

(AT-Physique Stellaire: les interfaces)

La physique stellaire au cœur de l'astrophysique moderne

Orlagh Creevey

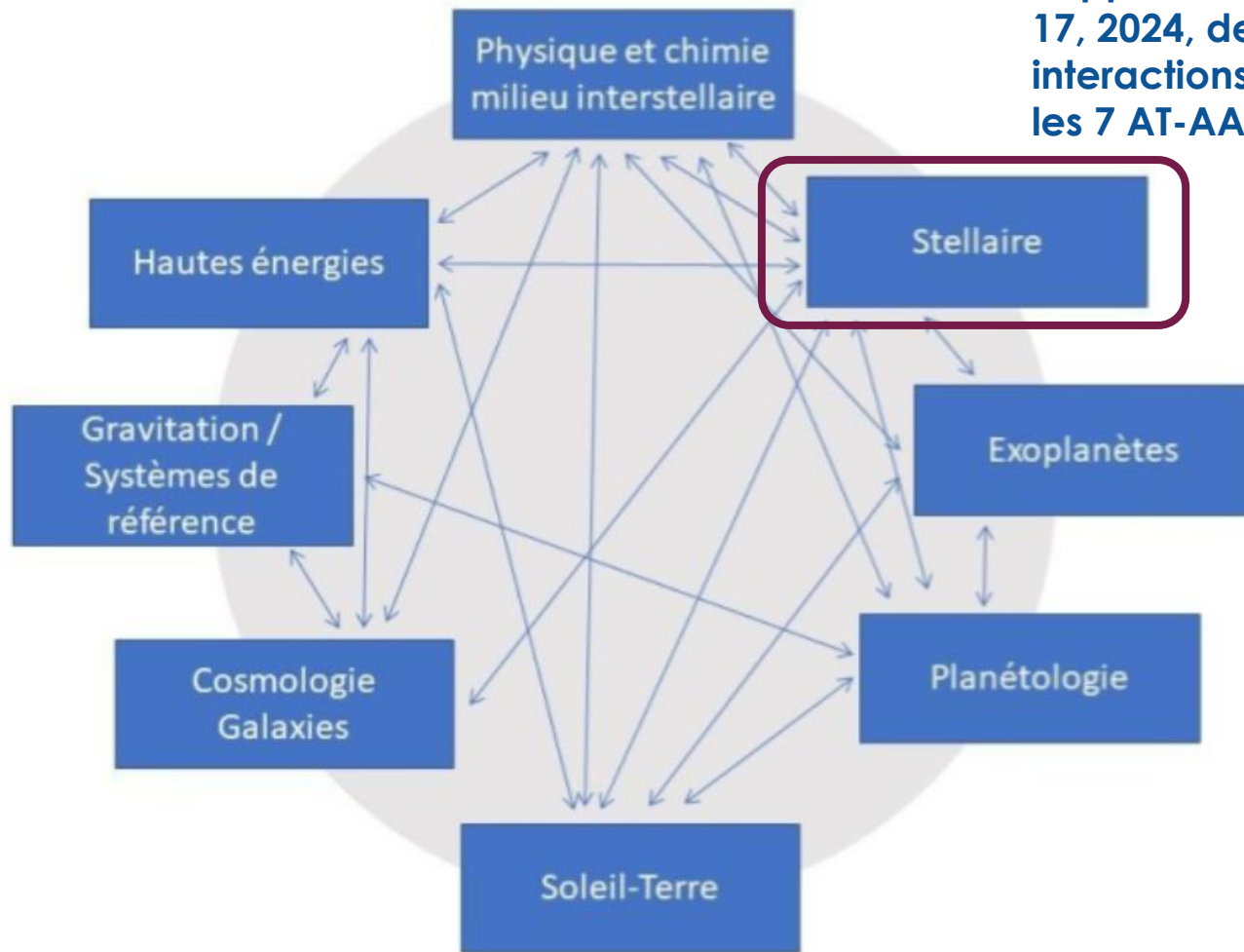
Laboratoire Lagrange (OCA/CNRS/UniCA)

24 juin 2026

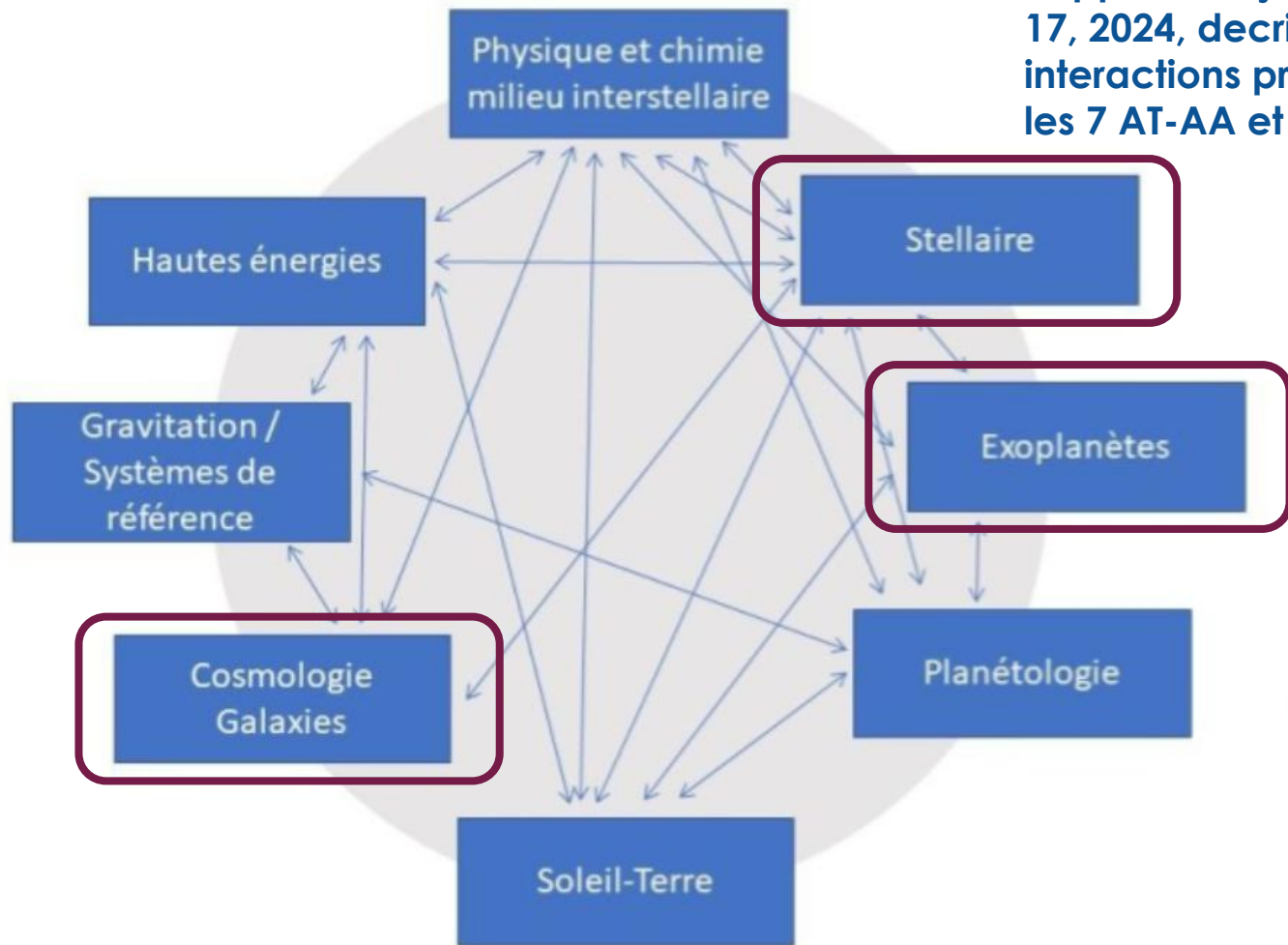
Combien d'entre vous s'intéressent à la physique stellaire ?

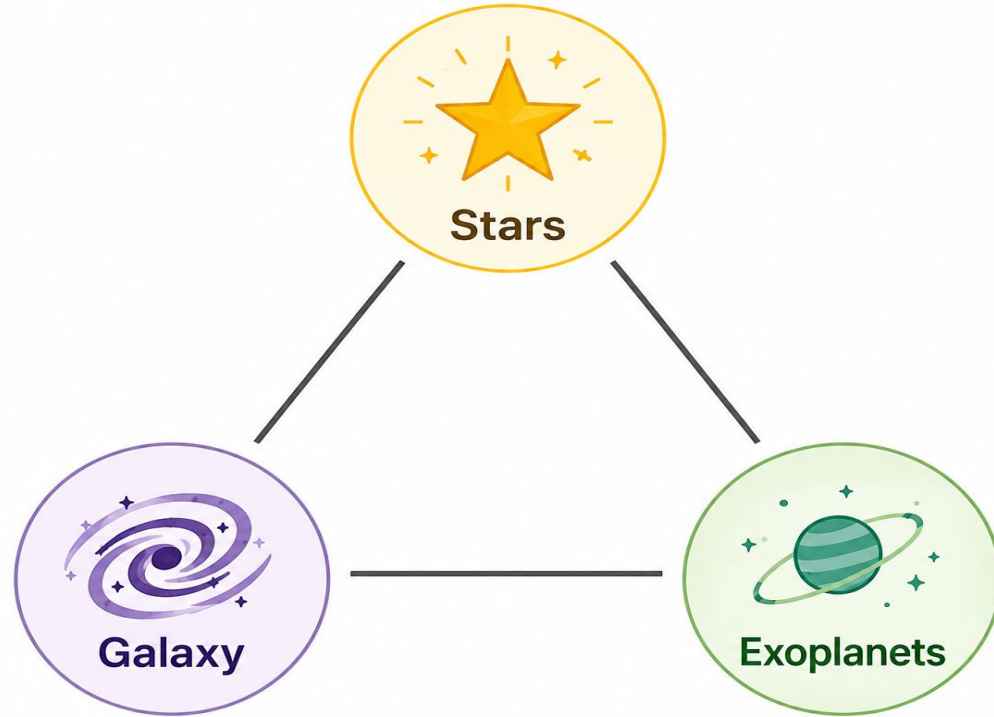
Do you think you are concerned by stellar physics ?

Rapport Conjoncture Section
17, 2024, décrivant les
interactions principales entre
les 7 AT-AA et PNP

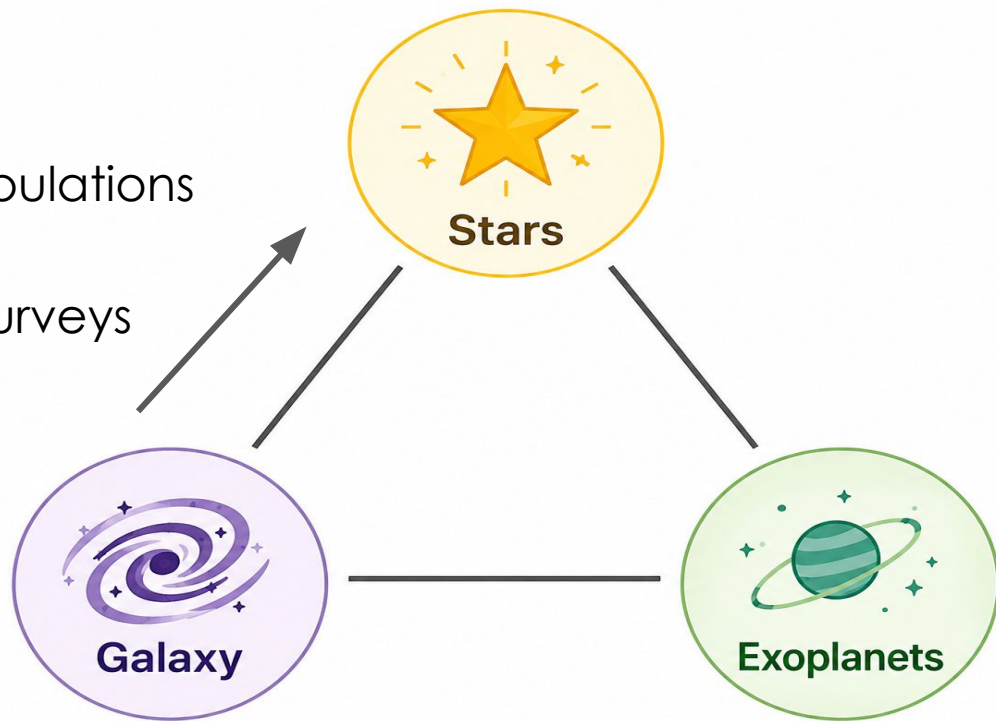


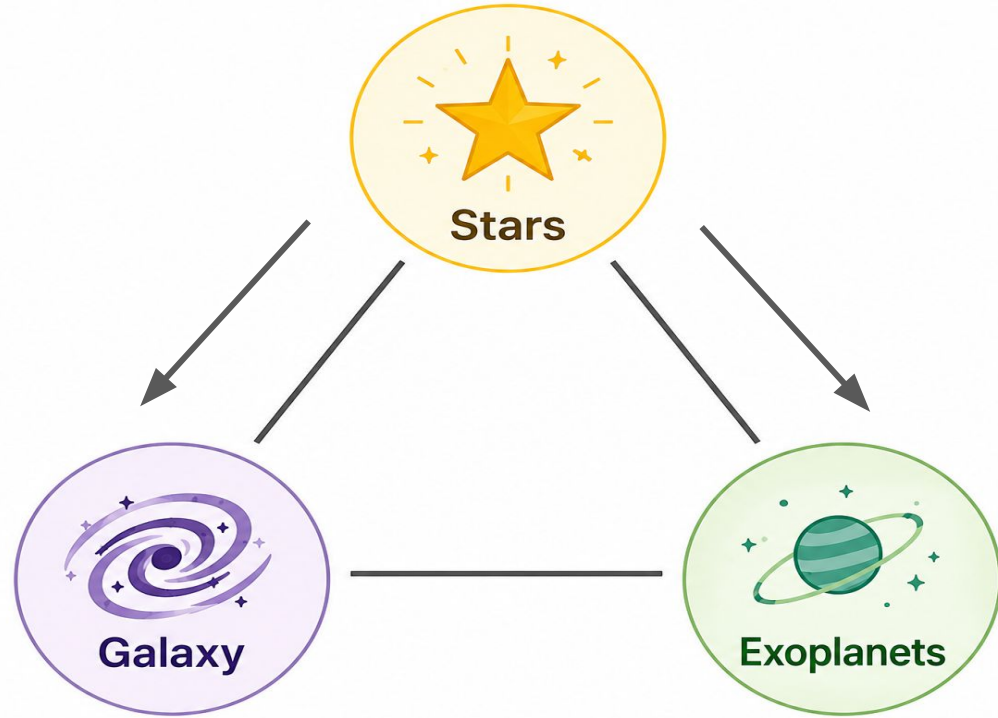
Rapport Conjoncture Section
17, 2024, décrivant les
interactions principales entre
les 7 AT-AA et PNP





Kinematics
Membership populations
Multiple systems
Spectroscopic surveys





This talk I focus on the
other direction

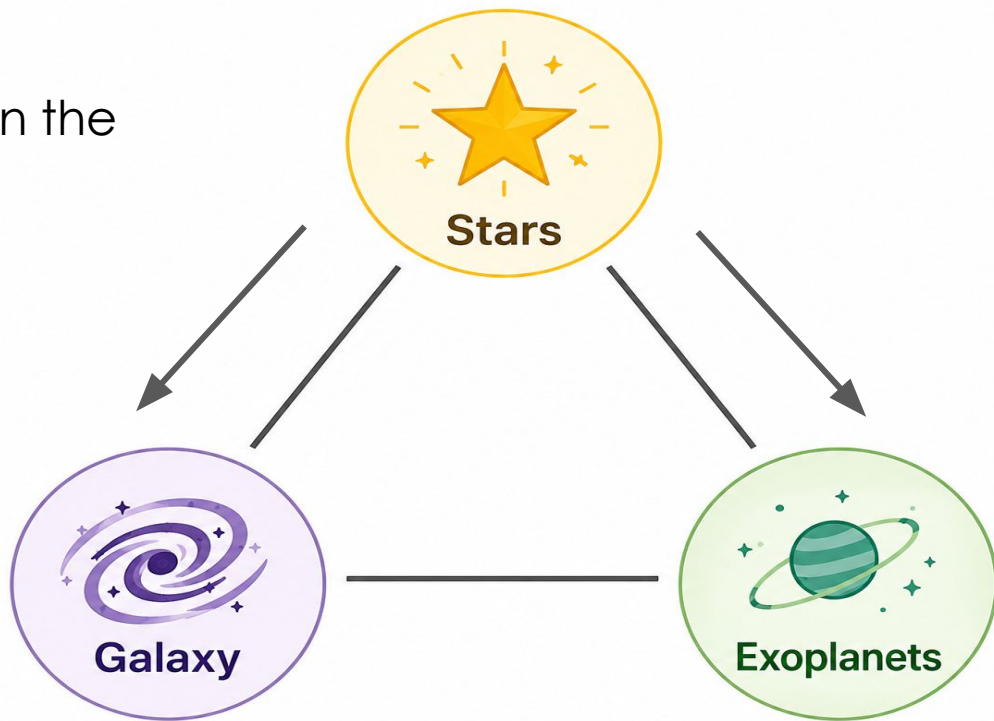
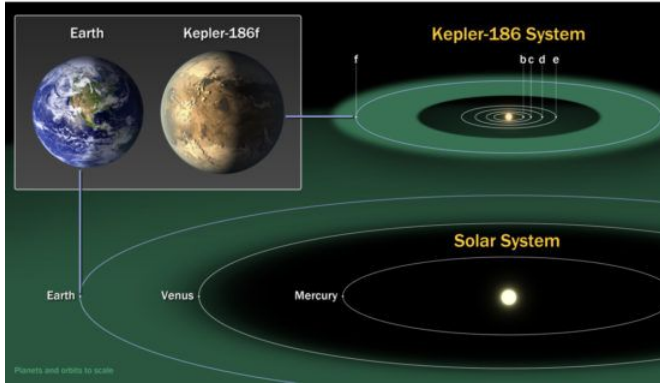
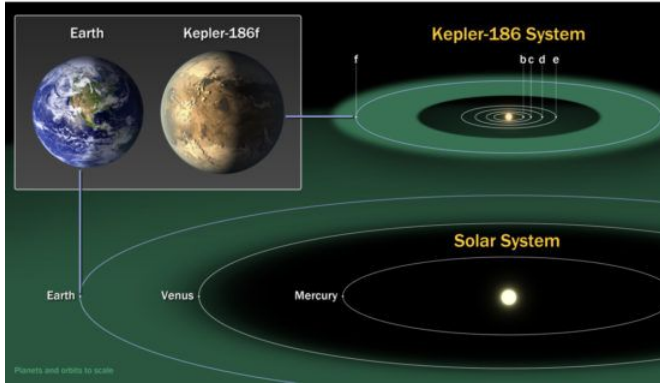


Image credit: NASA



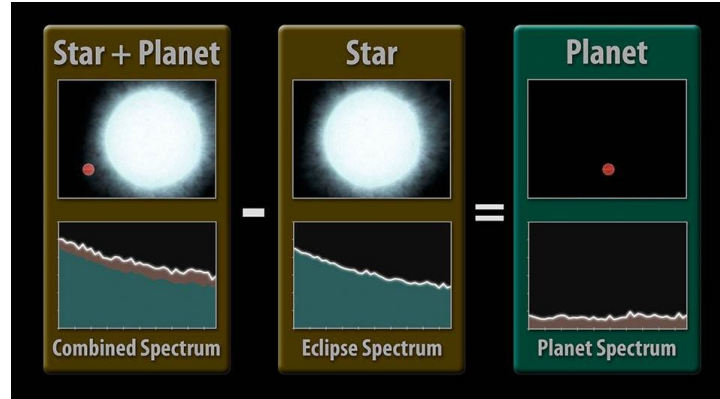
Stellar mass, radius, and T_{eff} →
Planet size, density, irradiation

Image credit: NASA



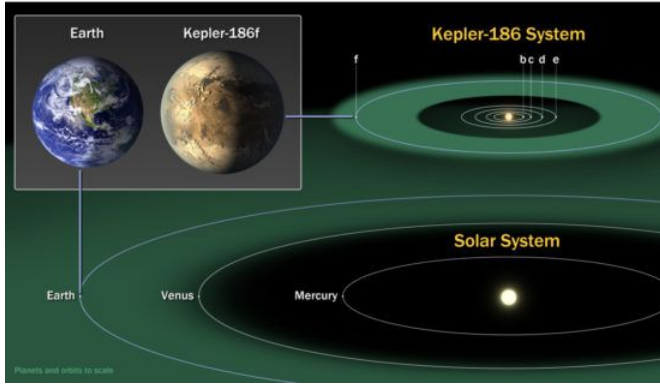
Stellar mass, radius, and T_{eff} $\rightarrow$
Planet size, density, irradiation

Image credit: NASA/JPL-Caltech/R. Hurt (SSC/Caltech);



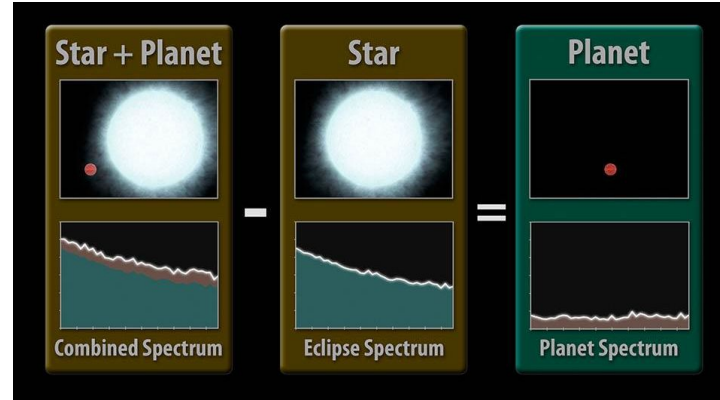
Stellar “contamination”
 $\rightarrow$ Planet atmosphere

Image credit: NASA



Stellar mass, radius, and T_{eff} →
Planet size, density, irradiation

Image credit: NASA/JPL-Caltech/R. Hurt (SSC/Caltech);



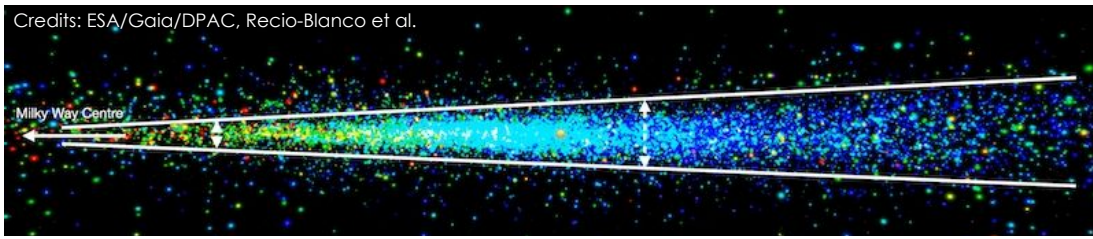
Stellar “contamination”
→ Planet atmosphere

Stellar age
→ Planet age

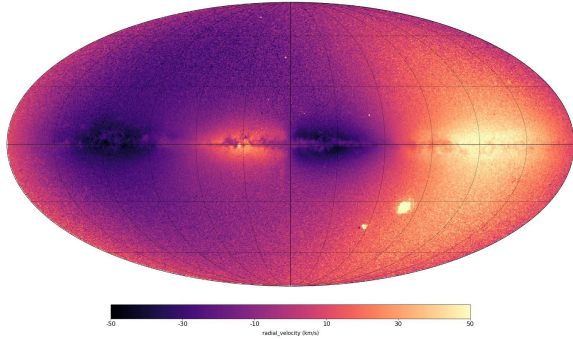
Image credit: NASA/JPL-Caltech/Lizbeth B. De La Torre; adapted by O. Creevey



Credits: ESA/Gaia/DPAC, Recio-Blanco et al.



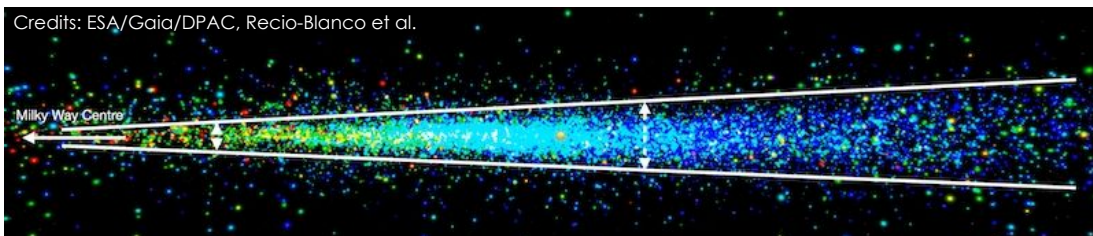
Stellar abundances →
Chemistry of the Galaxy



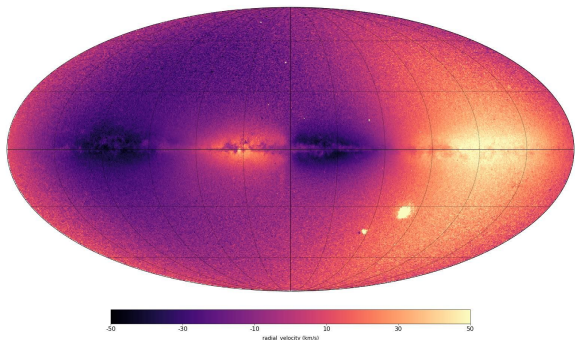
Stellar spectral lines analysis →
Velocities of Galaxy members

ESA/Gaia/DPAC/CU6, D. Katz, N. Leclerc, P. Sartoretti and the CU6 team

Credits: ESA/Gaia/DPAC, Recio-Blanco et al.



Stellar abundances →
Chemistry of the Galaxy

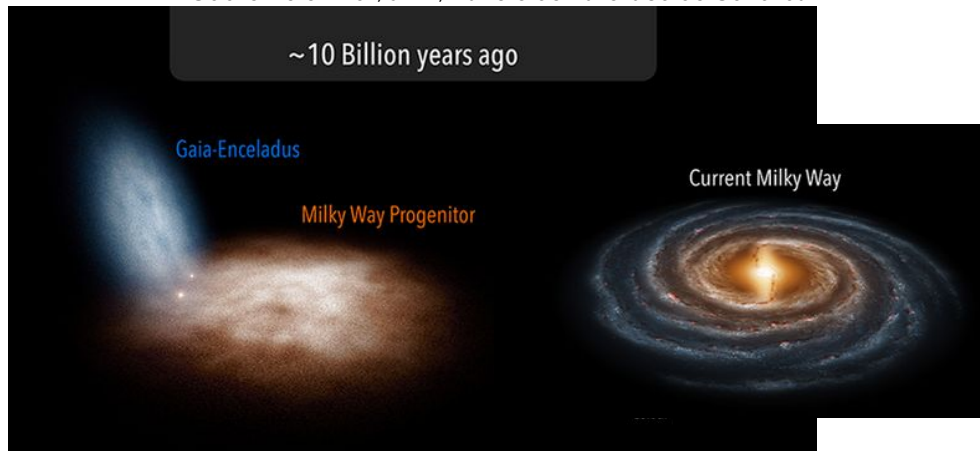


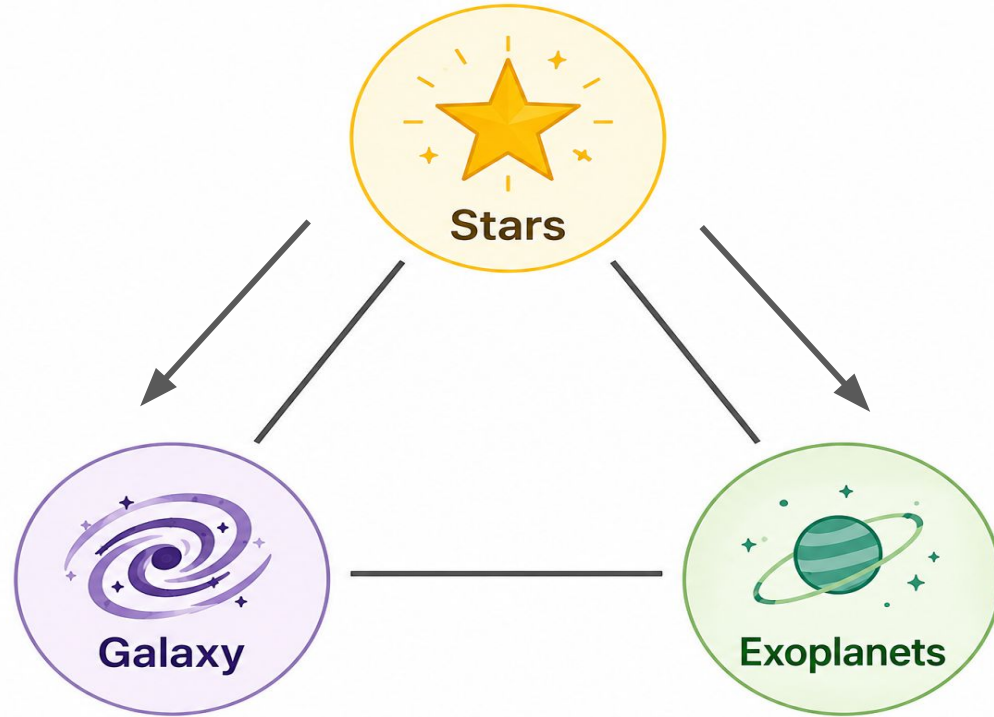
Stellar spectral lines analysis →
Velocities of Galaxy members

ESA/Gaia/DPAC/CU6, D. Katz, N. Leclerc, P. Sartoretti and the CU6 team

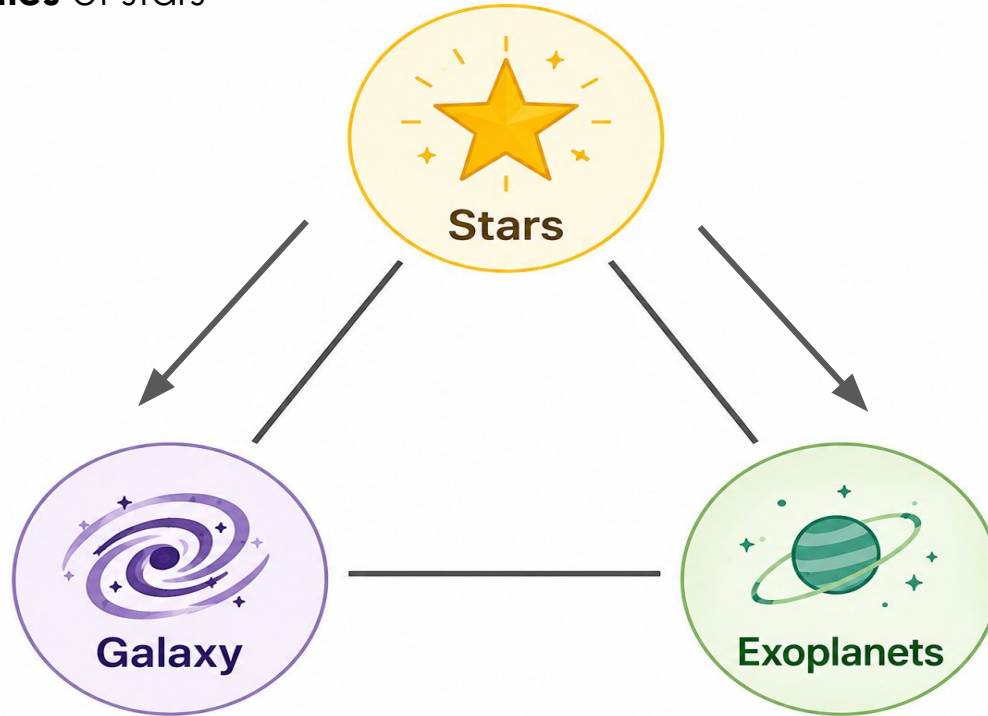
Ages of stellar populations

Gabriel Perez Díaz, SMM, Instituto de Astrofísica de Canarias





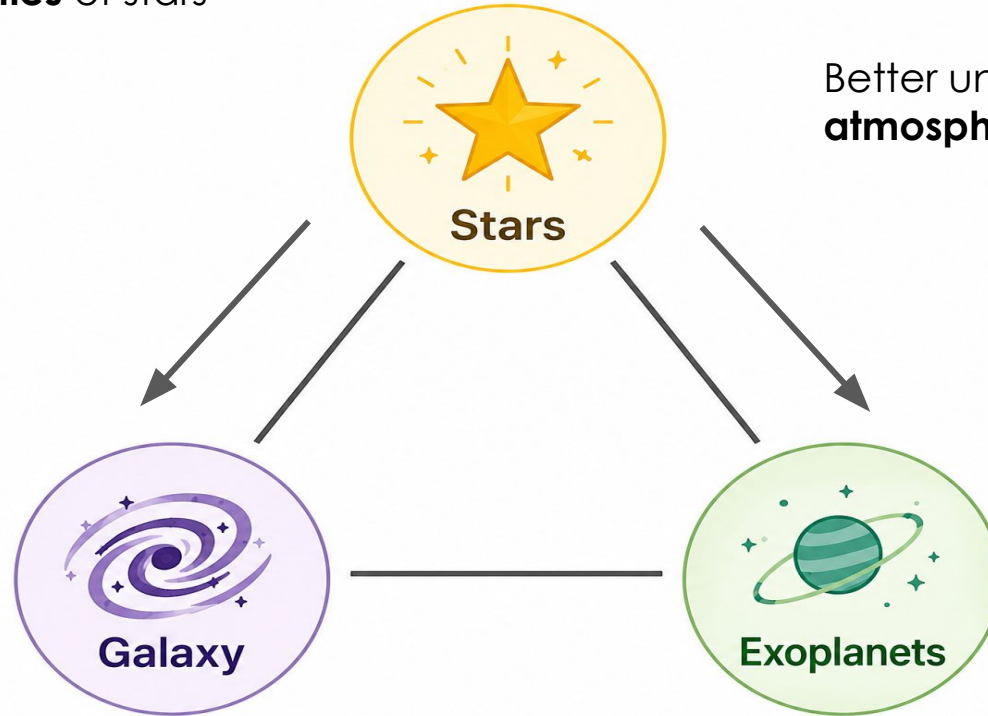
Precise and accurate
fundamental properties of stars



Precise and accurate
fundamental properties of stars

Better understanding of stellar
structure and evolution → Age

Better understanding of stellar
atmospheres
→ composition

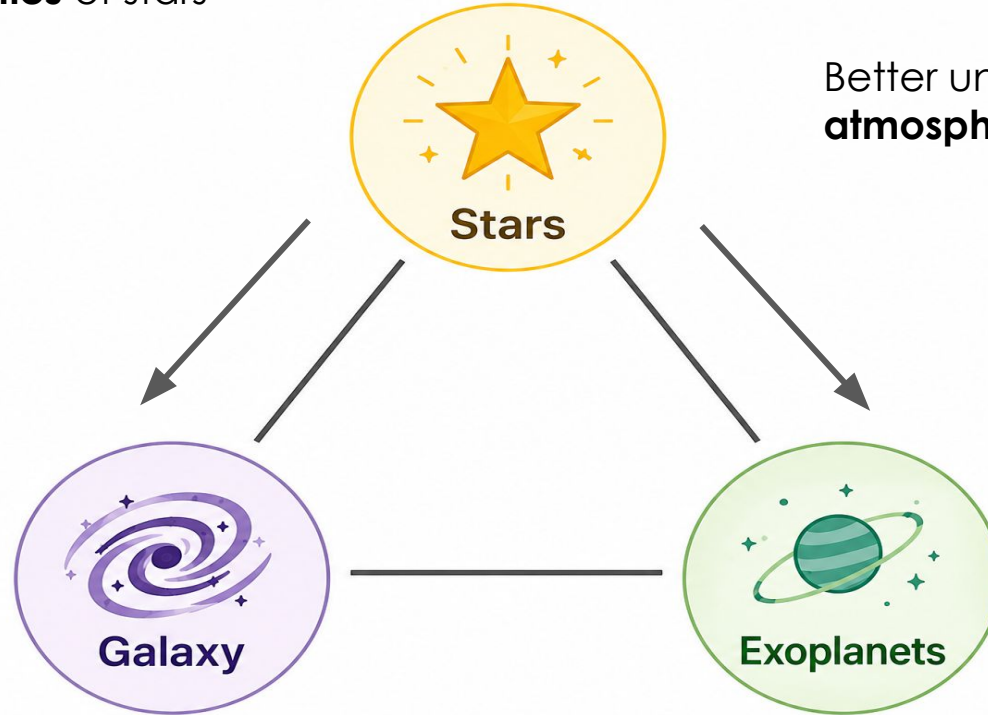


Precise and accurate
fundamental properties of stars

Observations

Better understanding of stellar
structure and evolution → Age

Better understanding of stellar
atmospheres
→ composition



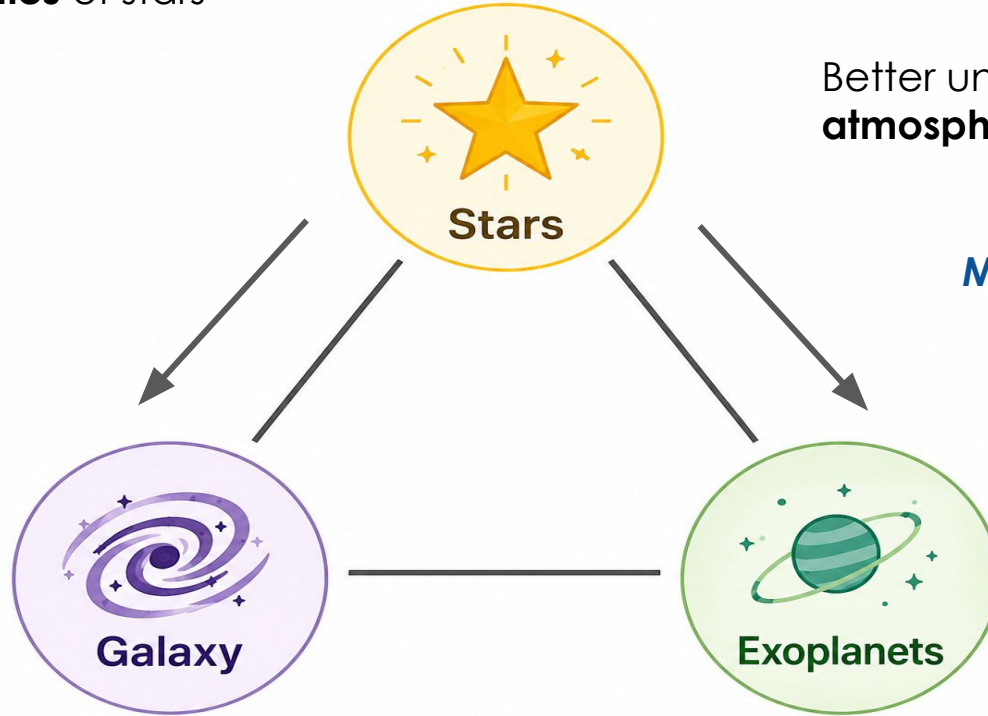
Precise and accurate
fundamental properties of stars

Observations

Better understanding of stellar
structure and evolution → Age

Better understanding of stellar
atmospheres
→ composition

Models



- Observations
 - Benchmark stars
 - Gaia
- Models
 - Physics of stellar interiors
 - Alpha Cen A & B

I could talk for hours on hundreds of amazing work being done,
but I have to focus on few (biased view)

- **Observations**

- Benchmark stars
- Gaia

- **Models**

- Physics of stellar interiors
- Alpha Cen A & B

I could talk for hours on hundreds of amazing work being done,
but I have to focus on few (biased view)

Benchmark stars

Stars for which fundamental properties can be measured with (little) intervention of models, or can be measured with many techniques

- better understand stellar models / physics by constraining fundamental properties
- use as a calibration set for (large scale) surveys

Benchmark stars

Stars for which fundamental properties can be measured with (little) intervention of models, or can be measured with many techniques

- better understand stellar models / physics by constraining fundamental properties
- use as a calibration set for (large scale) surveys
- important role of interferometry (large French-based community) and binarity

Benchmark stars

Soubiran et al. 2024: ~200 benchmark stars

- ~ 200 stars with direct measures of angular diameters through interferometry → θ
- Homogenous collection of photometric data covering visible to far-IR wavelengths → F_{bol}
- Homogenous distance estimators

Benchmark stars

Soubiran et al. 2024: ~200 benchmark stars

- ~ 200 stars with direct measures of angular diameters through interferometry → θ
- Homogenous collection of photometric data covering visible to far-IR wavelengths → F_{bol}
- Homogenous distance estimators

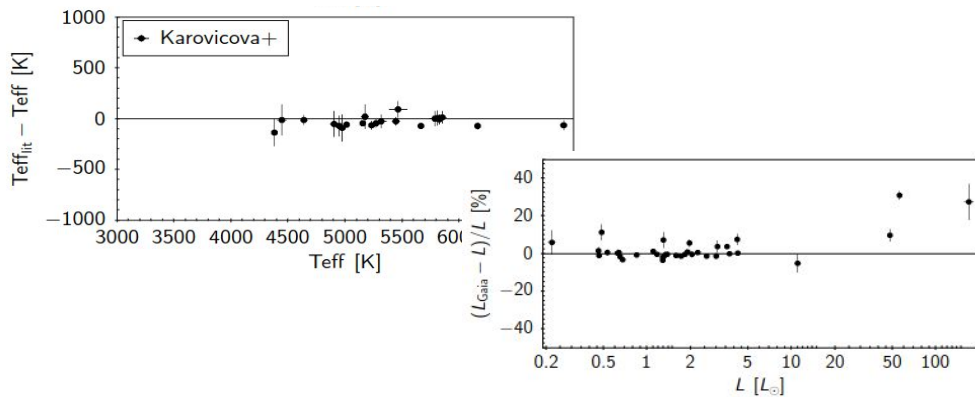
→ model-independent fundamental properties $T_{\text{eff}} = \left(\frac{1}{\sigma_{\text{SB}}} \frac{F_{\text{bol}}}{\theta^2} \right)^{0.25}$ $L = 4\pi d^2 F_{\text{bol}}$ $R = \frac{\theta}{\pi}$

Benchmark stars

Soubiran et al. 2024: ~200 benchmark stars

- ~ 200 stars with direct measures of angular diameters through interferometry → θ
- Homogenous collection of photometric data covering visible to far-IR wavelengths → F_{bol}
- Homogenous distance estimators

→ model-independent fundamental properties $T_{\text{eff}} = \left(\frac{1}{\sigma_{\text{SB}}} \frac{F_{\text{bol}}}{\theta^2} \right)^{0.25}$ $L = 4\pi d^2 F_{\text{bol}}$ $R = \frac{\theta}{\pi}$

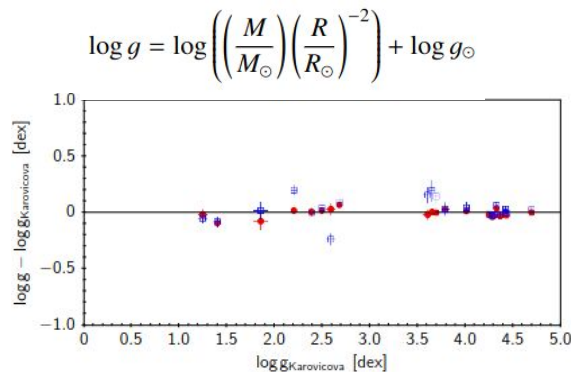
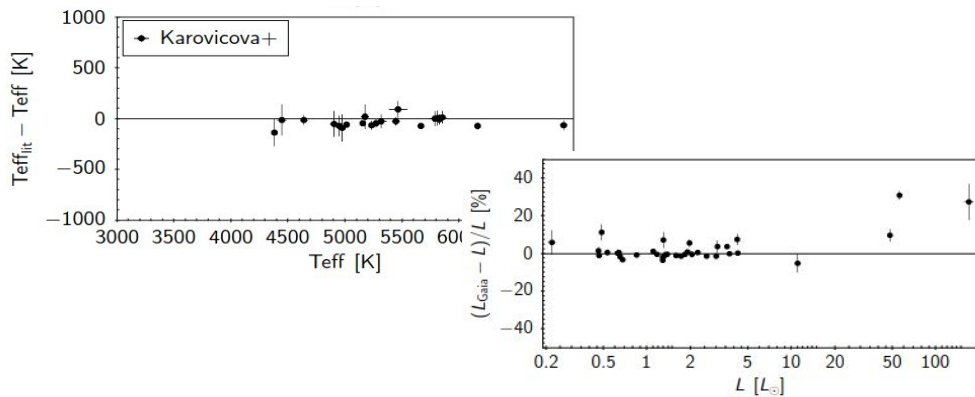


Benchmark stars

Soubiran et al. 2024: ~200 benchmark stars

- ~ 200 stars with direct measures of angular diameters through interferometry → θ
- Homogenous collection of photometric data covering visible to far-IR wavelengths → F_{bol}
- Homogenous distance estimators

→ model-independent fundamental properties $T_{\text{eff}} = \left(\frac{1}{\sigma_{\text{SB}}} \frac{F_{\text{bol}}}{\theta^2} \right)^{0.25}$ $L = 4\pi d^2 F_{\text{bol}}$ $R = \frac{\theta}{\pi}$



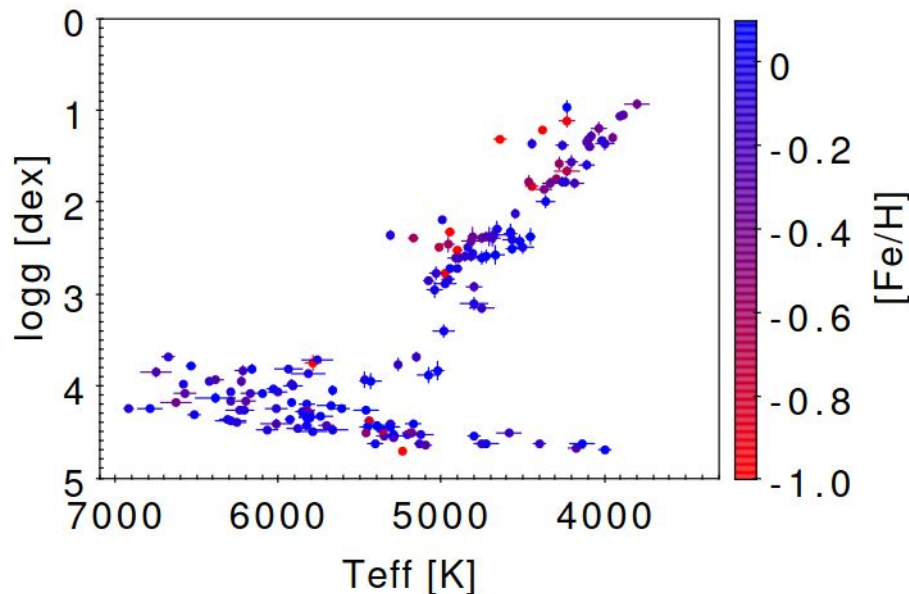
Benchmark stars

Soubiran et al. 2024: ~200 benchmark stars

- ~ 200 stars with direct measures of angular diameters through interferometry → θ
- Homogenous collection of photometric data covering visible to far-IR wavelengths → F_{bol}
- Homogenous distance estimators

→ 165 FGK stars with $\sigma(\text{Teff}) < 2\%$

and $\sigma(\log g) < 0.1 \text{ dex}$



Benchmark stars

Soubiran et al. 2024: ~200 benchmark stars

- ~ 200 stars with direct measures of angular diameters through interferometry → θ
- Homogenous collection of photometric data covering visible to far-IR wavelengths → F_{bol}
- Homogenous distance estimators

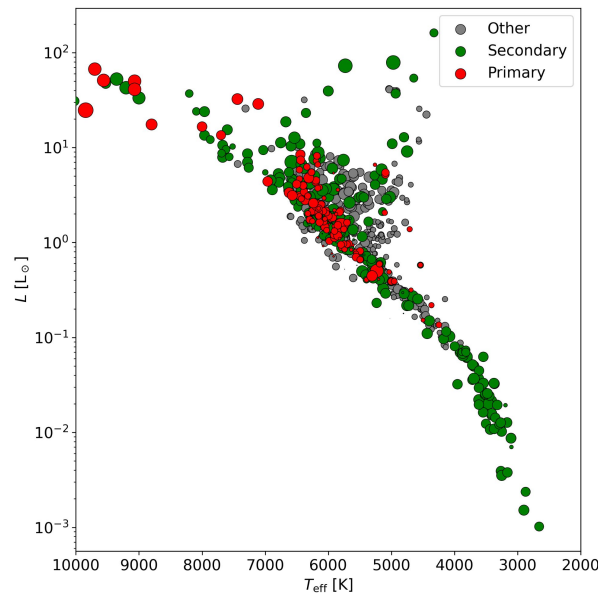
→ 165 FGK stars with $\sigma(\text{Teff}) < 2\%$

and $\sigma(\log g) < 0.1$ dex

- Focussing on mass, radius, age

In context of PLATO

→ Merle, Creevey et al. in prep.



Benchmark stars

Soubiran et al. 2024: ~200 benchmark stars

- ~ 200 stars with direct measures of angular diameters through interferometry → θ
- Homogenous collection of photometric data covering visible to far-IR wavelengths → F_{bol}
- Homogenous distance estimators

→ 165 FGK stars with $\sigma(\text{Teff}) < 2\%$

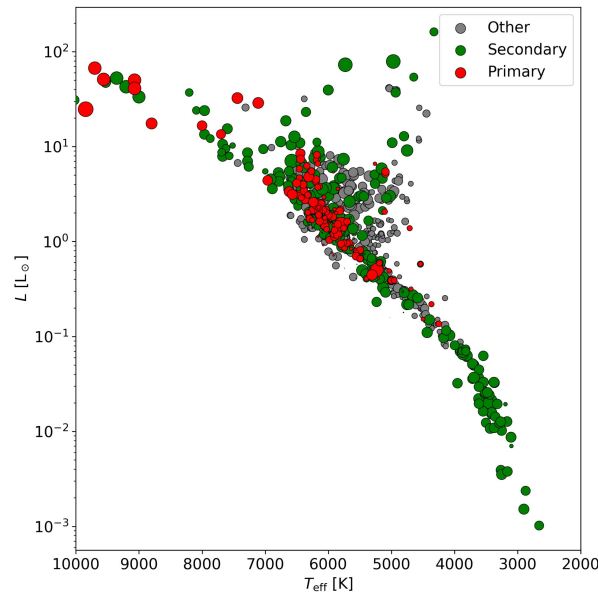
and $\sigma(\log g) < 0.1 \text{ dex}$

- Focussing on mass, radius, age

In context of PLATO

→ Merle, Creevey et al. in prep.

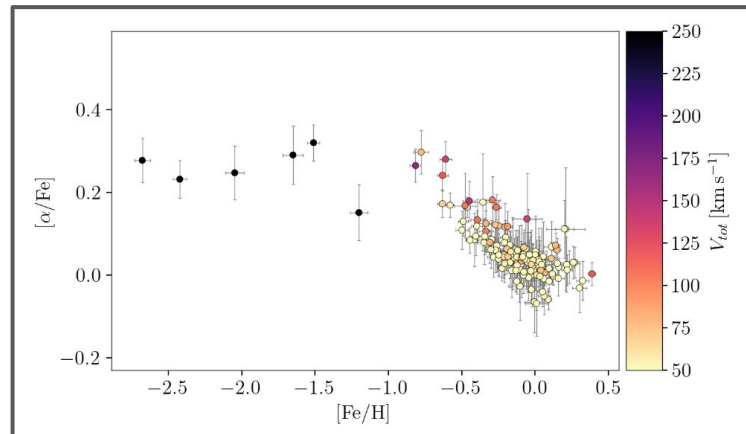
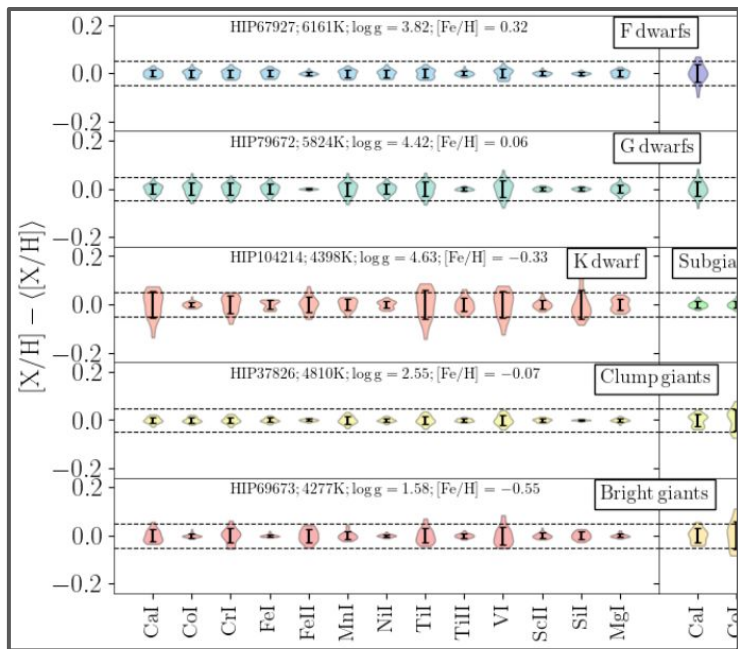
See Poster (ATPS) Kaushik



Benchmark stars

Casamiquela et al. 2025: ~200 benchmark stars

- Exploiting these benchmark stars → precise chemical abundances



- Observations

- Benchmark stars
- **Gaia**

- Models

- Physics of stellar interiors
- Alpha Cen A & B

Gaia

The Gaia mission has provided a wealth of new data on stars, the Galaxy and exoplanets (and more). These results rely on the production of stellar catalogues.

→ The French community plays a large role in the production of these catalogues

(Important contribution from the SNO and CNES)



Gaia

The Gaia mission has provided a wealth of new data on stars, the Galaxy and exoplanets (and more). These results rely on the production of stellar catalogues.

→ The French community plays a large role in the production of these catalogues

A&A 674, A1 (2023)
<https://doi.org/10.1051/0004-6361/202243940>
© The Authors 2023

**Astronomy
&
Astrophysics**

Special issue

Gaia Data Release 3

Gaia Data Release 3

Summary of the content and survey properties

Gaia Collaboration: A. Vallenari^{1,*}, A. G. A. Brown², T. Prusti³, J. H. J. de Bruijne³, F. Arenou⁴,
C. Babusiaux^{5,4}, M. Biermann⁶, O. L. Creevey⁷, C. Ducourant⁸, D. W. Evans⁹, L. Eyer¹⁰, R. Guerra¹¹,
A. Hutton¹², C. Jordi¹³, S. A. Klioner¹⁴, U. L. Lammers¹¹, L. Lindegren¹⁵, X. Luri¹³, F. Mignard⁷, C. Panem¹⁶,

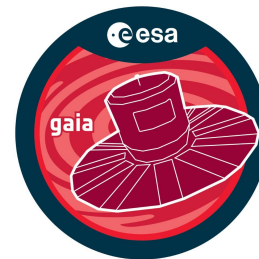


Gaia

The Gaia mission has provided a wealth of new data on stars, the Galaxy and exoplanets (and more). These results rely on the production of stellar catalogues.

→ The French community plays a large role in the production of these catalogues

A&A 674, A1 (2023) https://doi.org/10.1051/0004-6361/202243940 © The Authors 2023	Astronomy & Astrophysics
<i>Gaia Data Release 3</i> Supplement Gaia Collaboration: C. Babusiaux^{5,4}, M. B. A. Hutton¹², C. Jordi¹³, S.	A&A 674, A5 (2023) https://doi.org/10.1051/0004-6361/202244220 © The Authors 2023 <i>Gaia Data Release 3</i> Astronomy & Astrophysics Special issue Gaia Data Release 3 Properties and validation of the radial velocities D. Katz^{1,*}, P. Sartoretti¹, A. Guerrier², P. Panuzzo¹, G. M. Seabroke³, F. Thévenin⁴, M. Cropper³, K. Benson³,



Gaia

The Gaia mission has provided a wealth of new data on stars, the Galaxy and exoplanets (and more). These results rely on the production of stellar catalogues.

→ The French community plays a large role in the production of these catalogues

A&A 674, A1 (2023)
<https://doi.org/10.1051/0004-6361/202243940>
© The Authors 2023

**Astronomy
&
Astrophysics**

Gaia Data Release 3

A&A 674, A5 (2023)
<https://doi.org/10.1051/0004-6361/202244220>
© The Authors 2023

**Astronomy
&
Astrophysics**

Su

Gaia Data Release 3

A&A 674, A29 (2023)
<https://doi.org/10.1051/0004-6361/202243750>
© The Authors 2023

**Astronomy
&
Astrophysics**

Gaia Collaboration:
C. Babusiaux^{5,4}, M. B.
A. Hutton¹², C. Jordi¹³, S.

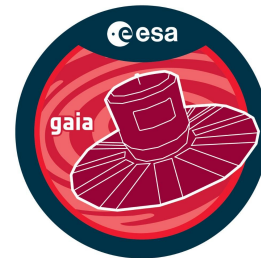
Pro

Gaia Data Release 3

Gaia Data Release 3

Analysis of RVS spectra using the General Stellar Parametriser from spectroscopy

A. Recio-Blanco^{1,*}, P. de Laverny¹, P. A. Palicio¹, G. Kordopatis¹, M. A. Álvarez², M. Schultheis¹,



Gaia

The Gaia mission has provided a wealth of new data on stars, the Galaxy and exoplanets (and more). These results rely on the production of stellar catalogues.

→ The French community plays a large role in the production of these catalogues

A&A 674, A1 (2023)
<https://doi.org/10.1051/0004-6361/202243940>
© The Authors 2023

**Astronomy
&
Astrophysics**

Gaia Data Release 3

A&A 674, A5 (2023)
<https://doi.org/10.1051/0004-6361/202244220>
© The Authors 2023

**Astronomy
&
Astrophysics**

Gaia Data Release 3

A&A 674, A29 (2023)
<https://doi.org/10.1051/0004-6361/202243750>
© The Authors 2023

**Astronomy
&
Astrophysics**

Gaia Collaboration:
C. Babusiaux^{5,4}, M. Bica¹,
A. Hutton¹², C. Jordi¹³, S. Kluge¹⁴,
D. Katz^{1,*}, P. Sartoretti¹, A. Teyssier¹⁵,
A. Recio-Blanco^{1,*}, P. de Laverny¹⁶,
S. Balaguer-Núñez¹⁷, J. A. Balaguer-Núñez¹⁸,
J. Balaguer-Núñez¹⁹, J. Balaguer-Núñez²⁰,
J. Balaguer-Núñez²¹, J. Balaguer-Núñez²²,
J. Balaguer-Núñez²³, J. Balaguer-Núñez²⁴,
J. Balaguer-Núñez²⁵, J. Balaguer-Núñez²⁶,
J. Balaguer-Núñez²⁷, J. Balaguer-Núñez²⁸,
J. Balaguer-Núñez²⁹, J. Balaguer-Núñez³⁰,
J. Balaguer-Núñez³¹, J. Balaguer-Núñez³²,
J. Balaguer-Núñez³³, J. Balaguer-Núñez³⁴,
J. Balaguer-Núñez³⁵, J. Balaguer-Núñez³⁶,
J. Balaguer-Núñez³⁷, J. Balaguer-Núñez³⁸,
J. Balaguer-Núñez³⁹, J. Balaguer-Núñez⁴⁰,
J. Balaguer-Núñez⁴¹, J. Balaguer-Núñez⁴²,
J. Balaguer-Núñez⁴³, J. Balaguer-Núñez⁴⁴,
J. Balaguer-Núñez⁴⁵, J. Balaguer-Núñez⁴⁶,
J. Balaguer-Núñez⁴⁷, J. Balaguer-Núñez⁴⁸,
J. Balaguer-Núñez⁴⁹, J. Balaguer-Núñez⁵⁰,
J. Balaguer-Núñez⁵¹, J. Balaguer-Núñez⁵²,
J. Balaguer-Núñez⁵³, J. Balaguer-Núñez⁵⁴,
J. Balaguer-Núñez⁵⁵, J. Balaguer-Núñez⁵⁶,
J. Balaguer-Núñez⁵⁷, J. Balaguer-Núñez⁵⁸,
J. Balaguer-Núñez⁵⁹, J. Balaguer-Núñez⁶⁰,
J. Balaguer-Núñez⁶¹, J. Balaguer-Núñez⁶²,
J. Balaguer-Núñez⁶³, J. Balaguer-Núñez⁶⁴,
J. Balaguer-Núñez⁶⁵, J. Balaguer-Núñez⁶⁶,
J. Balaguer-Núñez⁶⁷, J. Balaguer-Núñez⁶⁸,
J. Balaguer-Núñez⁶⁹, J. Balaguer-Núñez⁷⁰,
J. Balaguer-Núñez⁷¹, J. Balaguer-Núñez⁷²,
J. Balaguer-Núñez⁷³, J. Balaguer-Núñez⁷⁴,
J. Balaguer-Núñez⁷⁵, J. Balaguer-Núñez⁷⁶,
J. Balaguer-Núñez⁷⁷, J. Balaguer-Núñez⁷⁸,
J. Balaguer-Núñez⁷⁹, J. Balaguer-Núñez⁸⁰,
J. Balaguer-Núñez⁸¹, J. Balaguer-Núñez⁸²,
J. Balaguer-Núñez⁸³, J. Balaguer-Núñez⁸⁴,
J. Balaguer-Núñez⁸⁵, J. Balaguer-Núñez⁸⁶,
J. Balaguer-Núñez⁸⁷, J. Balaguer-Núñez⁸⁸,
J. Balaguer-Núñez⁸⁹, J. Balaguer-Núñez⁹⁰,
J. Balaguer-Núñez⁹¹, J. Balaguer-Núñez⁹²,
J. Balaguer-Núñez⁹³, J. Balaguer-Núñez⁹⁴,
J. Balaguer-Núñez⁹⁵, J. Balaguer-Núñez⁹⁶,
J. Balaguer-Núñez⁹⁷, J. Balaguer-Núñez⁹⁸,
J. Balaguer-Núñez⁹⁹, J. Balaguer-Núñez¹⁰⁰

**Astronomy
&
Astrophysics**

A&A 674, A26 (2023)
<https://doi.org/10.1051/0004-6361/202243688>
© The Authors 2023

**Astronomy
&
Astrophysics**

Gaia Data Release 3

Gaia Data Release 3

Astrophysical parameters inference system (Apsis).

I. Methods and content overview

O. L. Creevey^{1,*}, R. Sordo², F. Pailler³, Y. Frémat⁴, U. Heiter⁵, F. Thévenin¹, R. Andrae⁶,
J. Balaguer-Núñez⁷, J. Balaguer-Núñez⁸, J. Balaguer-Núñez⁹, J. Balaguer-Núñez¹⁰,
J. Balaguer-Núñez¹¹, J. Balaguer-Núñez¹², J. Balaguer-Núñez¹³, J. Balaguer-Núñez¹⁴,
J. Balaguer-Núñez¹⁵, J. Balaguer-Núñez¹⁶, J. Balaguer-Núñez¹⁷, J. Balaguer-Núñez¹⁸,
J. Balaguer-Núñez¹⁹, J. Balaguer-Núñez²⁰, J. Balaguer-Núñez²¹, J. Balaguer-Núñez²²,
J. Balaguer-Núñez²³, J. Balaguer-Núñez²⁴, J. Balaguer-Núñez²⁵, J. Balaguer-Núñez²⁶,
J. Balaguer-Núñez²⁷, J. Balaguer-Núñez²⁸, J. Balaguer-Núñez²⁹, J. Balaguer-Núñez³⁰,
J. Balaguer-Núñez³¹, J. Balaguer-Núñez³², J. Balaguer-Núñez³³, J. Balaguer-Núñez³⁴,
J. Balaguer-Núñez³⁵, J. Balaguer-Núñez³⁶, J. Balaguer-Núñez³⁷, J. Balaguer-Núñez³⁸,
J. Balaguer-Núñez³⁹, J. Balaguer-Núñez⁴⁰, J. Balaguer-Núñez⁴¹, J. Balaguer-Núñez⁴²,
J. Balaguer-Núñez⁴³, J. Balaguer-Núñez⁴⁴, J. Balaguer-Núñez⁴⁵, J. Balaguer-Núñez⁴⁶,
J. Balaguer-Núñez⁴⁷, J. Balaguer-Núñez⁴⁸, J. Balaguer-Núñez⁴⁹, J. Balaguer-Núñez⁵⁰,
J. Balaguer-Núñez⁵¹, J. Balaguer-Núñez⁵², J. Balaguer-Núñez⁵³, J. Balaguer-Núñez⁵⁴,
J. Balaguer-Núñez⁵⁵, J. Balaguer-Núñez⁵⁶, J. Balaguer-Núñez⁵⁷, J. Balaguer-Núñez⁵⁸,
J. Balaguer-Núñez⁵⁹, J. Balaguer-Núñez⁶⁰, J. Balaguer-Núñez⁶¹, J. Balaguer-Núñez⁶²,
J. Balaguer-Núñez⁶³, J. Balaguer-Núñez⁶⁴, J. Balaguer-Núñez⁶⁵, J. Balaguer-Núñez⁶⁶,
J. Balaguer-Núñez⁶⁷, J. Balaguer-Núñez⁶⁸, J. Balaguer-Núñez⁶⁹, J. Balaguer-Núñez⁷⁰,
J. Balaguer-Núñez⁷¹, J. Balaguer-Núñez⁷², J. Balaguer-Núñez⁷³, J. Balaguer-Núñez⁷⁴,
J. Balaguer-Núñez⁷⁵, J. Balaguer-Núñez⁷⁶, J. Balaguer-Núñez⁷⁷, J. Balaguer-Núñez⁷⁸,
J. Balaguer-Núñez⁷⁹, J. Balaguer-Núñez⁸⁰, J. Balaguer-Núñez⁸¹, J. Balaguer-Núñez⁸²,
J. Balaguer-Núñez⁸³, J. Balaguer-Núñez⁸⁴, J. Balaguer-Núñez⁸⁵, J. Balaguer-Núñez⁸⁶,
J. Balaguer-Núñez⁸⁷, J. Balaguer-Núñez⁸⁸, J. Balaguer-Núñez⁸⁹, J. Balaguer-Núñez⁹⁰,
J. Balaguer-Núñez⁹¹, J. Balaguer-Núñez⁹², J. Balaguer-Núñez⁹³, J. Balaguer-Núñez⁹⁴,
J. Balaguer-Núñez⁹⁵, J. Balaguer-Núñez⁹⁶, J. Balaguer-Núñez⁹⁷, J. Balaguer-Núñez⁹⁸,
J. Balaguer-Núñez⁹⁹, J. Balaguer-Núñez¹⁰⁰

**Astronomy
&
Astrophysics**

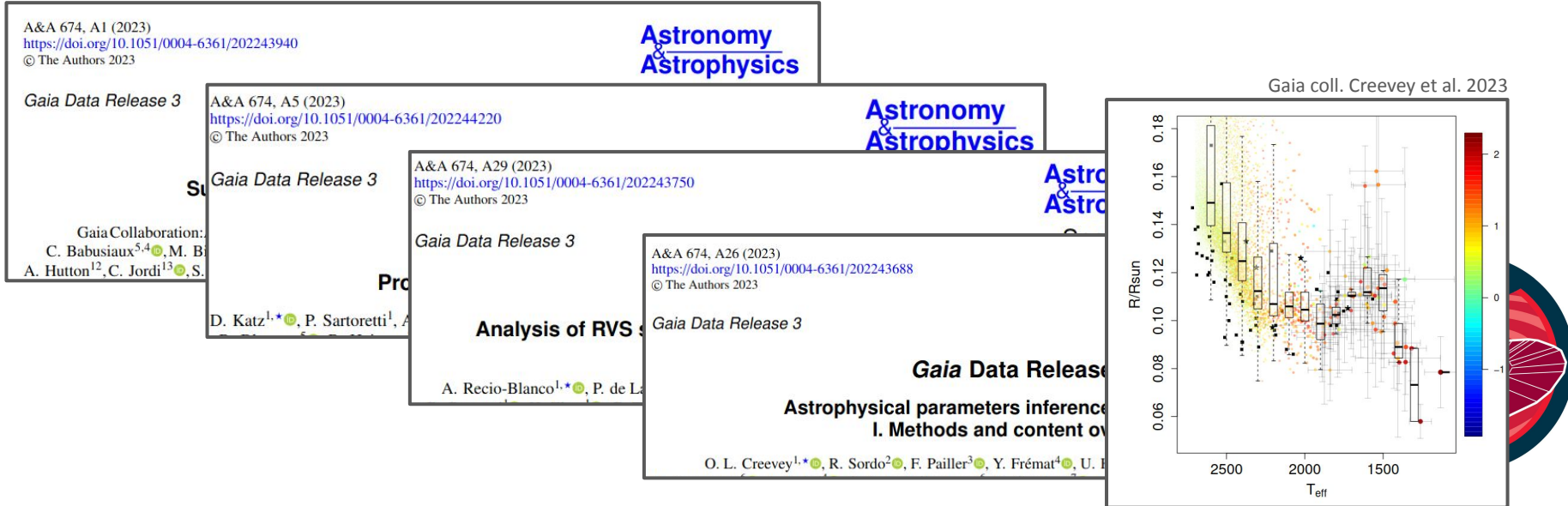
Special issue



Gaia

The Gaia mission has provided a wealth of new data on stars, the Galaxy and exoplanets (and more). These results rely on the production of stellar catalogues.

→ The French community plays a large role in the production of these catalogues



Gaia: a close up of the binary content

A&A 674, A9 (2023)
<https://doi.org/10.1051/0004-6361/202243969>
© The Authors 2023

Gaia Data Release 3

Gaia Data Release 3

Astrometric binary stars

Jean-Louis Halbwachs¹, Dimitri Pourbaix^{2,4},
Nathalie Bauchet⁵, Olivier Marcel

**Astronomy
&
Astrophysics**

A&A 674, A34 (2023)
<https://doi.org/10.1051/0004-6361/202243782>
© The Authors 2023

Gaia Data Release 3

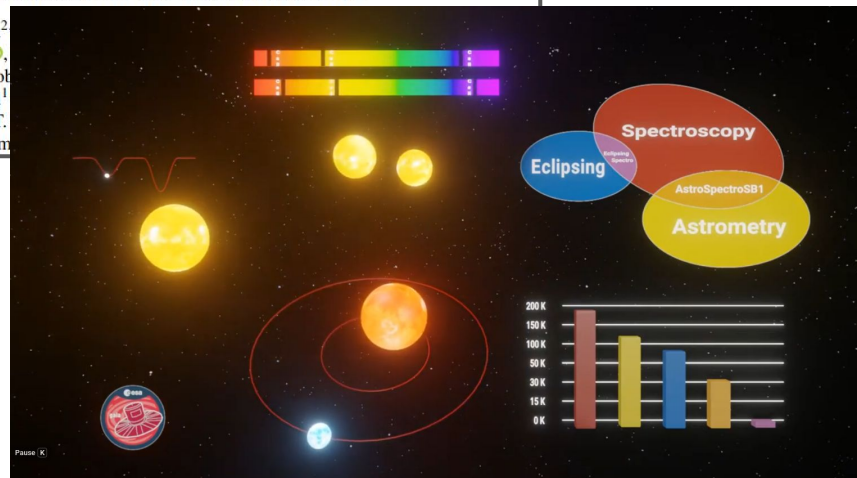
Gaia Data Release 3

Stellar multiplicity, a teaser for the hidden treasure

Gaia Collaboration: F. Arenou^{1,*}, C. Babusiaux²,
T. Mazeh⁴, N. Mowlavi⁷, P. Panuzzo¹,
Y. Damerdjji^{12,11}, P. Gavras⁸, P. Giacobbe¹,
M. G. Lattanzi^{10,16}, N. Leclerc¹, T. Morel¹,
D. Ségransan⁷, C. Siopis⁵, D. Teyssier¹⁷, T.
T. Prusti²¹, J. H. J. de Bruijne²¹, M. Bierman

**Astronomy
&
Astrophysics**

Special issue



Gaia: binaries

Gaia observations are

- Astrometric
- Photometric
- Spectroscopic

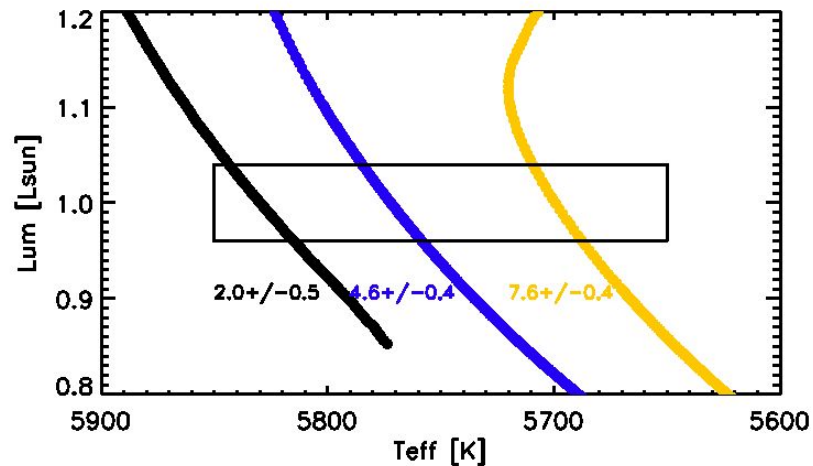
→ direct determinations of mass

Gaia: binaries

Gaia observations are

- Astrometric
- Photometric
- Spectroscopic

→ direct determinations of mass



Impact of mass on the age of a star.

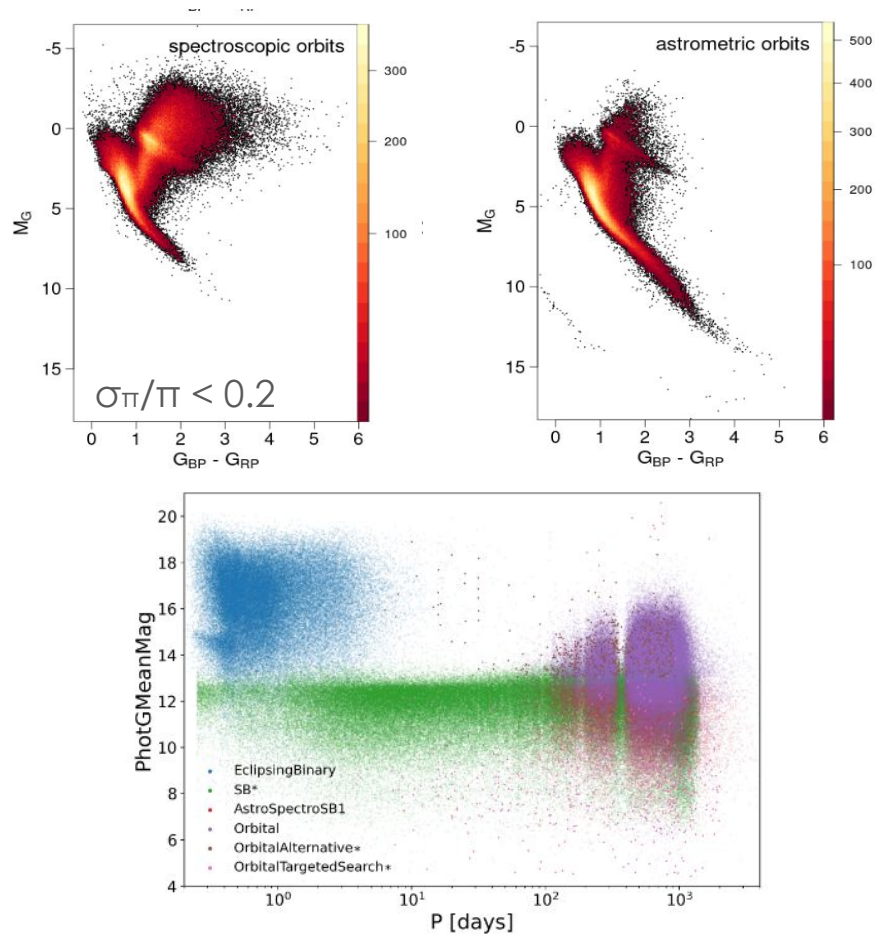
1.04, 1.00, 0.96 Msun

Gaia: binaries

Gaia observations are

- Astrometric
- Photometric
- Spectroscopic

→ direct determinations of mass



Gaia: direct determination of mass

Constraints on mass from Gaia only

Table 3. Content summary of the catalogue of masses.

Combination method	Number	$\mathcal{M}_1$	$\mathcal{M}_2$	F_2/F_1
Orbital+SB2	23	✓	✓	✓
EclipsingSpectro(SB2)	3	✓	✓	
Eclipsing+SB2	53	✓	✓	
AstroSpectroSB1+M1	17 578		✓	✓
Orbital+SB1+M1	1513		✓	✓
EclipsingSpectro+M1	71		✓	
Eclipsing+SB1+M1	155		✓	
SB2+M1	3856		✓	
Orbital+M1	111 792	Lower/upper		
SB1+M1	60 271	Lower		

Notes. The full table is available in the *Gaia* table `binary_masses`.

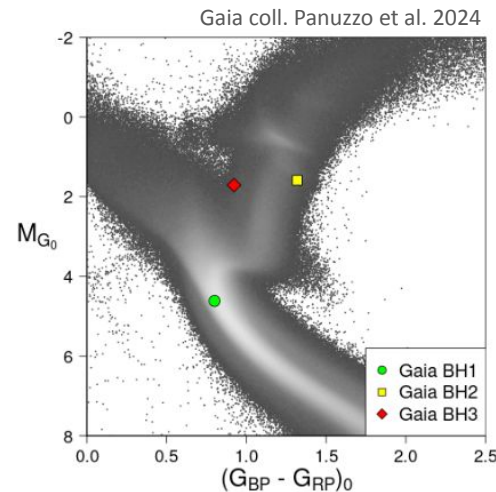
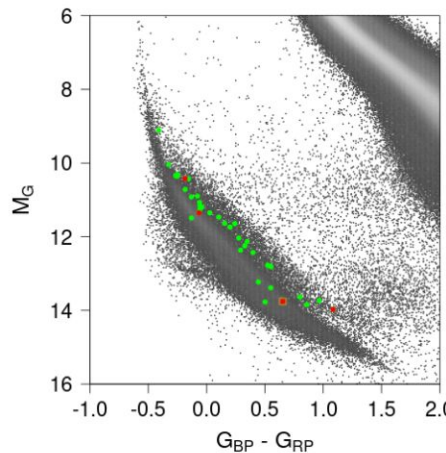
Gaia: direct determination of mass

Constraints on mass from Gaia only

Table 3. Content summary of the catalogue of masses.

Combination method	Number	$\mathcal{M}_1$	$\mathcal{M}_2$	F_2/F_1
Orbital+SB2	23	✓	✓	✓
EclipsingSpectro(SB2)	3	✓	✓	
Eclipsing+SB2	53	✓	✓	
AstroSpectroSB1+M1	17 578		✓	✓
Orbital+SB1+M1	1513		✓	✓
EclipsingSpectro+M1	71		✓	
Eclipsing+SB1+M1	155		✓	
SB2+M1	3856		✓	
Orbital+M1	111 792	Lower/upper		
SB1+M1	60 271	Lower		

Notes. The full table is available in the *Gaia* table `binary_masses`.



Constraints from SB1 systems

Gaia: direct determination of mass

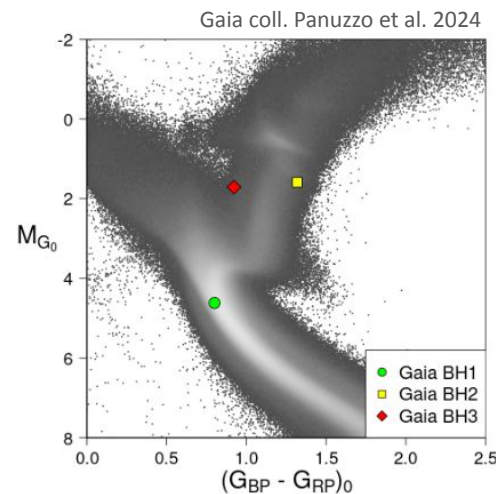
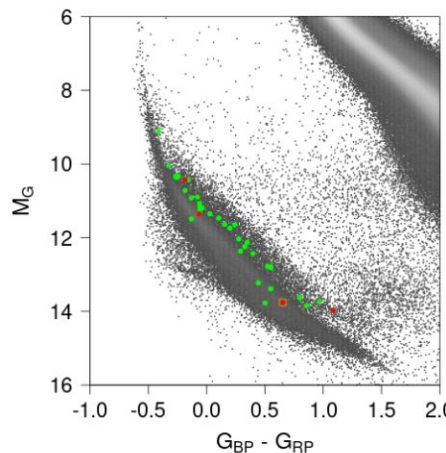
Constraints on mass from Gaia only

Table 3. Content summary of the catalogue of masses.

Combination method	Number	$\mathcal{M}_1$	$\mathcal{M}_2$	F_2/F_1
Orbital+SB2	23	✓	✓	✓
EclipsingSpectro(SB2)	3	✓	✓	
Eclipsing+SB2	53	✓	✓	
AstroSpectroSB1+M1	17 578		✓	✓
Orbital+SB1+M1	1513		✓	✓
EclipsingSpectro+M1	71		✓	
Eclipsing+SB1+M1	155		✓	
SB2+M1	3856		✓	
Orbital+M1	111 792	Lower/upper		
SB1+M1	60 271	Lower		

Notes. The full table is available in the *Gaia* table `binary_masses`.

→ and Gaia DR4 (Dec 2, 2026)



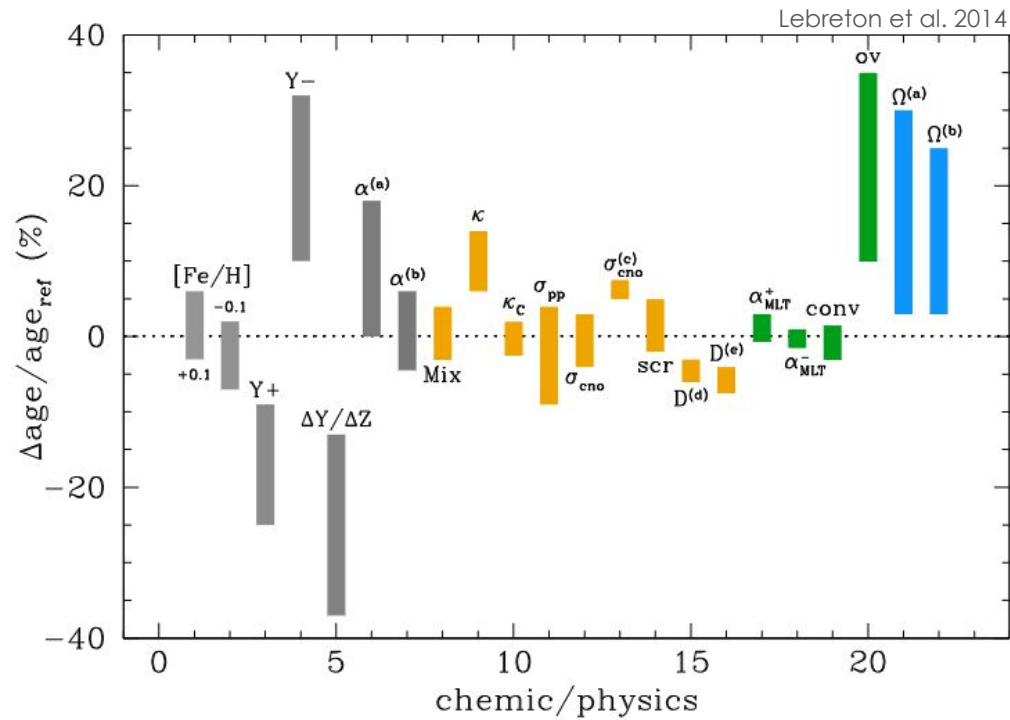
Constraints from SB1 systems

- Observations

- Benchmark stars
- Gaia

- **Models**

- Physics of stellar interiors
- Alpha Cen A & B



Impact of model uncertainties on the age

Modelling the Sun as a star

Many details of modelling micro- and macroscopic processes in stellar interiors are not well constrained.

Modelling the Sun as a star

Many details of modelling micro- and macroscopic processes in stellar interiors are not well constrained.

Using the Sun as a reference and the community-supported CESAM2k20 stellar evolution code (Morel & Lebreton 2008, Marques+2013, Manchon+2025, Manchon+2026), and the CLES (Scuflaire et al. 2008),

Deal et al. 2025 tested the impact of various formalisms for atomic diffusion on helioseismic data

Modelling the Sun as a star

Many details of modelling micro- and macroscopic processes in stellar interiors are not well constrained.

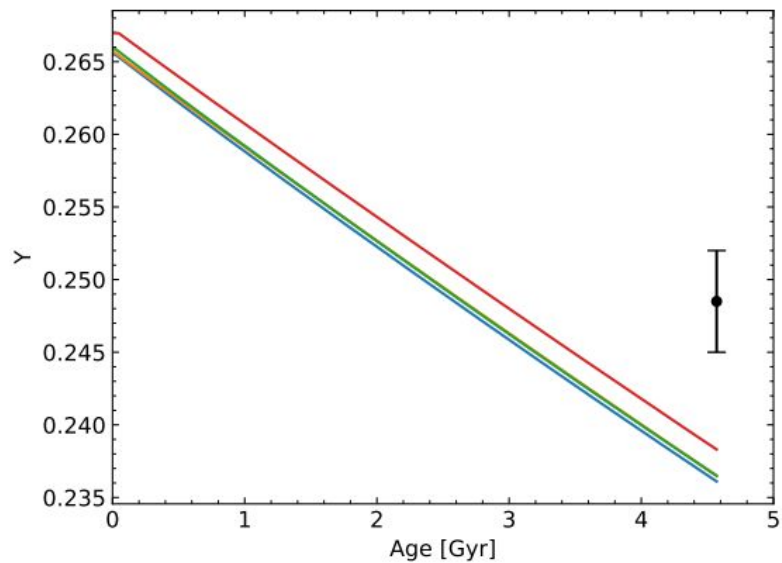
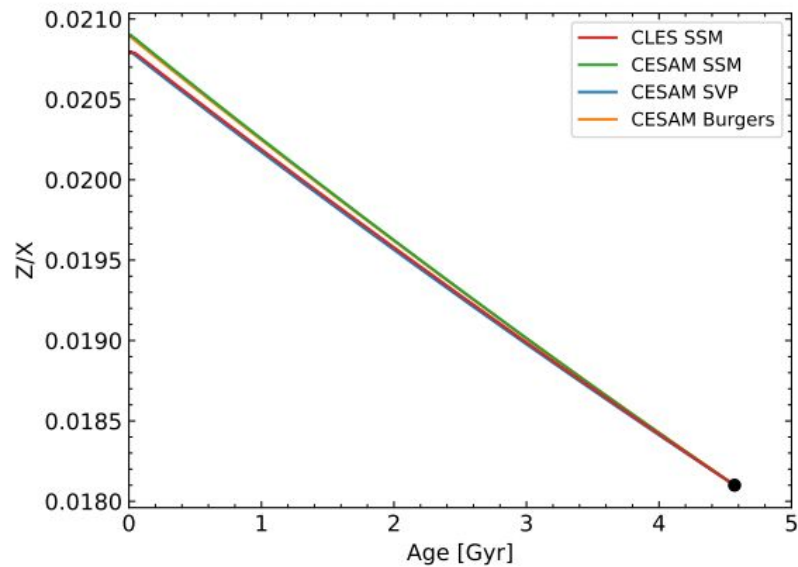
Using the Sun as a reference and the community-supported CESAM2k20 stellar evolution code (Morel & Lebreton 2008, Marques+2013, Manchon+2025, Manchon+2026), and the CLES (Scuflaire et al. 2008),

Deal et al. 2025 tested the impact of various formalisms for atomic diffusion on helioseismic data

→ “best” models for exploitation of PLATO

Modelling the Sun as a star

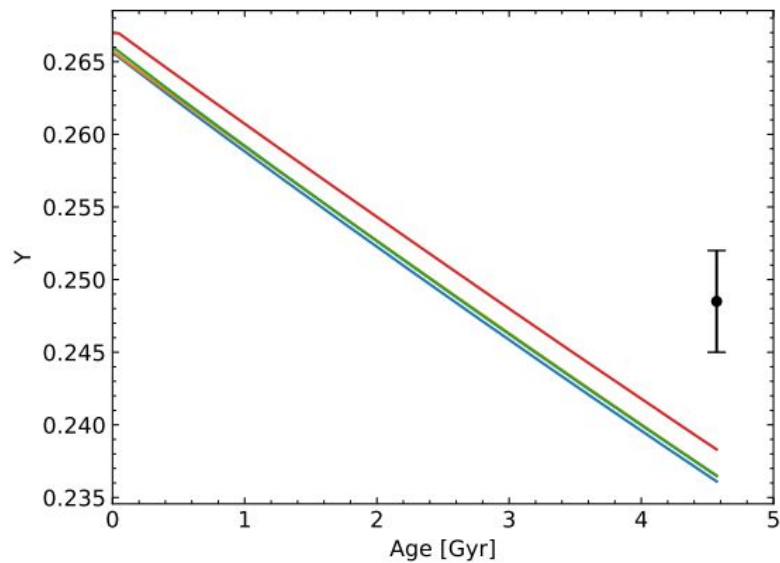
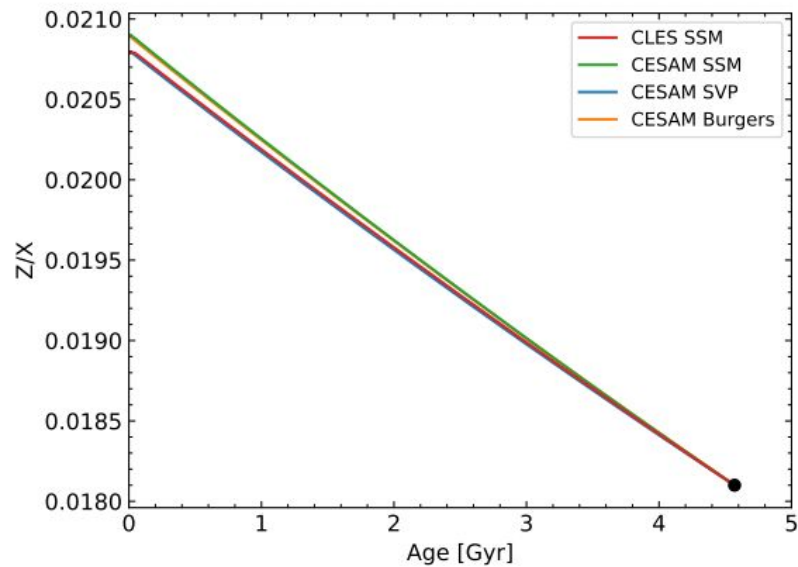
Deal et al. 2025: atomic diffusion of chemical elements



→ can not reproduce element depletion

Modelling the Sun as a star

Deal et al. 2025: atomic diffusion of chemical elements

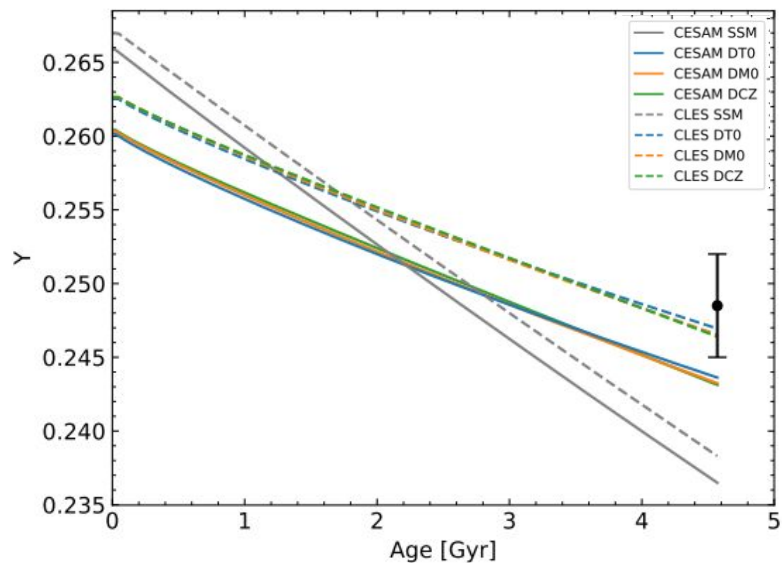
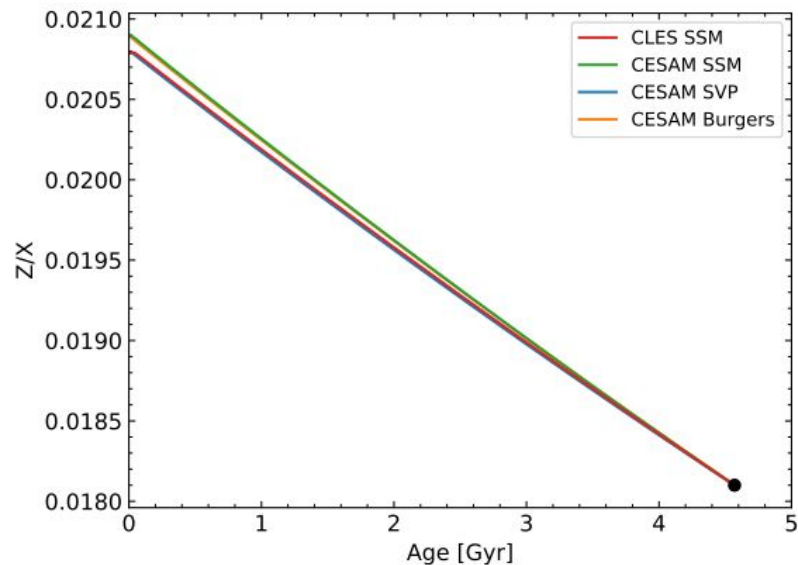


→ can not reproduce element depletion

→ introducing some other “extra-mixing” processes

Modelling the Sun as a star

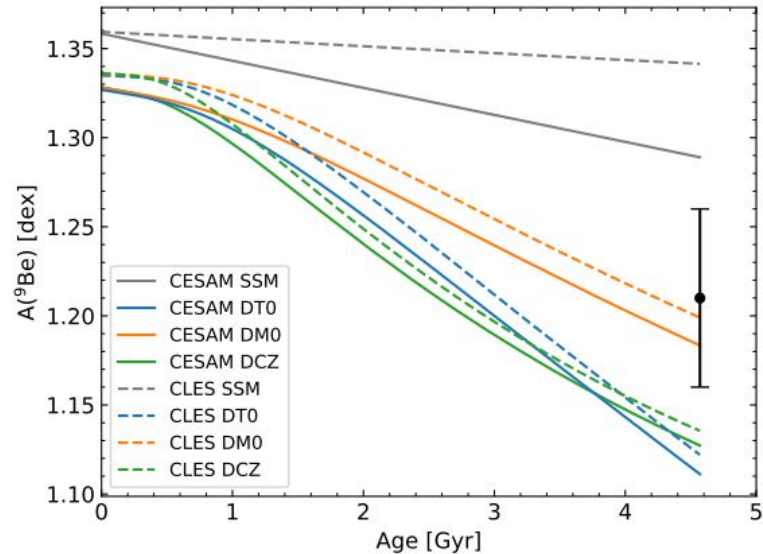
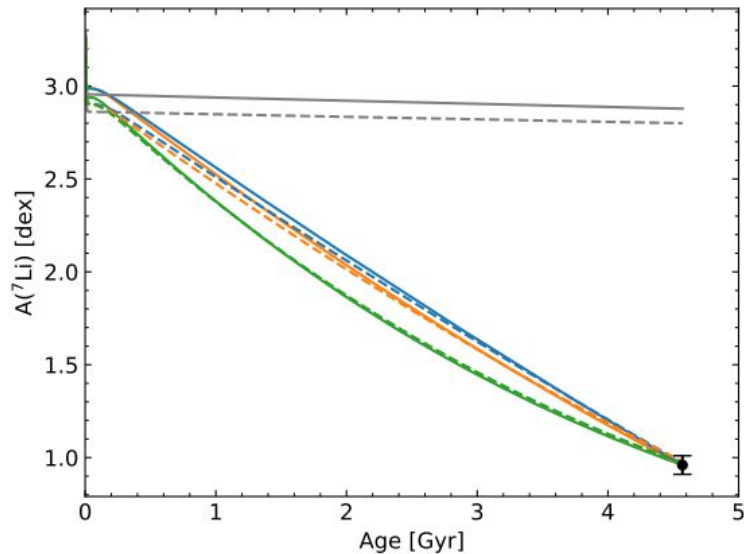
Deal et al. 2025: atomic diffusion of chemical elements and with extra mixing processes



→ can reproduce element depletion

Modelling the Sun as a star

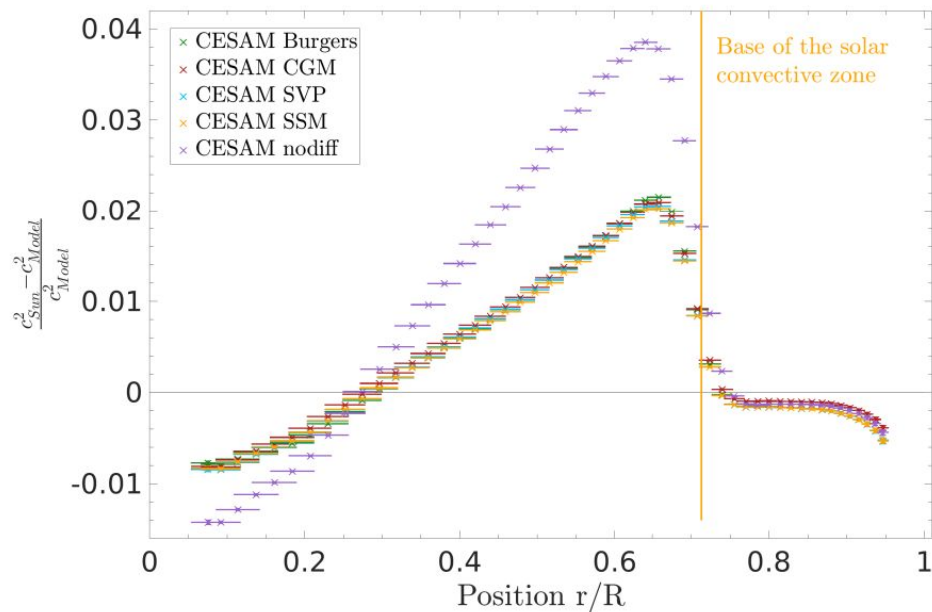
Deal et al. 2025: atomic diffusion of chemical elements and with extra mixing processes



→ many can not reproduce light element depletion

Modelling the Sun as a star

Deal et al. 2025: atomic diffusion of chemical elements and with extra mixing processes



→ comparison with seismic data shows equal agreement for many implementations, but base of convective zone is slightly displaced

Modelling the Sun as a star

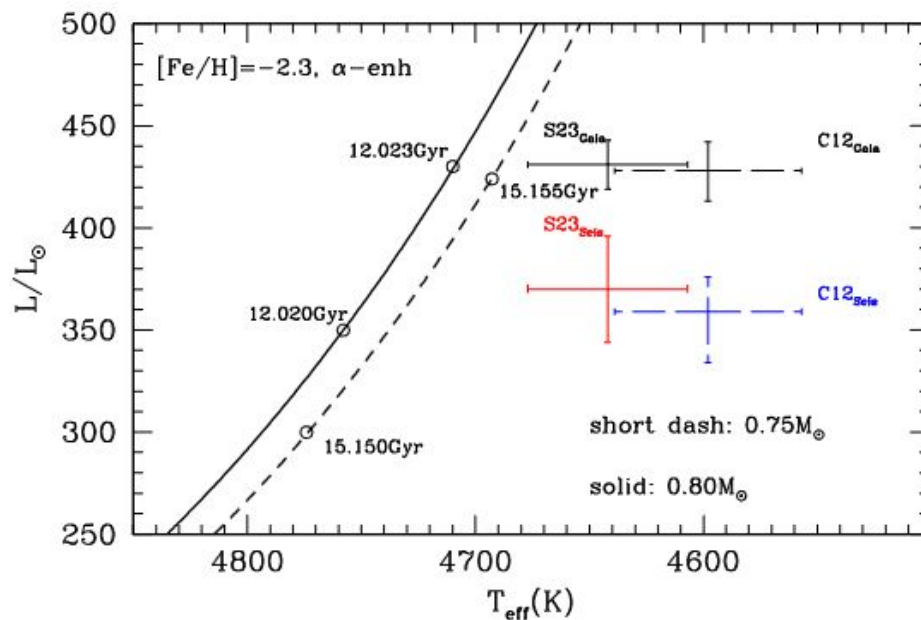
Need to continue tests with the Sun and

exploit asteroseismic data on many stars spanning the HR diagram with well-constrained properties, including accurate elemental abundances

Metal-poor stars in our Galaxy

Inability of public stellar models to reproduce the position in the HR diagram of metal-poor stars:
the case of HD 122563 (Creevey+2024)

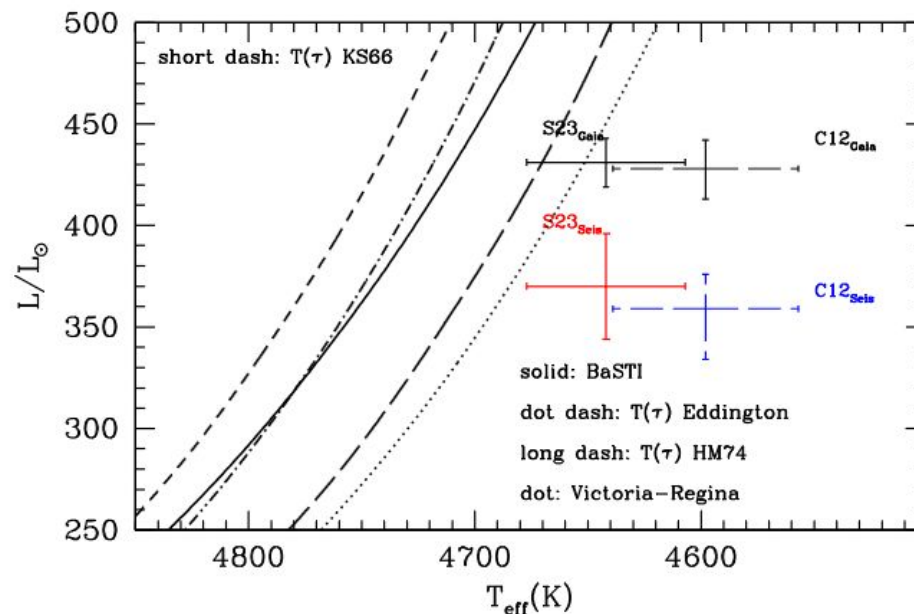
- “Benchmark star” ($V \sim 6$)
- Detailed study of its observations
- Detected oscillations
- Best model does not agree



Metal-poor stars in our Galaxy

Inability of public stellar models to reproduce the position in the HR diagram of metal-poor stars:
the case of HD 122563 (Creevey+2024)

- “Benchmark star” ($V \sim 6$)
- Detailed study of its observations
- Detected oscillations
- Impact of changing the boundary conditions



- Observations
 - Benchmark stars
 - Gaia
- Models
 - Physics of stellar interiors
 - **Alpha Cen A & B**

alpha Cen

Closest stars to the Sun

- Close and bright
- Similar to the Sun
- Binary system → same age, same initial composition
- Well-measured astrometric properties → dynamical masses (Kervella+2016,2017, Akeson+2020)

alpha Cen

Closest stars to the Sun

- Close and bright
- Similar to the Sun
- Binary system → same age, same initial composition
- Well-measured astrometric properties → dynamical masses (Kervella+2016,2017, Akeson+2020)

Thevenin et al. 2025 applied an inverse mapping technique to estimate the initial composition and age of alpha Cen A&B while also testing

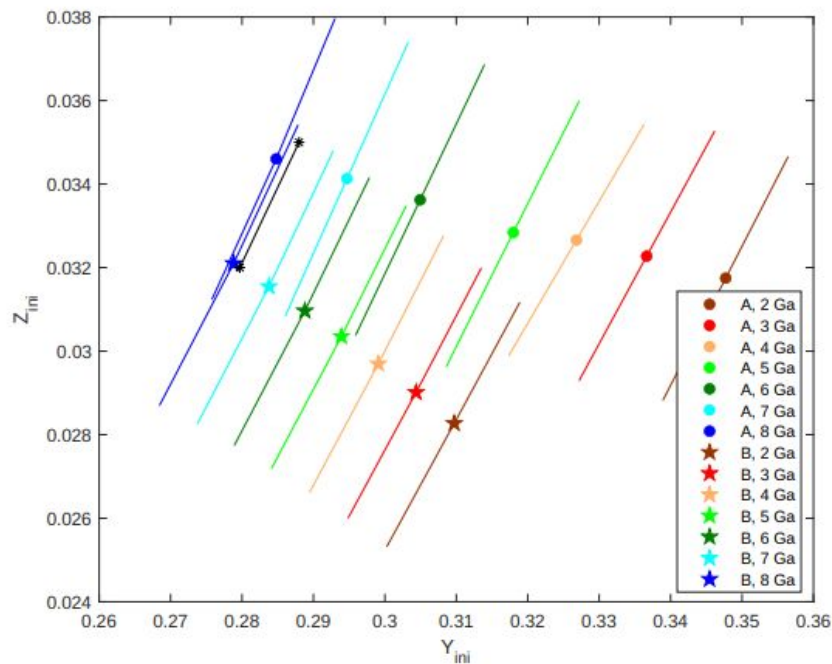
- Impact of solar mixture ($\log A(O) = 8.87$ (Grevesse & Noels 93) or 8.69 (Asplund+09))
- Impact of overshoot in core of alpha Cen A (when convective)

alpha Cen

Combinations of $(Y,Z)_{\text{ini}}$ that satisfy the individual observational constraints

- The overlapping colours are the possible solutions
- $Z_{\text{ini}} = 0.032 - 0.035$
- $Y_{\text{ini}} = 0.276 - 0.288$

→ Age: 7.80 – 7.83 Gyr



alpha Cen

Similar analysis with different Solar Z and Core A properties

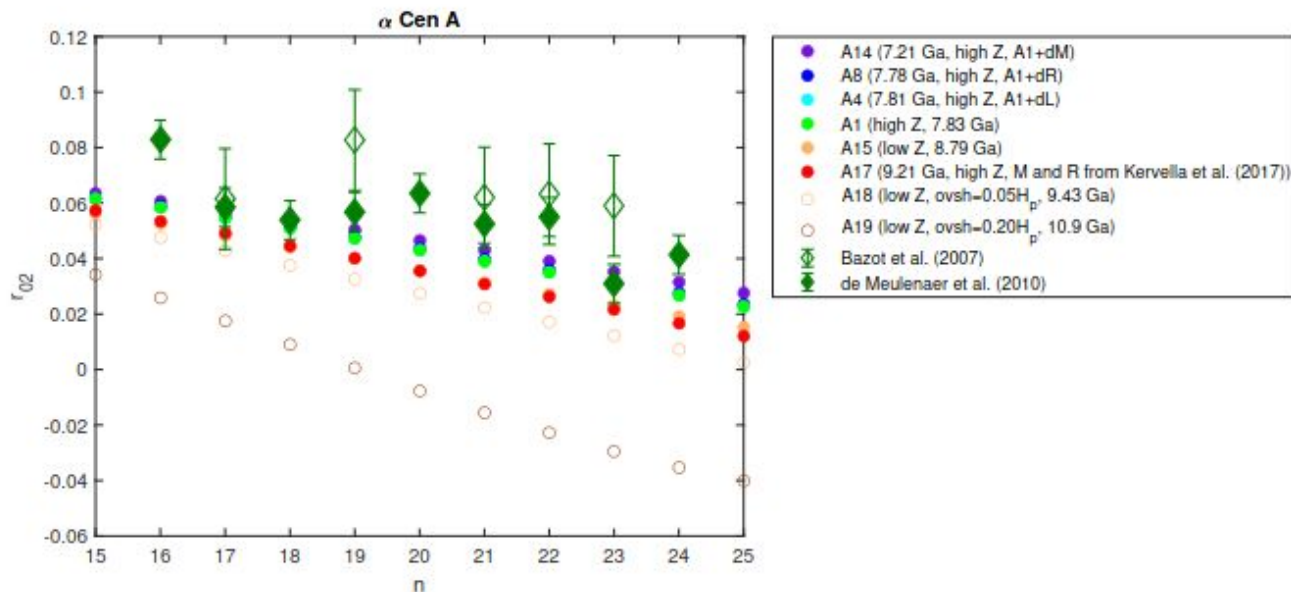
Exploiting asteroseismic data to help distinguish the models

alpha Cen

Similar analysis with different Solar Z and Core A properties

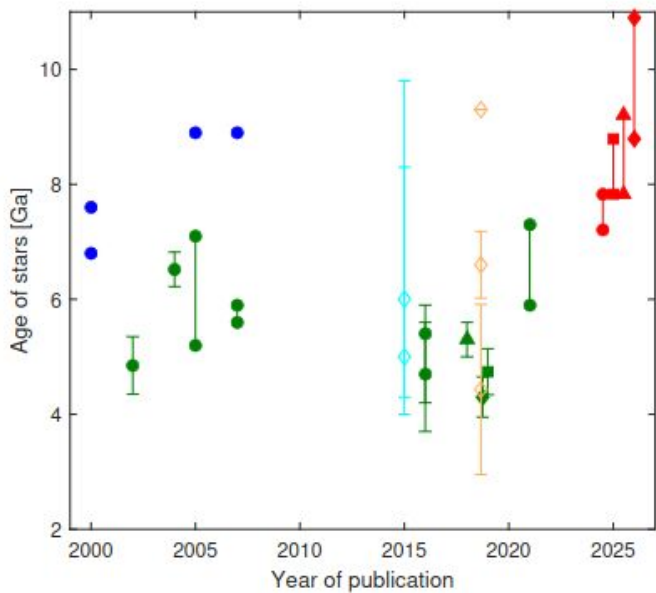
Exploiting asteroseismic data to help distinguish the models

→ rule out the low Z models, No core overshoot favoured, Age of ~7.2 Gyr



alpha Cen

Age of alpha Cen as a function of time



- Guenther and Demarque (2000)
- Miglio and Montalbán (2005)
- Yildiz (2007)
- Thevenin et al. (2002)
- Eggenberger et al. (2004)
- Miglio and Montalbán (2005)
- Yildiz (2007)
- Bazot et al. (2016)
- Nsamba et al. (2018)
- Nsamba et al. (2019)
- ▲ Joyce and Chaboyer (2018)
- Salmon et al. (2021)
- Angus et al. (2015), gyrochronology
- Morel (2018), chemical indicators
- This work: effect of M (models 1 and 14)
- This work: effect of Z/X (models 1 and 15)
- ▲ This work: cumulated effect of $M, L, R, Z/X$ (models 1 and 17)
- ◆ This work: effect of overshooting (models 15 and 19)

Age of alpha Cen as a function of time



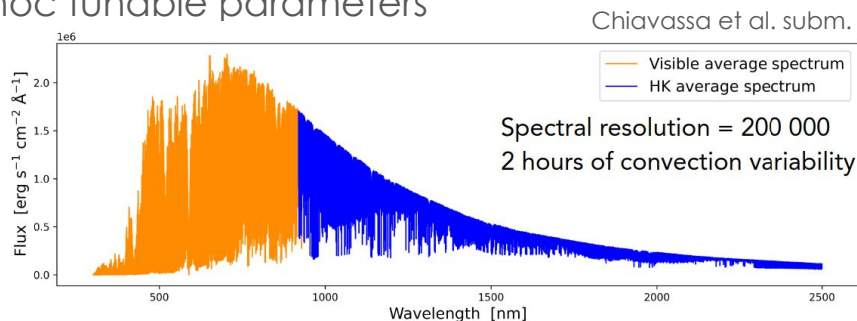
- Ebrahimkuty + subm. exploiting
interferometric data, but using
published evolution tracks with a
fixed chemical enrichment law
and mlp

Prospects

- New interferometric facilities allowing better precision (VLTI/CHARA), and higher resolution
- Large-scale spectroscopic surveys with increased resolution/size bringing atmospheric data
- Exploitation of Gaia Data Release 3, 4 (Dec 2026), and 5 (~2030)
- PLATO targeting “bright” stars for better characterisation (and testing)
- LSST, HWO, ELT, Haydn, ...

Prospects

- New interferometric facilities allowing better precision (VLTI/CHARA), and higher resolution
- Large-scale spectroscopic surveys with increased resolution/size bringing atmospheric data
- Exploitation of Gaia Data Release 3, 4 (Dec 2026), and 5 (~2030)
- PLATO targeting “bright” stars for better characterisation (and testing)
- LSST, HWO, ELT, Haydn, ...
- Availability of numerical tools, allowing us to build upon what has been done and not redo it in order to move on, e.g. SPiNS stellar parameter determination
- Community support in models, e.g. CESAM2k20 (Manchon+2026)
- 3D simulations removing the need for ad-hoc tunable parameters



Conclusions

- Stellar physics is at the core of many research topics
- I focussed on the synergy with exoplanets - Galaxy - Sun
 - Fundamental properties
 - Improvement of stellar models → Age and chemical composition
- I talked about
 - Observations: Benchmark stars, Gaia DR3
 - Models: testing processes in Sun, alpha Cen system
- 3D atmospheres, understanding of activity, rotation, magneto-asteroseismology, ...

Conclusions

- Stellar physics is at the core of many research topics
- I focussed on the synergy with exoplanets - Galaxy - Sun
 - Fundamental properties
 - Improvement of stellar models → Age and chemical composition
- I talked about
 - Observations: Benchmark stars, Gaia DR3
 - Models: testing processes in Sun, alpha Cen system
- 3D atmospheres, understanding of activity, rotation, magneto-asteroseismology, ...

Merci pour votre attention !

