Evolutionary models for ultracool dwarfs

implications for the Trappist-1 star

C. S. Fernandes,[1,2] V. Van Grootel,[1] S. J. A. J. Salmon,[1] B. Aringer,[3,4] A. J. Burgasser,[5] R. Scuflaire,[1] P. Brassard,[6] and G. Fontaine[6]

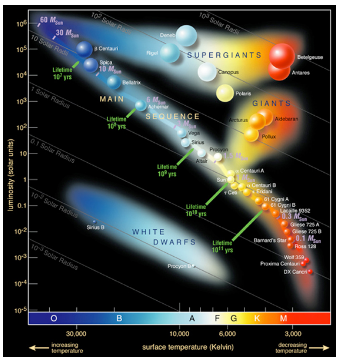
[1] STAR Institute, Université de Liège, Belgium | [2] Niels Bohr Institute, University of Copenhagen, Denmark | [3] Dipartimento di Fisica e Astronomia Galileo Galilei, Università di Padova, Italy | [4] INAF, Italy

[5] Center for Astrophysics and Space Science, University of California San Diego, USA | [6] Département de Physique, Université de Montréal, Canada

1. Ultracool dwarf stars (UCDs)

UCDs:

- lie at the bottom end of the H-R diagram: faint and red
- Spectral-type: M7 and cooler [1]
- Properties: small, dim and cool
- Excellent targets for detecting transiting earth-like exoplanets



Characterise UCDs:

- precise estimates of the mass, radius, luminosity, effective temperature and age
- fundamental to constrain the physical properties of orbiting exoplanets

Fig. 1: H-R diagram. Credits: NASA/CXC/SAO

2. Stellar evolution models for UCDs

We adapted Code Liégeois d'Evolution Stellaire, CLES[2]

- it now accounts for the physics of UCDs
- Asplund et al. 2009 chemical mixture [3]
- Equations-of-state for H, He, C and O that cover UCDs at all stages [4], [5]

Fernandes et al. 2019 accepted for publication at ApJ

Similar results between CLES and BHAC15 [6] (solar metallicity)

Compared our results with observations for:

- M7 binary: LSPM J1314+1320AB [7]
- GJ 65AB [8]
- Proxima Centauri [8]

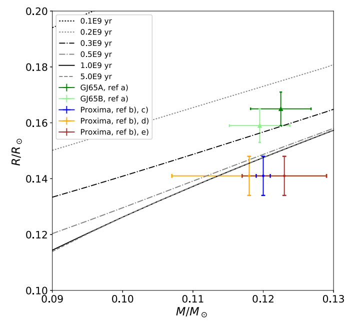


Fig.2: Mass-radius isochrones (0.1-5.0 Gyr), assuming solar composition. Comparison to measurements for Proxima and GJ65AB.

References: a) Kervella et al. 2016, b) Demory et al. 2009, c) this work, d) Henry et al. 1999, e) Delfosse et al. 2000

3. Grid of stellar evolution models for UCDs with CLES

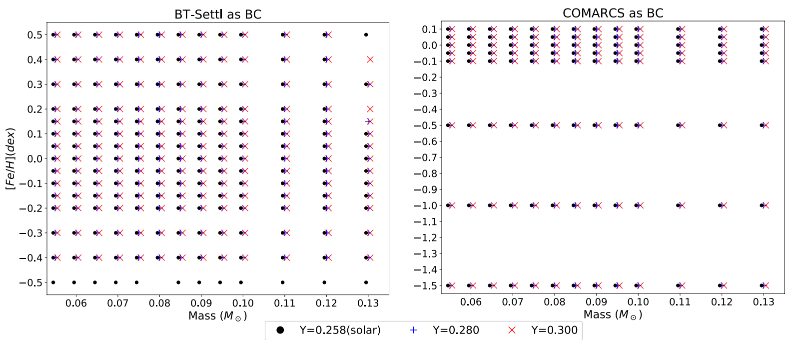
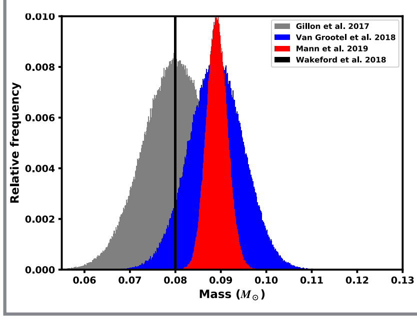


Fig.3: Illustration on the currently available stellar evolution models for UCDs [9] computed with CLES [3]: selected for two different atmosphere models as boundary condition (BC) and for different combinations of metallicity and helium mass fraction. We present our evolution models for Teff > 2000K if BC is set by BT-Settl [10] as this includes grain formation, and models for Teff > 2600K when the BC is set by a dust-free COMARCS [11] atmosphere model.

Public tables available at

✦ www.astro.ulg.ac.be/ASTA/cles-models-UCDs/

4. The mass of Trappist-1



- Evolution models: mass as free-parameter to match observables [12]
- Evolution models: mass and metallicity as free-parameters to account for stellar age estimation [13] and to match observables [14]
- Mass-Luminosity relation: mass estimated, given stellar distance and magnitude [15]

Fig.4: Plot inspired and adapted from Mann et al. 2019: mk_mass.py(tester)

Conclusion

- Computed stellar evolution models of UCDs with CLES
  - for different metallicities, and two flavours of model atmospheres as BCs.
  - Public tables are available online
  - Improvements and extensions are ongoing
- Trappist-1mass estimated with the CLES models in Van Grootel et al. 2018 is in agreement with estimated mass from M-L relations of Mann et al. 2019

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Contact

Catarina Fernandes, PhD student: c.fernandes at uliege.be

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