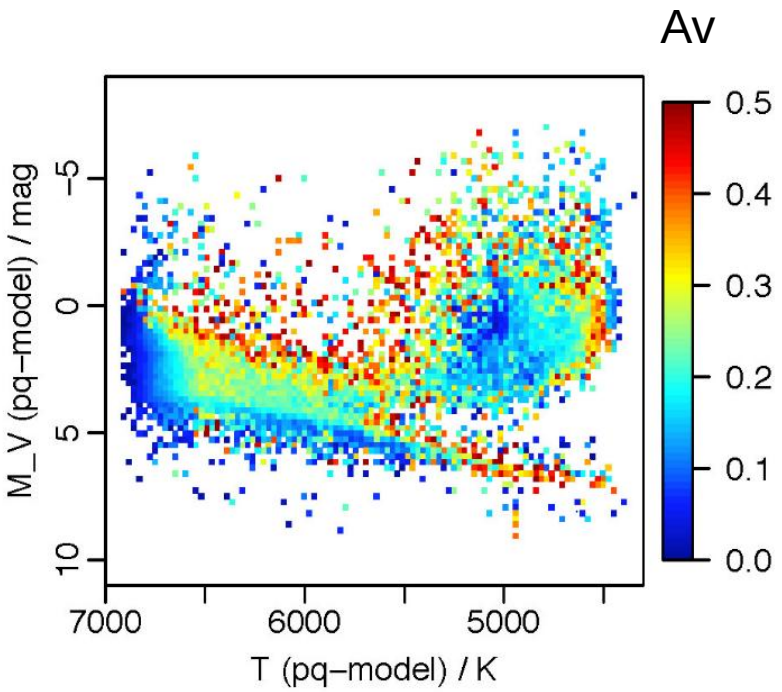
- Gaia Simulated spectra

- *To be hosted and made accessible at the ASDC*



Jordi, ..Vallenari et al 2010

Gaia Classification



Gaia Classification of a set of 85 000 stars with Hipparcos parallaxes and BVJHK photometry. (Bayler Jones, …Vallenari 2009)

Expected performances at G=19

AP	SVM	ILIUM	Aeneas	
			p-model	pq-model
$T_{\rm eff}$ (K)	98	198	110	119
[Fe/H] (dex)	0.25	0.27	0.19	0.21
log g (dex)	0.26	0.60	0.37	0.28

(Liu..Vallenari, Sordo.. 2013)

Accurate distances, magnitudes, APs→ accurate comparison with stellar models

Stellar evolution tests: Gaia+ Surveys

- Gaia: accurate distances, parameters

Missing :

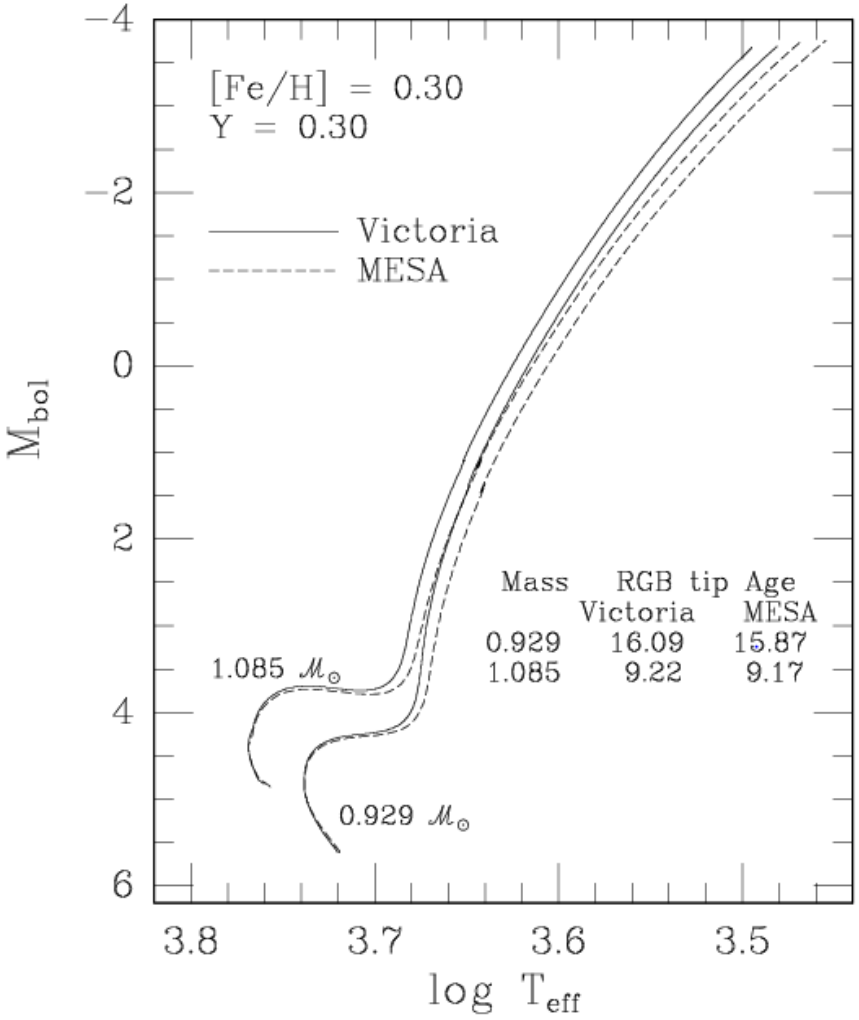
- Accurate photometry (HST, ground based surveys, Vista, PAN-STARRs,...)
- metallicities (to 0.2dex) for the faint part of Gaia survey 16-17<V<20
- Detailed chemical compositions (to 0.1dex accuracies) and high accuracy radial velocities for 12<V<17
- GES: precise [Fe/H] and abundances, radial velocities (faint objects), rotation (at 10%) → Sofia talk

Current status of Stellar models

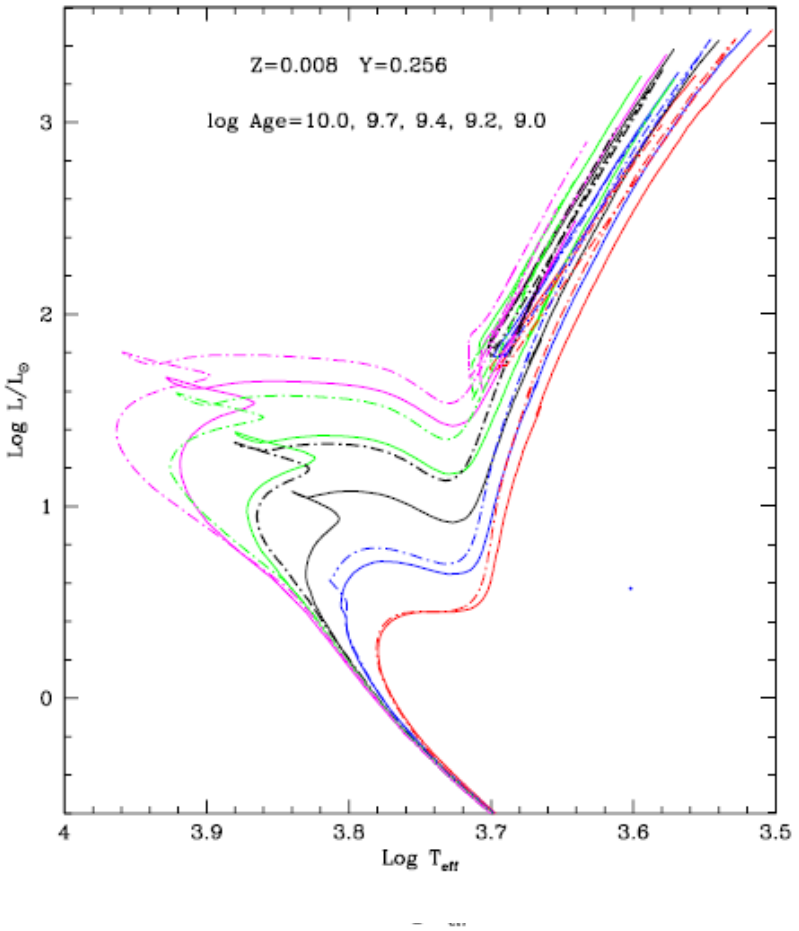
- 3D hydrodynamical models (Viallet et al 2011, Freytag et al 1996, Bigot et al 2006) → still a challenge
- 1D models: simplified approched using free parameters: EV (Eggleton 1971), EVOL (Herwig 2004),EZ (Paxton 2004), FLASH-the-tortoise (Lesaffre et al. 2006),GARSTEC (Weiss & Schlattl 2008), NOVA (Starrfield et al.2000), TITAN(Gehmeyr&Mihalas 1994), andTYCHO(Young & Arnett 2005), FRANEC (Pietrinferni et al 2004), Girardi et al 2008
  - **mixing**(semiconvection,overshoot,diffusion,extra-mixing)
  - **rotation (**magnetic braking, rotational mixing)
  - **EOS** (critical for m<0.7 Mo)
  - **nuclear reaction rates**
    - NACRE compilation (Angulo et al.1999)
    - LUNA Collaboration(Bemmerer et al., 2006)
    - revision $^{14}N(p, \gamma)^{15}O$ (Weiss et al 2008, Marta et al 2008)
  - **bolometric corrections** (ATLAS9, Phoenix...)

Current status of Stellar models

Bertelli et al 2009



Paxton 2011



New Padova tracks and Teramo
Solid lines correspond to PD08
models, dash-dotted ones to Teramo tracks.

Gaia+GES observational templates

- Distances+stellar parameters →Fiducial sequences vs metallicity to calibrate stellar models
- Asteroseismology : 10 Ocs Corot/Kepler. NGC 6633

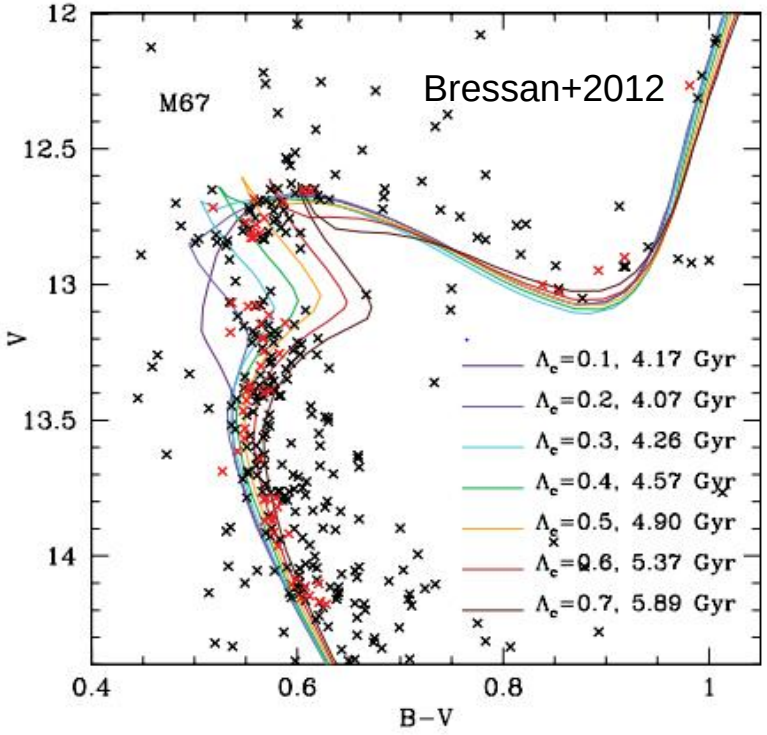


Figure 16. PARSEC isochrones overlaid in the CMD of the intermediate-age star cluster M 67. The distance modulus and colour excess were fixed as $V - M_V = 9.75$ and $E(B - V) = 0.03$, as shown in Fig. 17 next.

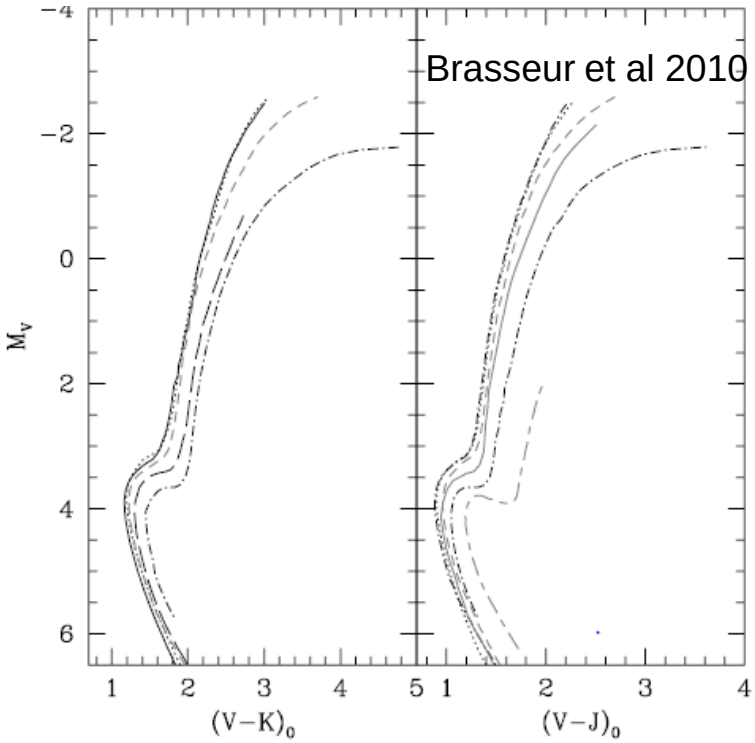
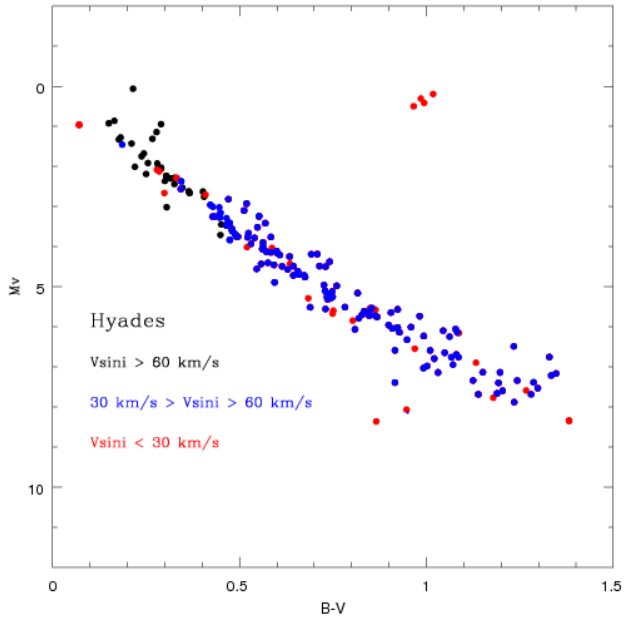
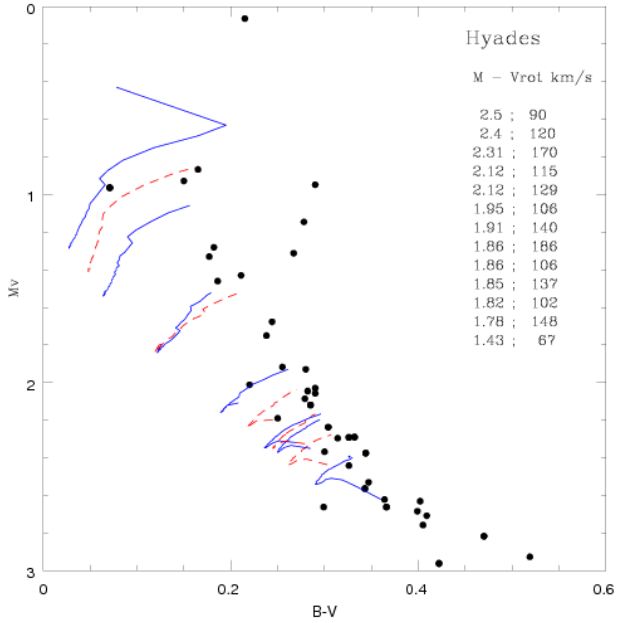


Figure 21. Our cluster fiducials mapped to the $[(V - K_S)_0, M_V]$- and $[(V - J)_0, M_V]$-planes using the reddenings and distance moduli given in Table 2. From left to right, corresponding to increasing metallicity, are M 15 (solid black), M 92 (dotted black), M 13 (gray short-dashed), NGC 1851 (black long-dashed), M 5 (black solid line), M 71 (black dot-dashed), and NGC 6791

Test case: Hyades

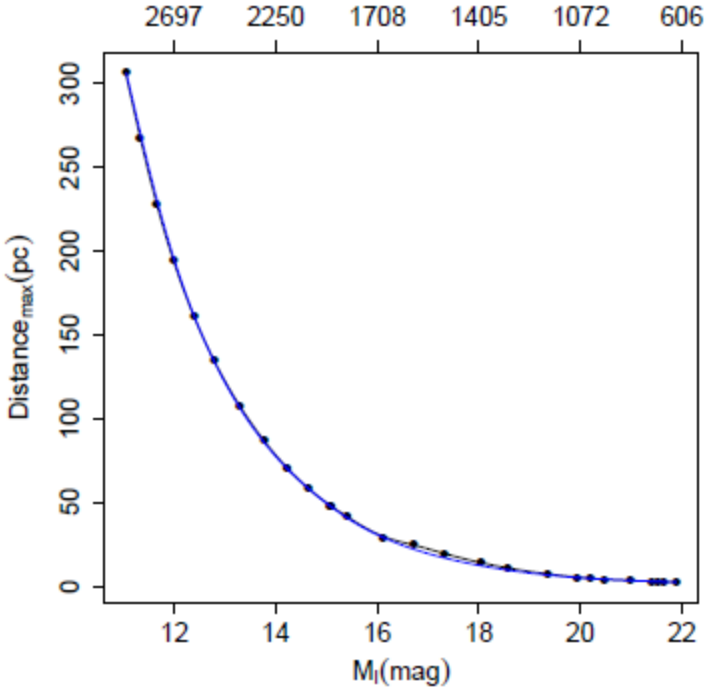


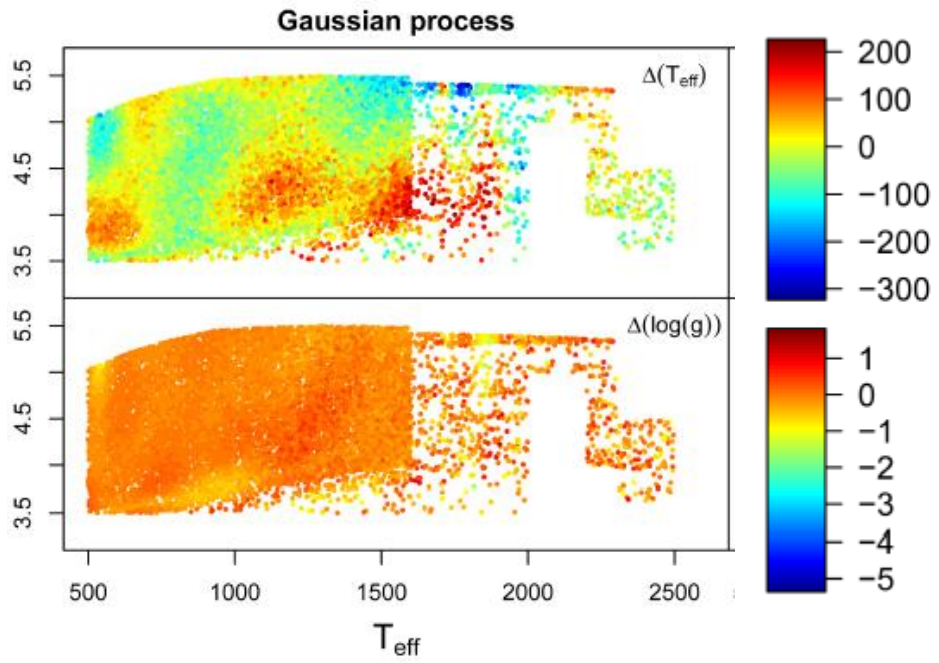


Santoro+ 2013

- 625±50 Myr (first Hipparcos data) Perryman et al. 1998
- 650 Myr (wide binaries He enhanced) Lebreton et al. 2001
- 625 Myr (second Hipparcos catalogue) De Bruijne et al. 2001
- 570±15Myr without rotation (diffusion) Morel & Thévenin 2002
- 700±20 Myr with ad hoc models for rotation+diffusion (Santoro et al 2013)
- 648 ±45 Myr WD cooling sequence De Gennaro et al 2009

Late type dwarfs





- Late type dwarfs visible to 300 pc
- Precise parameter determinations (Teff, log(g)) [FE/H] and m and Radius by comparison with stellar models

→ Crucial to derive planetary radii in transiting systems to discriminate interior models of exoplanets

Conclusions

- Gaia classification will provide precise parameter determination
- Synergies with existing surveys (GES) and Corot/Kepler
- Gaia data will allow calibration of stellar models