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Analysis of eclipsing binaries in multiple stellar systems: the case of V1200 Centauri

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Solaris network

- Solaris: network of four autonomous observatories in the Southern Hemisphere (Kozłowski et al. 2014, 2017).
  - Solaris-1 and -2 in the South African Astronomical Observatory (South Africa).
  - Solaris-3 in Siding Spring Observatory (Australia).
  - Solaris-4 in Complejo Astronómico El Leoncito (Argentina).

Solaris-4 site (CASLEO, Argentina)

Solaris network

- Goal: detect exoplanets around binaries and multiple stars using high cadence and high-precision photometry (Konacki et al. 2012).
- ∼240 stars observed photometrically by the Solaris network between 2015 June and 2021 April.
- V1200 Centauri observed by Solaris during three main campaigns between:
  - 2017 February and August (∼75 observation nights).
  - 2018 March and August (∼55 observation nights).
  - 2019 February and April (∼25 observation nights).

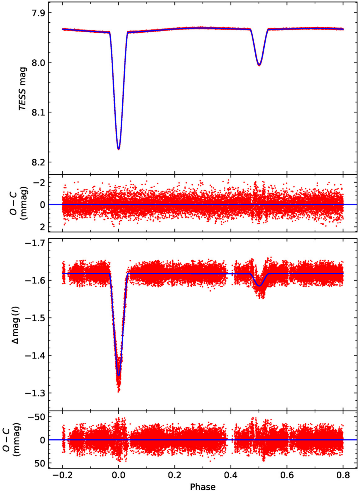
$\Rightarrow$ ∼30 000 data points collected both with V and I filters.

Interest of V1200 Centauri

- V1200 Centauri: eclipsing binary of Algol type (Samus et al. 2017).
- Bright detached system ($V = 8.5$ mag; Høg et al. 2000) with an orbital period of $\sim$2.5 d (Coronado et al. 2015).
- Coronado et al. (2015) reported the presence of a third stellar-mass companion in a large orbit ($P \simeq 352$ d).
- Coronado et al. (2015): depth of secondary eclipse comparable to the scatter of data.

  $\Rightarrow$ Large uncertainties on the resulting parameters (R, $T_{\rm eff}$, age).

LC modelling

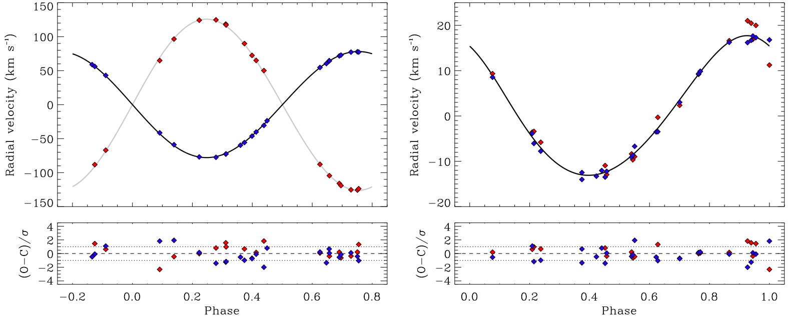


(Marcadon et al. 2020)

- Photometric data from Solaris and *TESS* (Transiting Exoplanet Survey Satellite).
- Solaris: ∼30 000 data points collected with a *I* filter during ∼155 nights (2017–2019).
- *TESS*: ∼14 000 data points obtained in 2-min cadence for 27.1 d (sector 11).
- Light curves fitted using the JKTEBOP code (Southworth et al. 2004).

RVs and orbital solution

- Radial velocities obtained with different spectrographs.
  - 18 previous measurements from PUCHEROS and CORALIE.
  - 6 new measurements from CHIRON used in this work.
- Optimal solution found for a 180-d outer period by fitting a double-Keplerian orbit.



RV observations and orbital solution for V1200 Cen (Marcadon et al. 2020)

Physical parameters

- Physical parameters derived from our analysis:

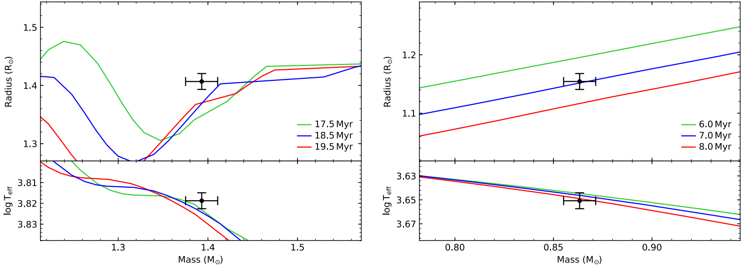
$$M_{Aa} = 1.393 \pm 0.018\, M_\odot \qquad M_{Ab} = 0.863 \pm 0.008\, M_\odot$$
$$R_{Aa} = 1.407 \pm 0.014\, R_\odot \qquad R_{Ab} = 1.154 \pm 0.014\, R_\odot$$

- Effective temperatures computed using the Gaia DR2 parallax:

$$T_{\mathrm{eff},Aa} = 6\,588 \pm 58\,\mathrm{K} \qquad T_{\mathrm{eff},Ab} = 4\,475 \pm 68\,\mathrm{K}$$

- Individual ages deduced from the MESA isochrones:

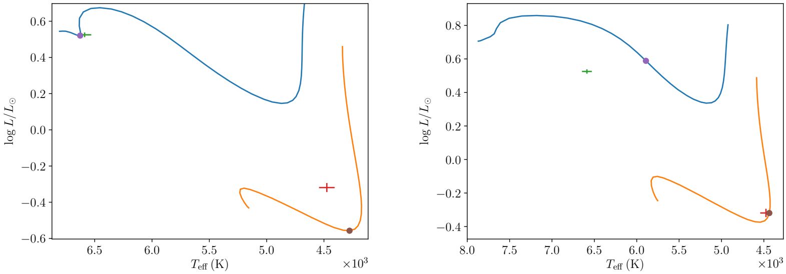
$$\mathrm{Age}_{Aa} = 18.5\,\mathrm{Myr} \qquad \mathrm{Age}_{Ab} = 7.0\,\mathrm{Myr}$$



Stellar parameters of V1200 Cen and MESA isochrones (Marcadon et al. 2020)

Physical parameters

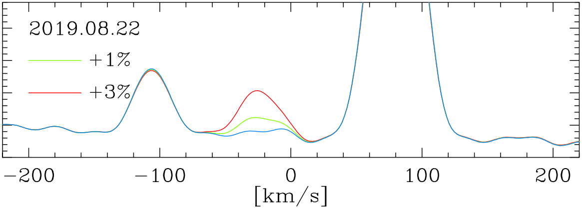
- Stellar parameters determined with a precision better than 1.5%.
- Age difference of 11.5 Myr between the two eclipsing components.
  $\Rightarrow$ Stars belonging to a multiple system are assumed to have the same age.
  $\Rightarrow$ Similar results obtained by J. Marques (IAS, France) using CESTAM.
- CESTAM: Code d'évolution stellaire, avec transport, adaptatif et modulaire (Morel and Lebreton 2008; Marques et al. 2013).



Evolutionary tracks in the HR diagram (Marcadon et al. 2020)

Main results

- V1200 Centauri: quadruple star system with a 180-d outer period.
  ⇒ Minimum mass of the third body: $M_B = 0.871 \pm 0.020\, M_\odot$.
  ⇒ Consistent with a sub-system B composed of two low-mass stars.
- Dynamical interactions between stars in close multiple systems can explain the observed age difference (Stassun et al. 2014).
  ⇒ Impact on the stellar parameters during the early evolution stage.
  ⇒ Impossible to fit both pre-main-sequence stars with the same age.



Broadening function of V1200 Cen (Marcadon et al. 2020)

Future prospects

- PLATO – Planetary transits and oscillations of stars (ESA, 2026).
  - Future space mission dedicated to asteroseismology and exoplanet searches.
- Research proposal: binary and multiple star systems as benchmarks for stellar evolutionary models.

  ⇒ Creating a catalogue of well-characterised binary and multiple systems in preparation for PLATO.

  ⇒ Studying the formation and evolution of stars and planets belonging to binary or multiple systems.