Massive binaries in 30 Doradus

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Reminder:

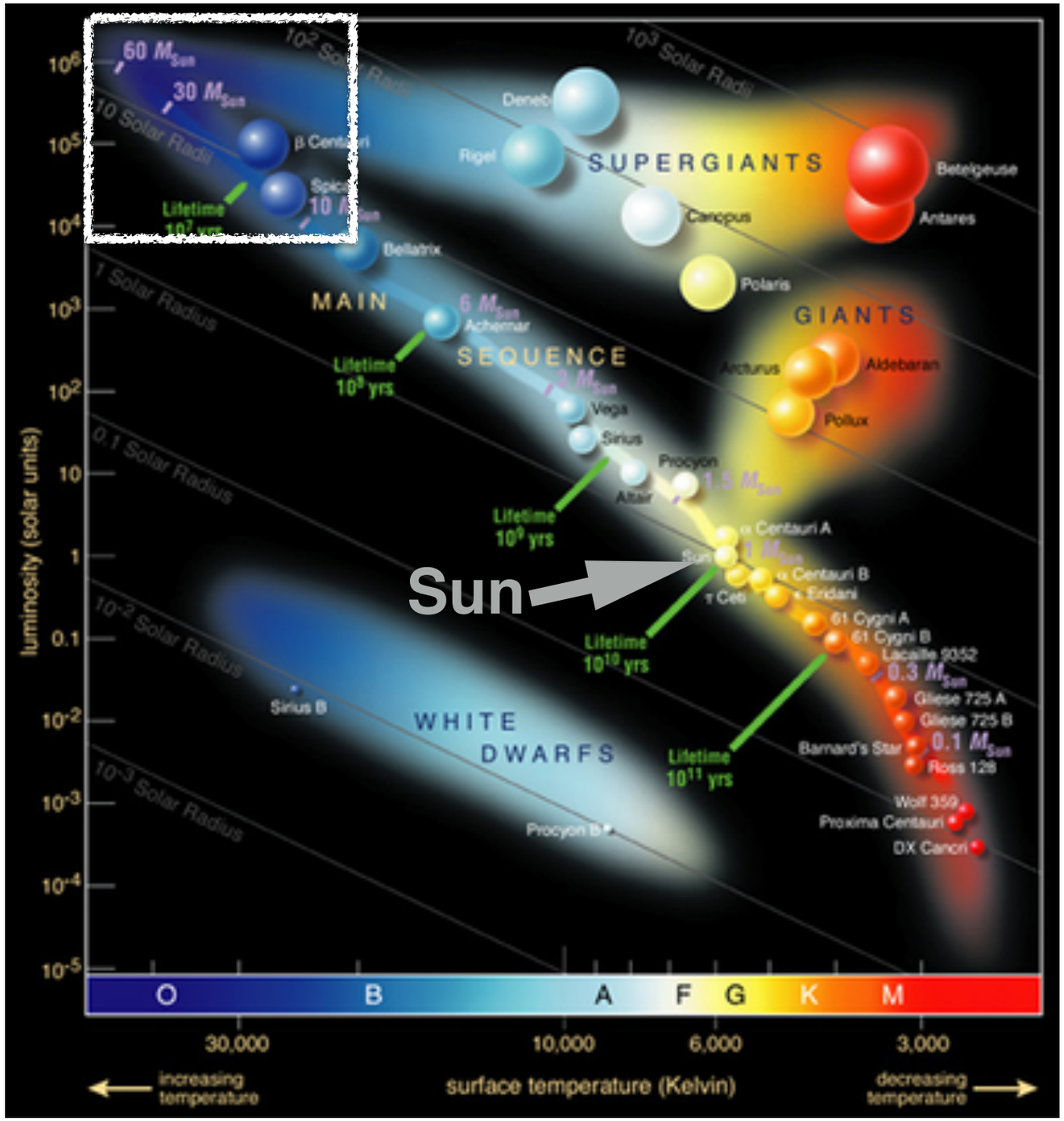
- Luminosity > $10^{4\text{-}5}$ $L_\odot$
- Temperature > 25000K
- Powerful stellar winds

  Mass loss ~10^{-5} $M_\odot$/year

  Winds can reach 3000 km/s
- Short lifetime < 10^7 yrs while Sun ~ 10^{10} yrs

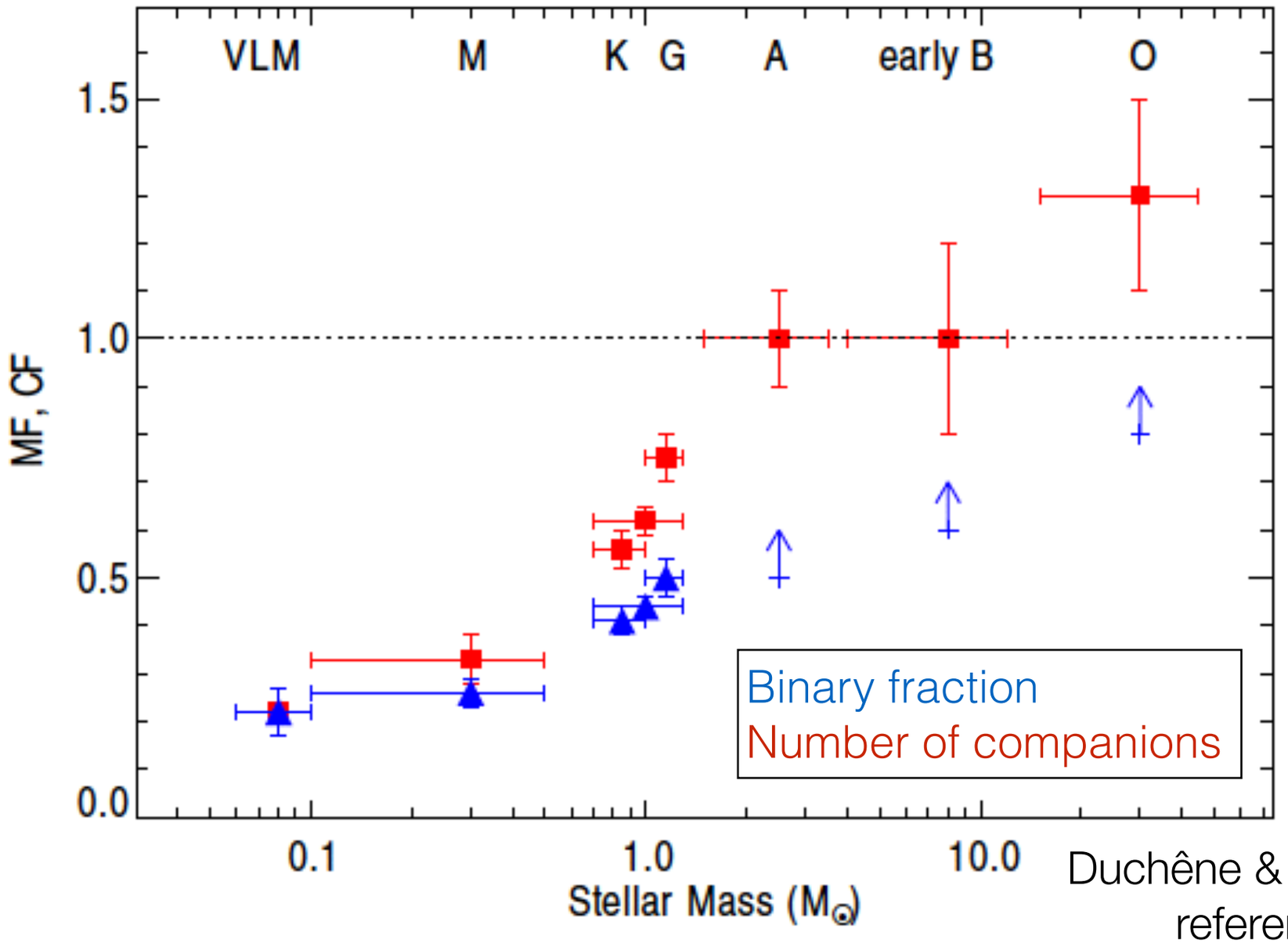
Rare

- O -> LBV/RSG -> WR -> BH/SNe



Reminder:

- > 70% are binary or multiple systems



Duchêne & Kraus (2013) and references therein

A&A 530, A108 (2011)
DOI: 10.1051/0004-6361/201116782

Astronomy & Astrophysics

The VLT-FLAMES Tarantula Survey

I. Introduction and observational overview⋆

C. J. Evans[1], W. D. Taylor[2], V. Hénault-Brunet[2], H. Sana[3], A. de Koter[3,4], S. Simón-Díaz[5,6], G. Carraro[7], T. Bagnoli[3], N. Bastian[8,9], J. M. Bestenlehner[10], A. Z. Bonanos[11], E. Bressert[9,12,13], I. Brott[4,14], M. A. Campbell[2], M. Cantiello[15], J. S. Clark[16], E. Costa[17], P. A. Crowther[18], S. E. de Mink[19,⋆⋆], E. Doran[18], P. L. Dufton[20], P. R. Dunstall[20], K. Friedrich[15], M. Garcia[5,6], M. Gieles[21], G. Gräfener[10], A. Herrero[5,6], I. D. Howarth[22], R. G. Izzard[15], N. Langer[15], D. J. Lennon[23], J. Maíz Apellániz[24,⋆⋆⋆], N. Markova[25], F. Najarro[26], J. Puls[27], O. H. Ramirez[3], C. Sabín-Sanjulián[5,6], S. J. Smartt[20], V. E. Stroud[16,28], J. Th. van Loon[29], J. S. Vink[10], and N. R. Walborn[19]

A&A 550, A107 (2013)
DOI: 10.1051/0004-6361/201219621

Astronomy & Astrophysics

The VLT-FLAMES Tarantula Survey★,★★,★★★

VIII. Multiplicity properties of the O-type star population

H. Sana[1], A. de Koter[1,2], S. E. de Mink[3,4,★★★★], P. R. Dunstall[5], C. J. Evans[6], V. Hénault-Brunet[7], J. Maíz Apellániz[8], O. H. Ramírez-Agudelo[1], W. D. Taylor[7], N. R. Walborn[3], J. S. Clark[9], P. A. Crowther[10], A. Herrero[11,12], M. Gieles[13], N. Langer[14], D. J. Lennon[15,3], and J. S. Vink[16]

The VLT-FLAMES Tarantula Survey.*

XXIX. Massive star formation in the local 30 Doradus starburst

F.R.N. Schneider[1]**, O.H. Ramírez-Agudelo[2], F. Tramper[3], J.M. Bestenlehner[4,5], N. Castro[6], H. Sana[7], C.J. Evans[2], C. Sabín-Sanjulián[8], S. Simón-Díaz[9,10], N. Langer[11], L. Fossati[12], G. Gräfener[11], P.A. Crowther[5], S.E. de Mink[13], A. de Koter[13,7], M. Gieles[14], A. Herrero[9,10], R.G. Izzard[14,15], V. Kalari[16], R.S. Klessen[17], D.J. Lennon[3], L. Mahy[7], J. Maíz Apellániz[18], N. Markova[19], J.Th. van Loon[20], J.S. Vink[21], and N.R. Walborn[22]***

A&A 598, A84 (2017)
DOI: 10.1051/0004-6361/201629844

Astronomy & Astrophysics

The Tarantula Massive Binary Monitoring

I. Observational campaign and OB-type spectroscopic binaries*

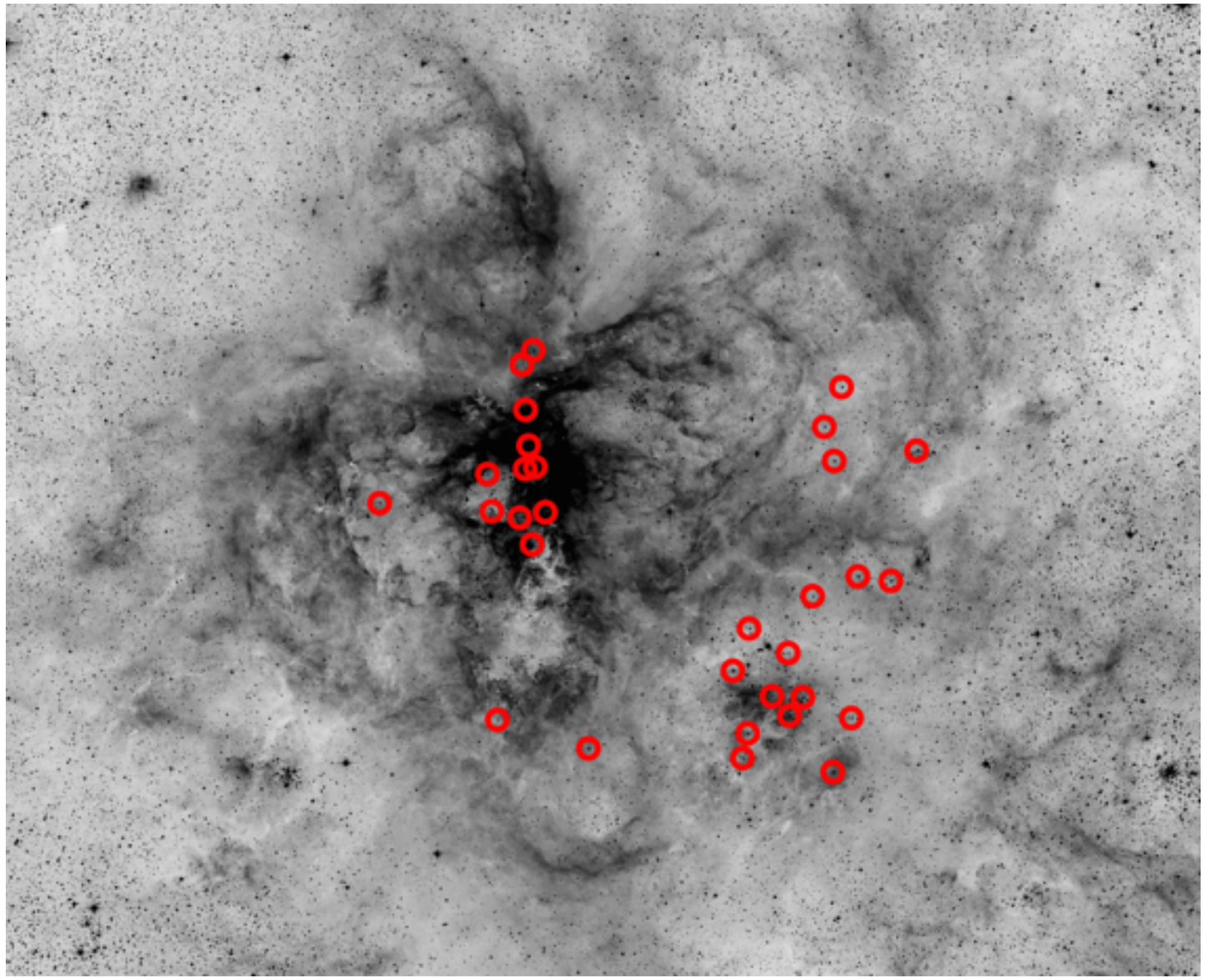
L. A. Almeida[1,2], H. Sana[3,4], W. Taylor[5], R. Barbá[6], A. Z. Bonanos[7], P. Crowther[8], A. Damineli[1], A. de Koter[9,3], S. E. de Mink[9], C. J. Evans[5], M. Gieles[10], N. J. Grin[12], V. Hénault-Brunet[11], N. Langer[12], D. Lennon[13], S. Lockwood[4], J. Maíz Apellániz[14], A. F. J. Moffat[15], C. Neijssel[9], C. Norman[2], O. H. Ramírez-Agudelo[5], N. D. Richardson[16], A. Schootemeijer[12], T. Shenar[17], I. Soszyński[18], F. Tramper[13], and J. S. Vink[19]

TMBM:

- 32 epochs randomly observed
- FLAMES spectra:

  [3950:4560] Å

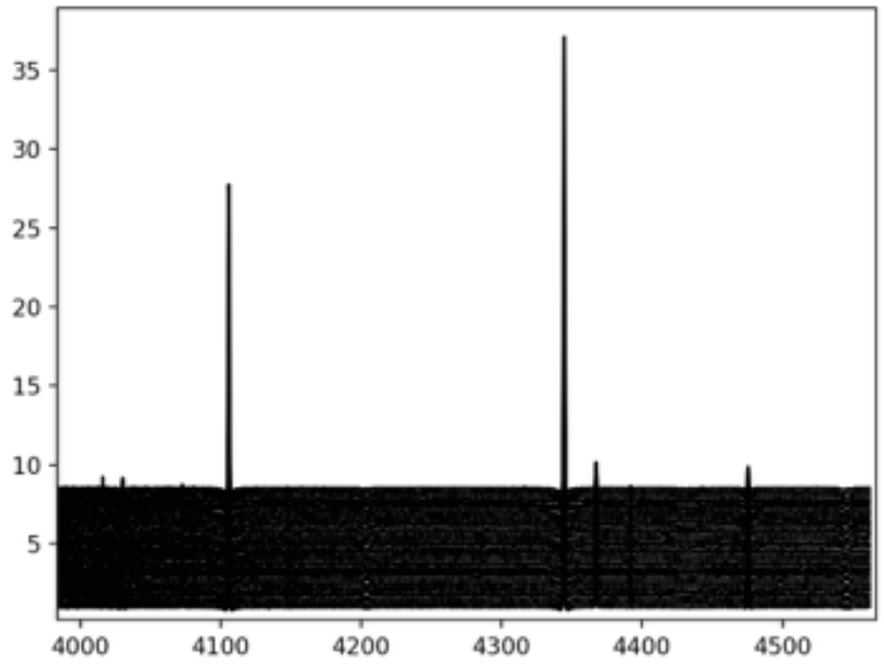
  [H, He I, He II, C III, N III, Si IV]
- 31 SB2 systems:
  - ✳ 19 only spectroscopic
  - ✳ 12 photometric + spectroscopic
    - ➡ 5 showing eclipses
    - ➡ 2 (over-)contact
    - ➡ 5 ellipsoidal var.



METHODOLOGY:

- Almeida et al. (2017) measured the radial velocities for all the epochs and compute the orbital periods, mass ratios, and eccentricities

- Use orbital solutions from Almeida et al. (2017) as inputs



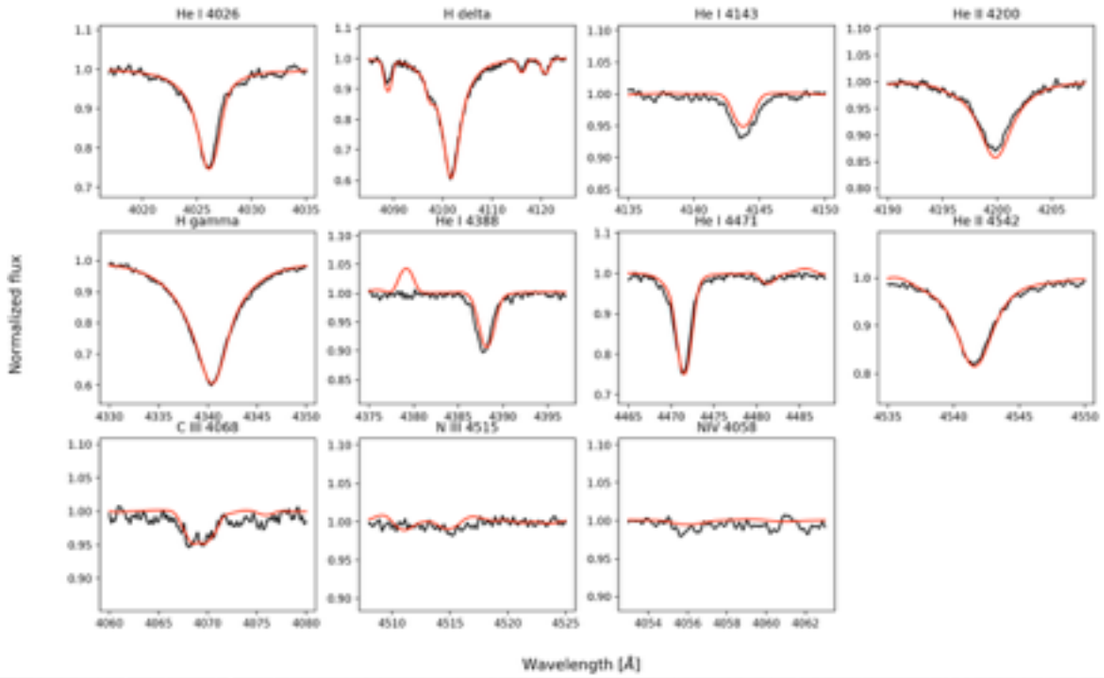
- Fourier spectral disentangling (Simon & Sturm 1994, Ilijic et al. 2004)
  - ★ Nebular contamination - line clipping is forbidden
  - ★ 3-component disentangling to estimate the nebular lines
  - ★ Estimation of the scaling
  - ★ Use the scaling factors as light factor for the nebular lines

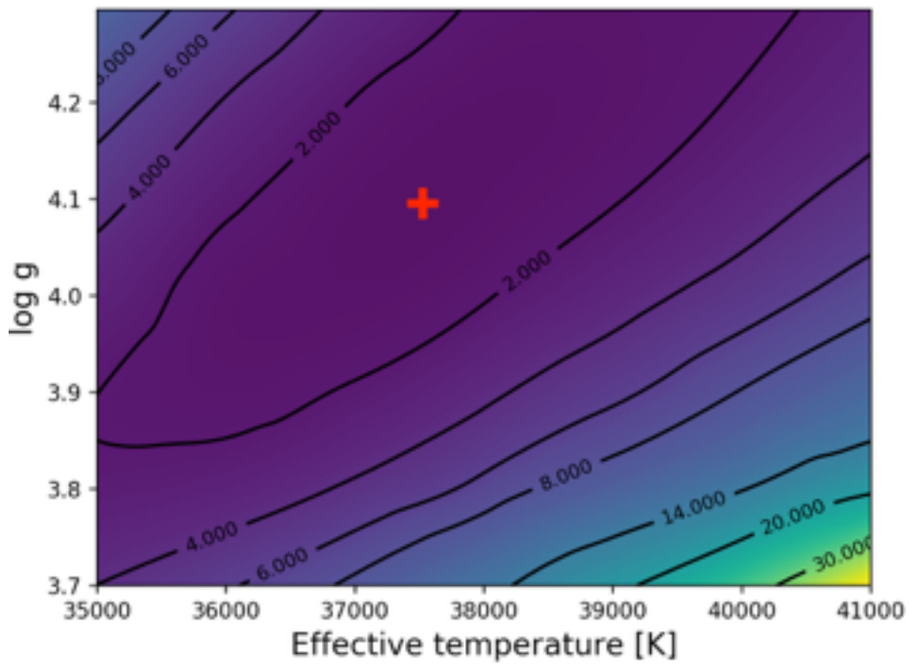
➡ The S/N of extracted spectra are higher than the observed ones

$$(S/N)_{ext} \sim (S/N)_{obs} \times Nobs^{0.5}$$

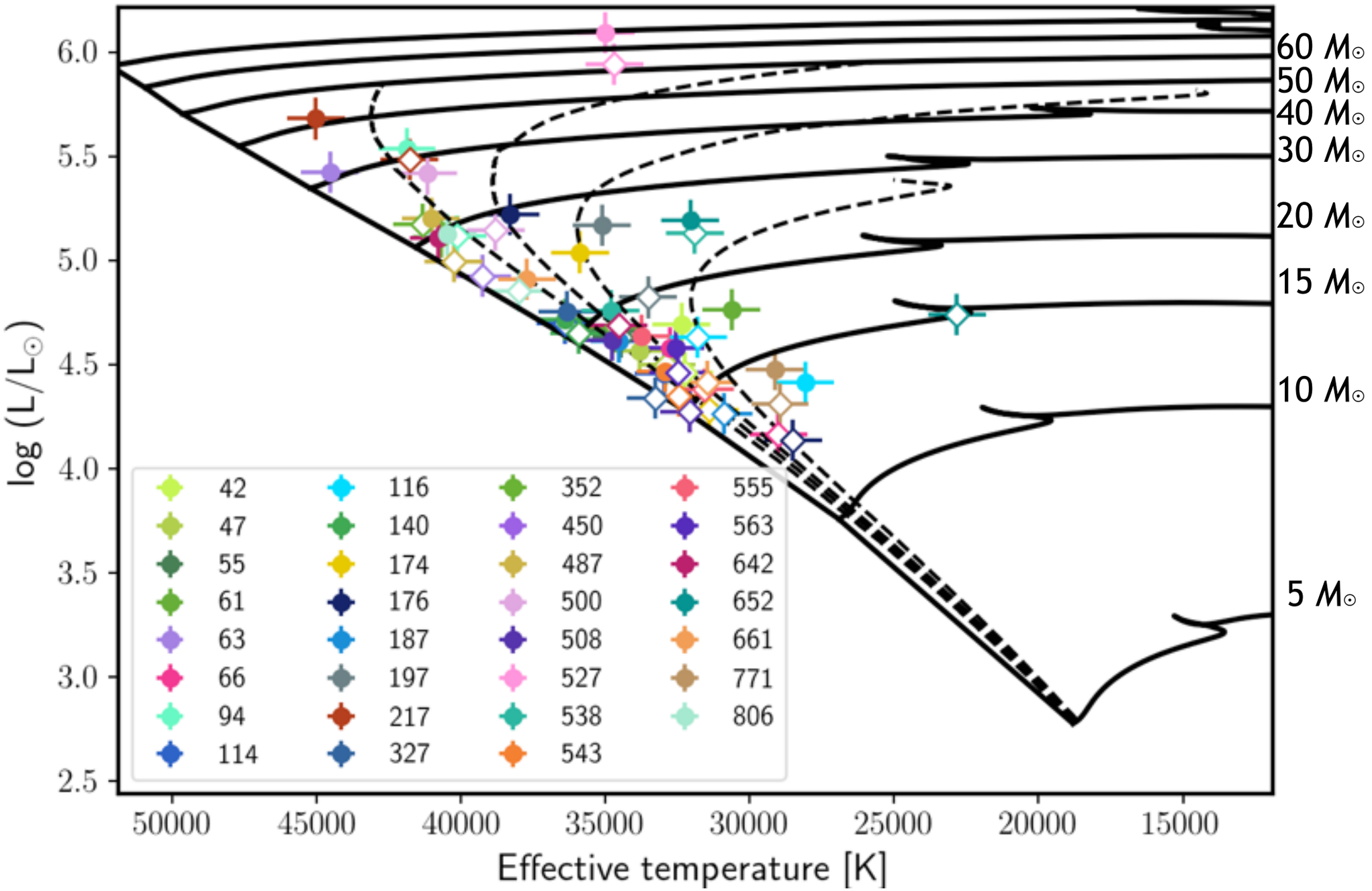
METHODOLOGY:

- Use the CMFGEN atmosphere code (Hillier & Miller 1998)
  - ★ Determination of the Teff, log g
  - ★ Determination of the C and N abundances - no O lines
  - ★ Hydrogen and Helium lines used to scale the disentangling spectra for non-photometric systems i.e. $I_1+I_2 = 1$.
- Comparaison with BONNSAI (Bayesian tool) for the theoretically predicted values

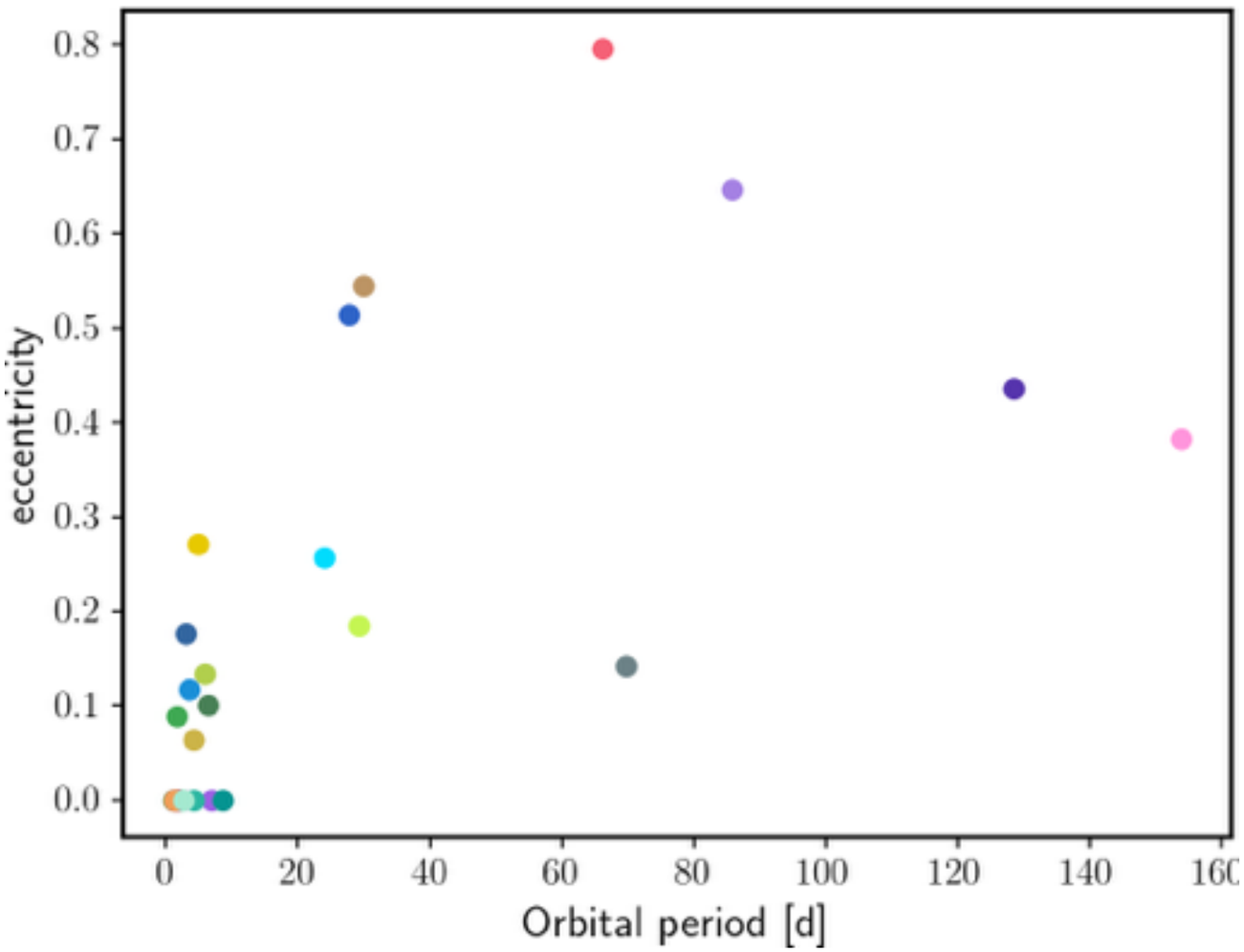




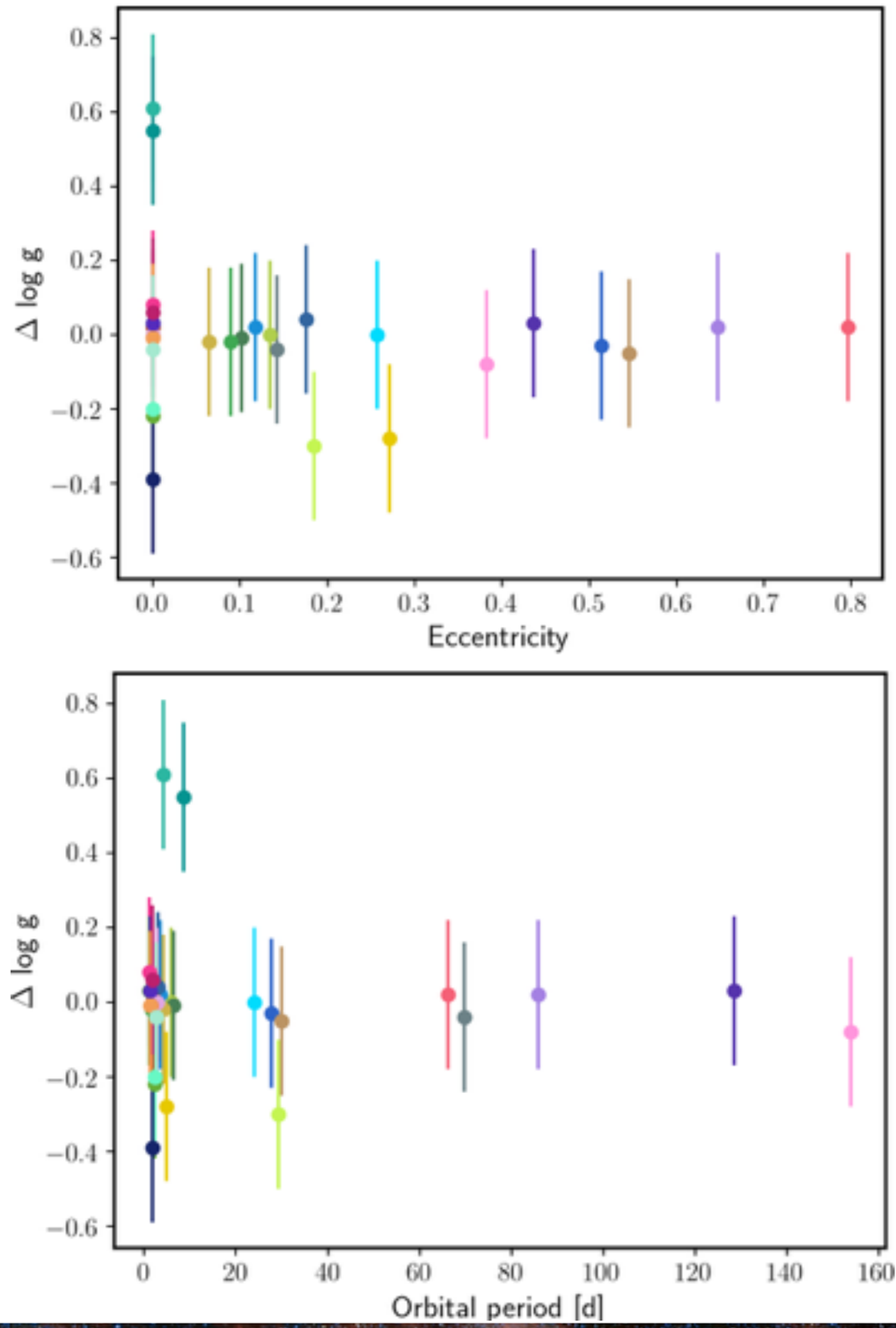
HERTZSPRUNG-RUSSELL DIAGRAM



ORBITAL PERIOD–ECCENTRICITY DIAGRAM



Eccentricities and orbital periods from Almeida et al. (2017)



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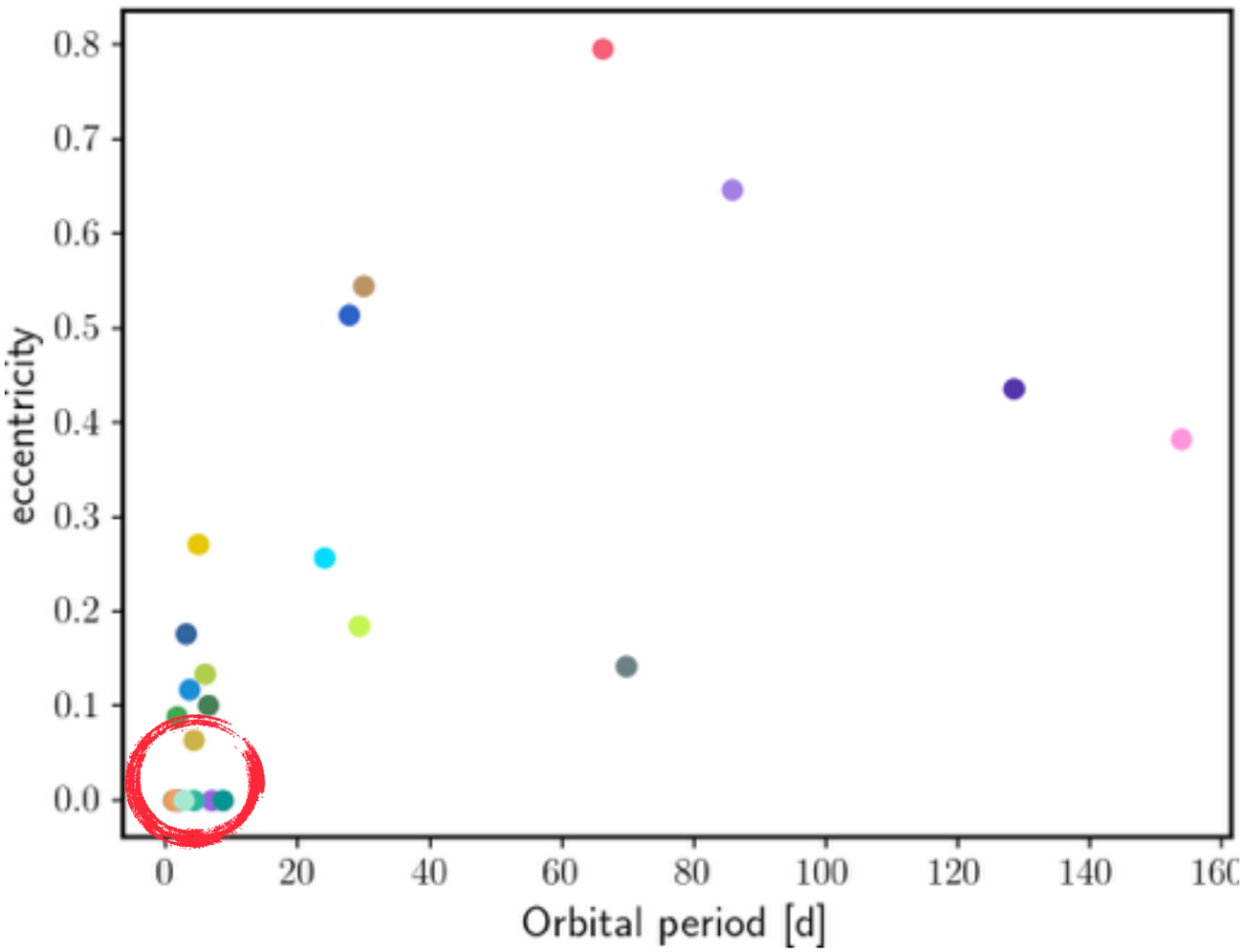

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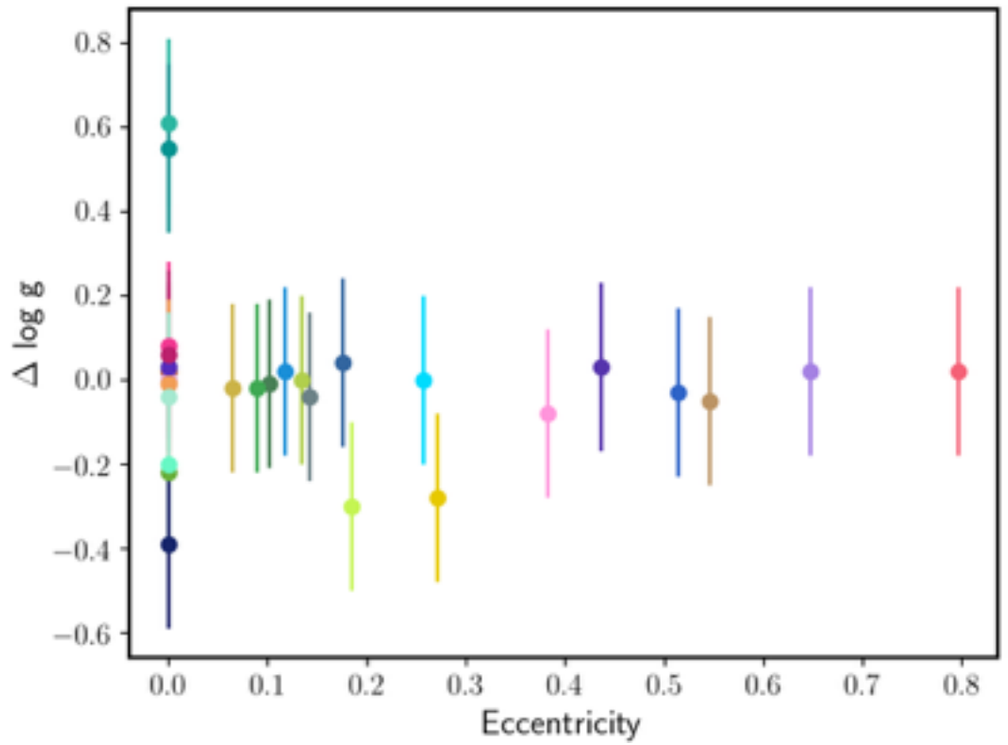

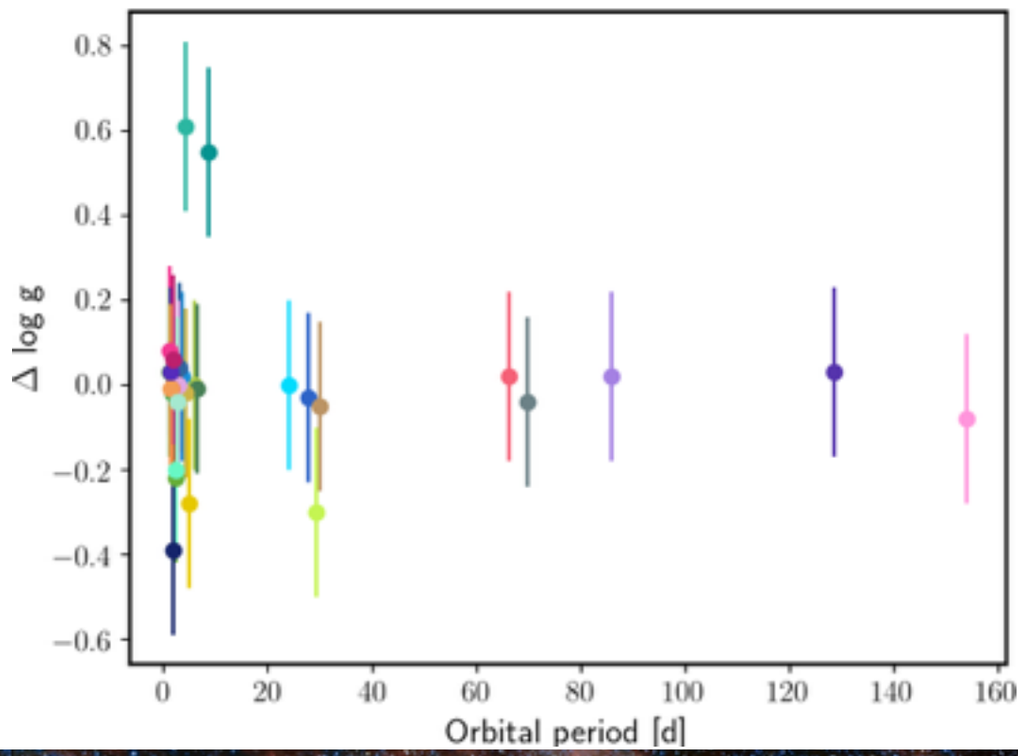

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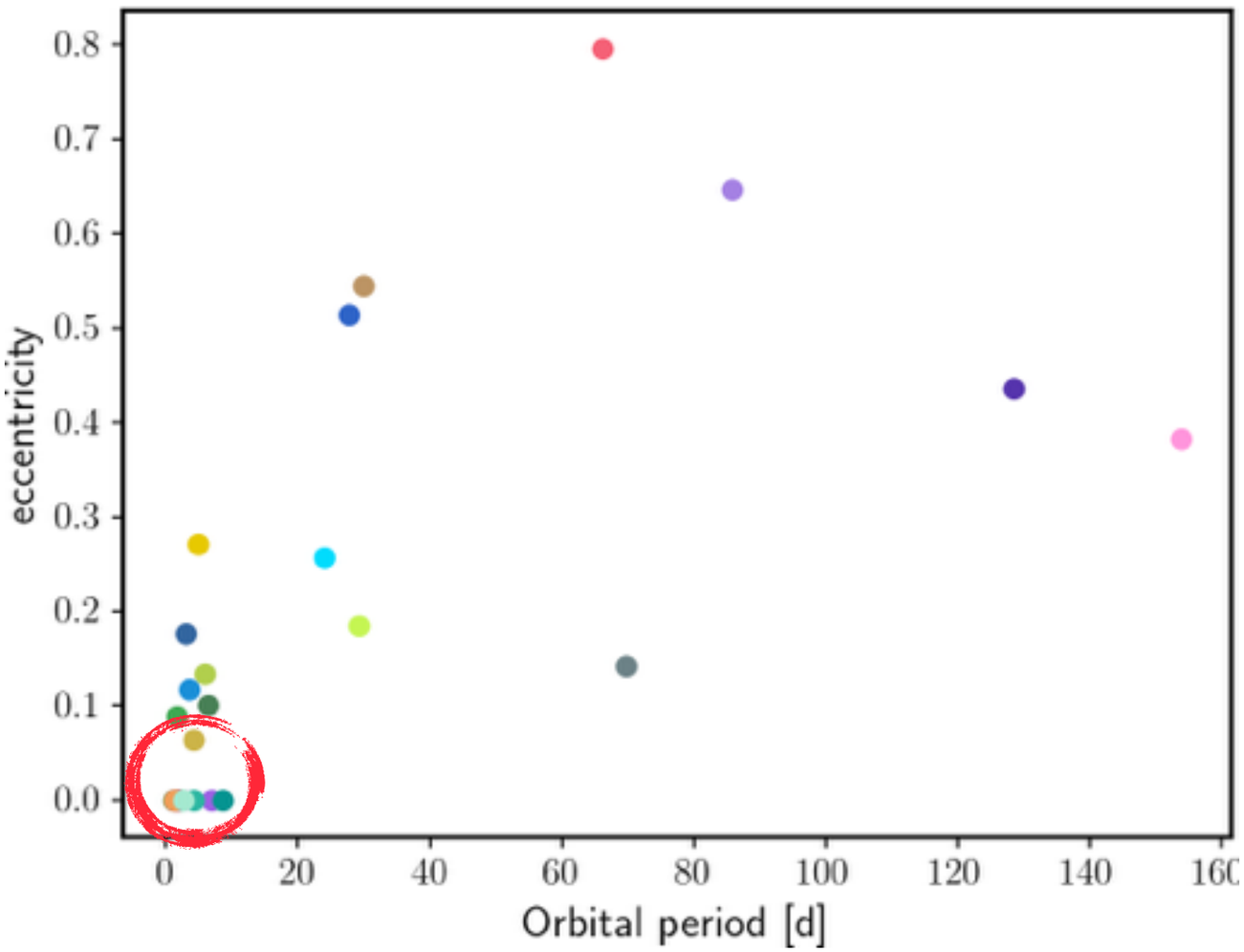

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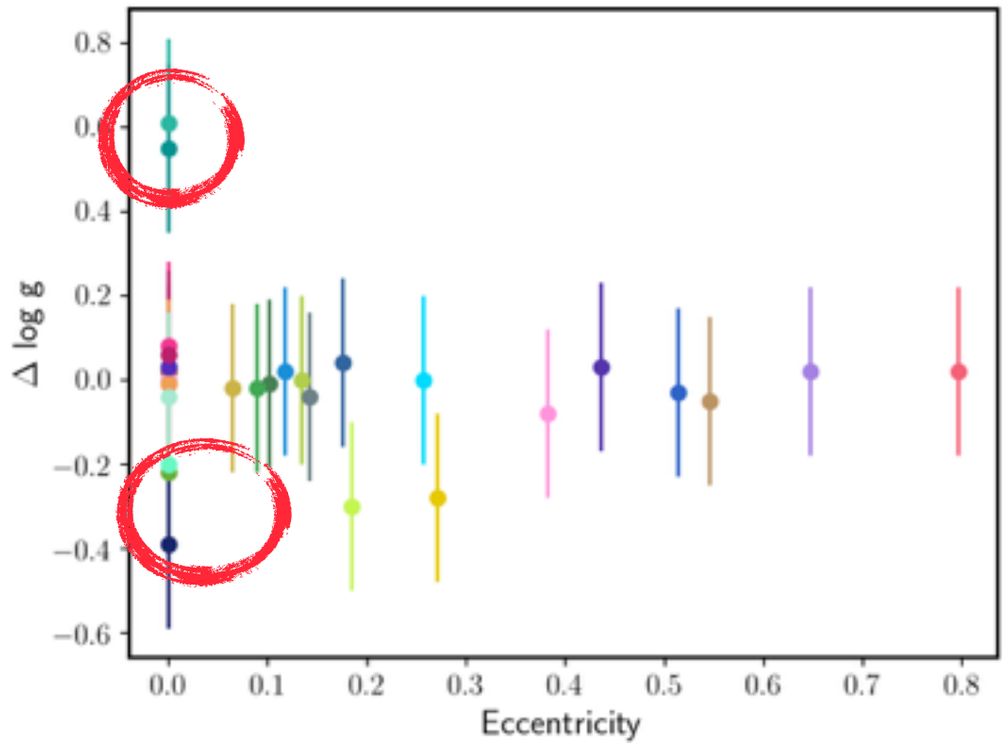

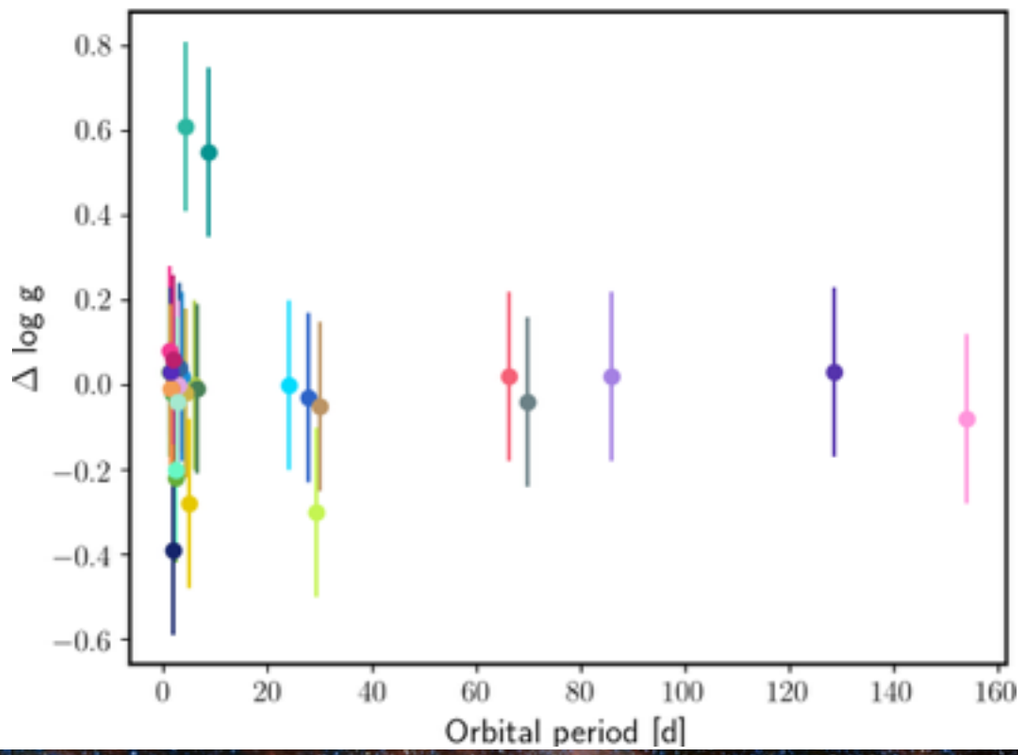

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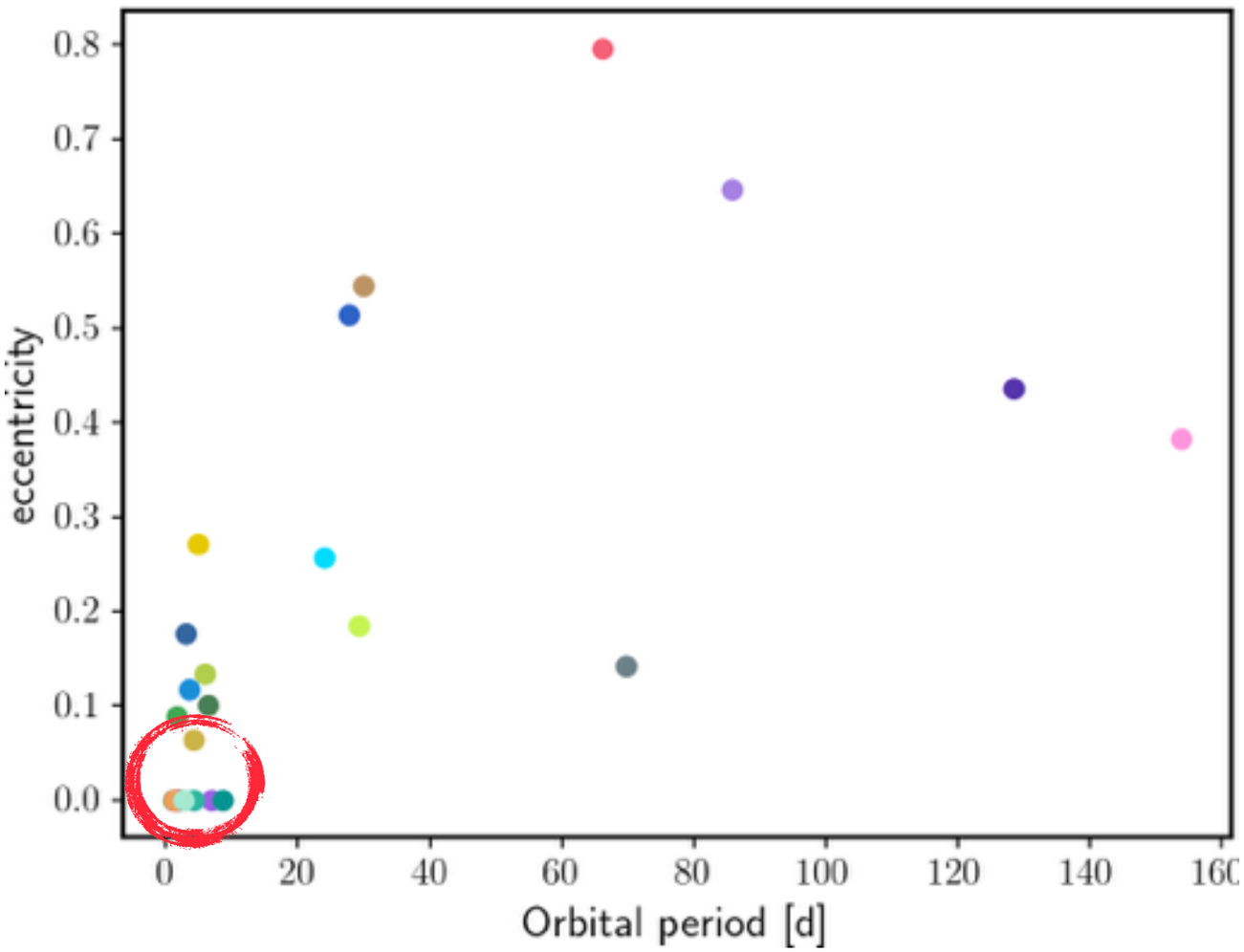

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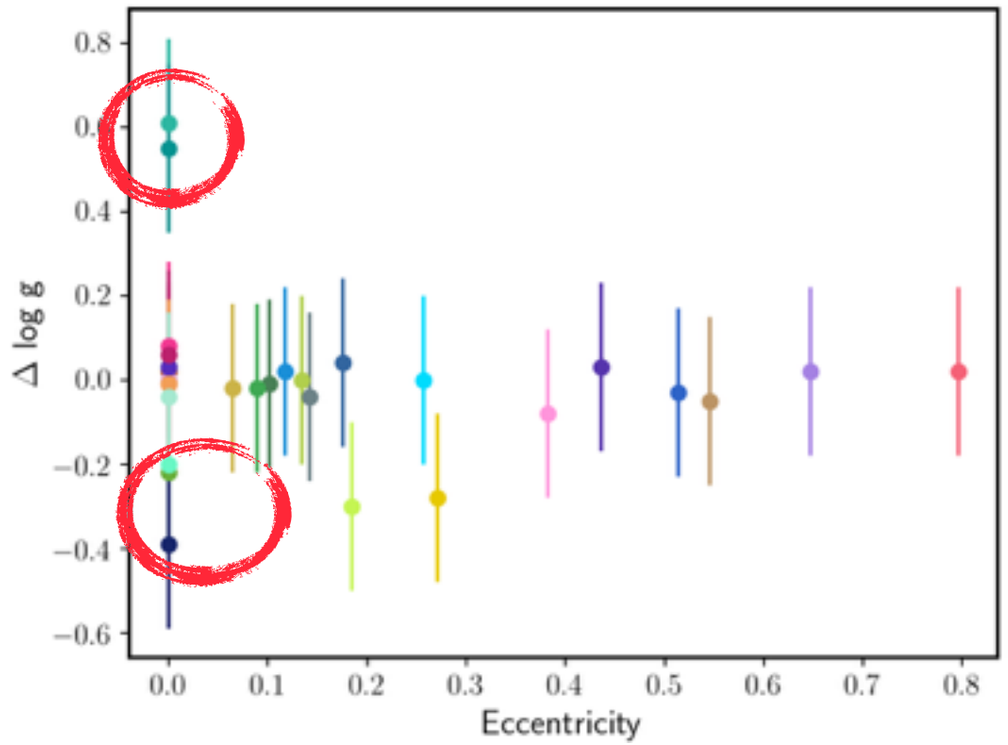
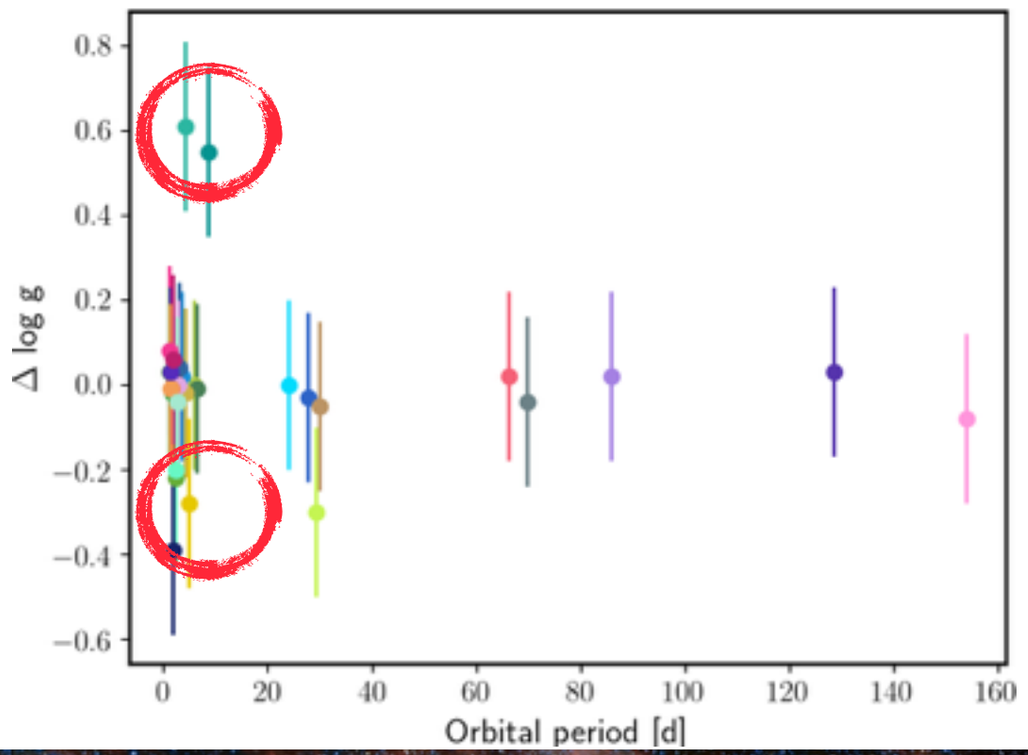
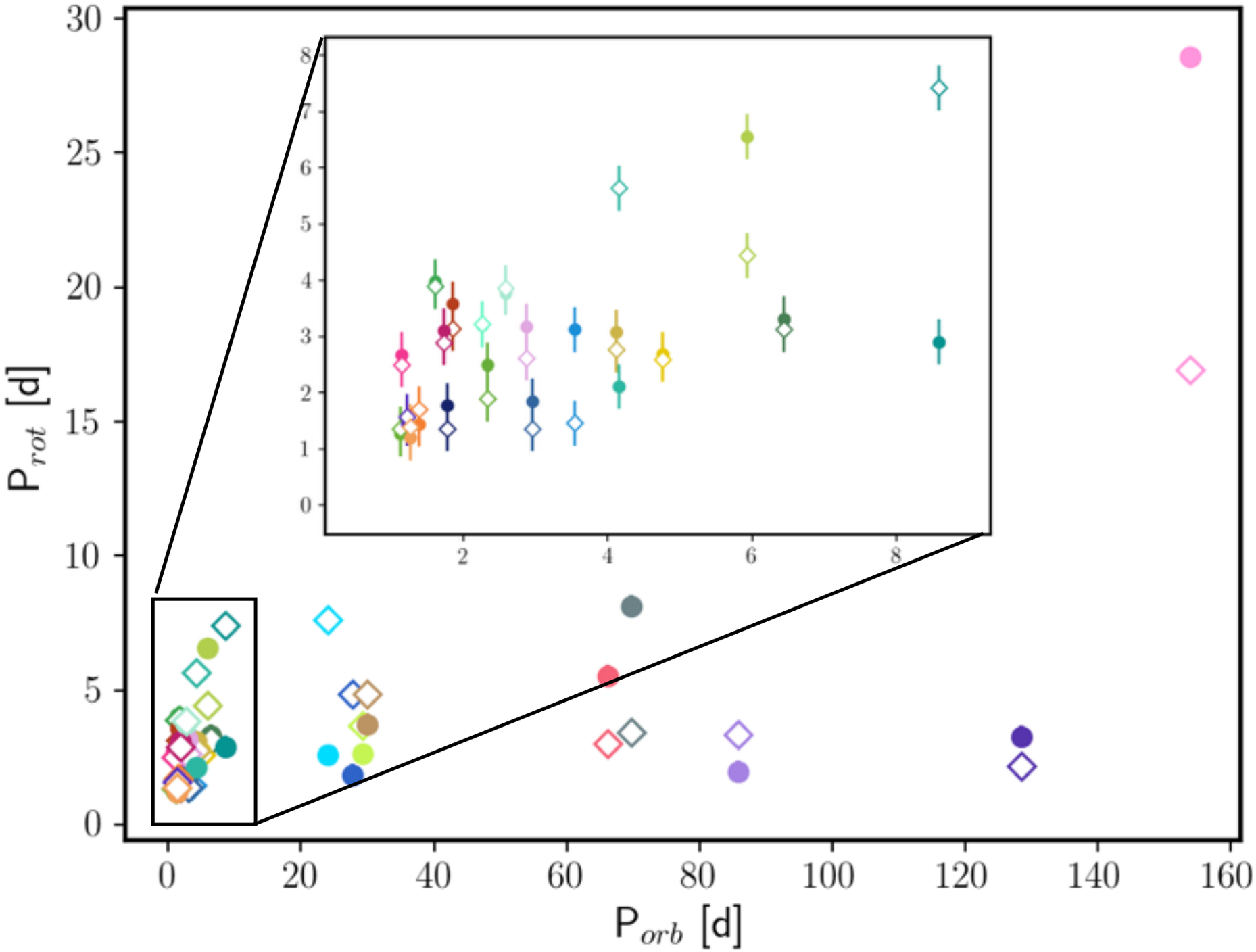
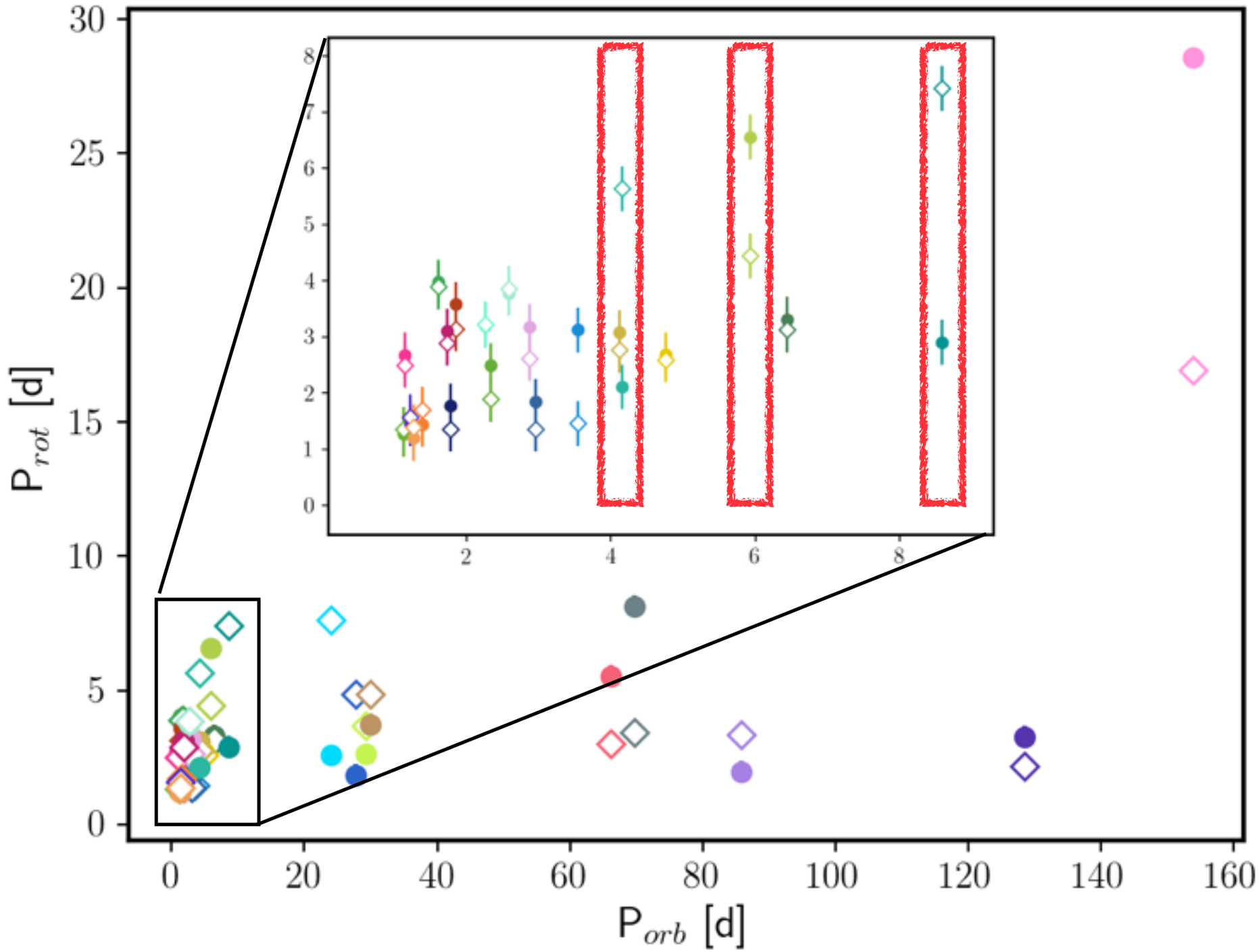




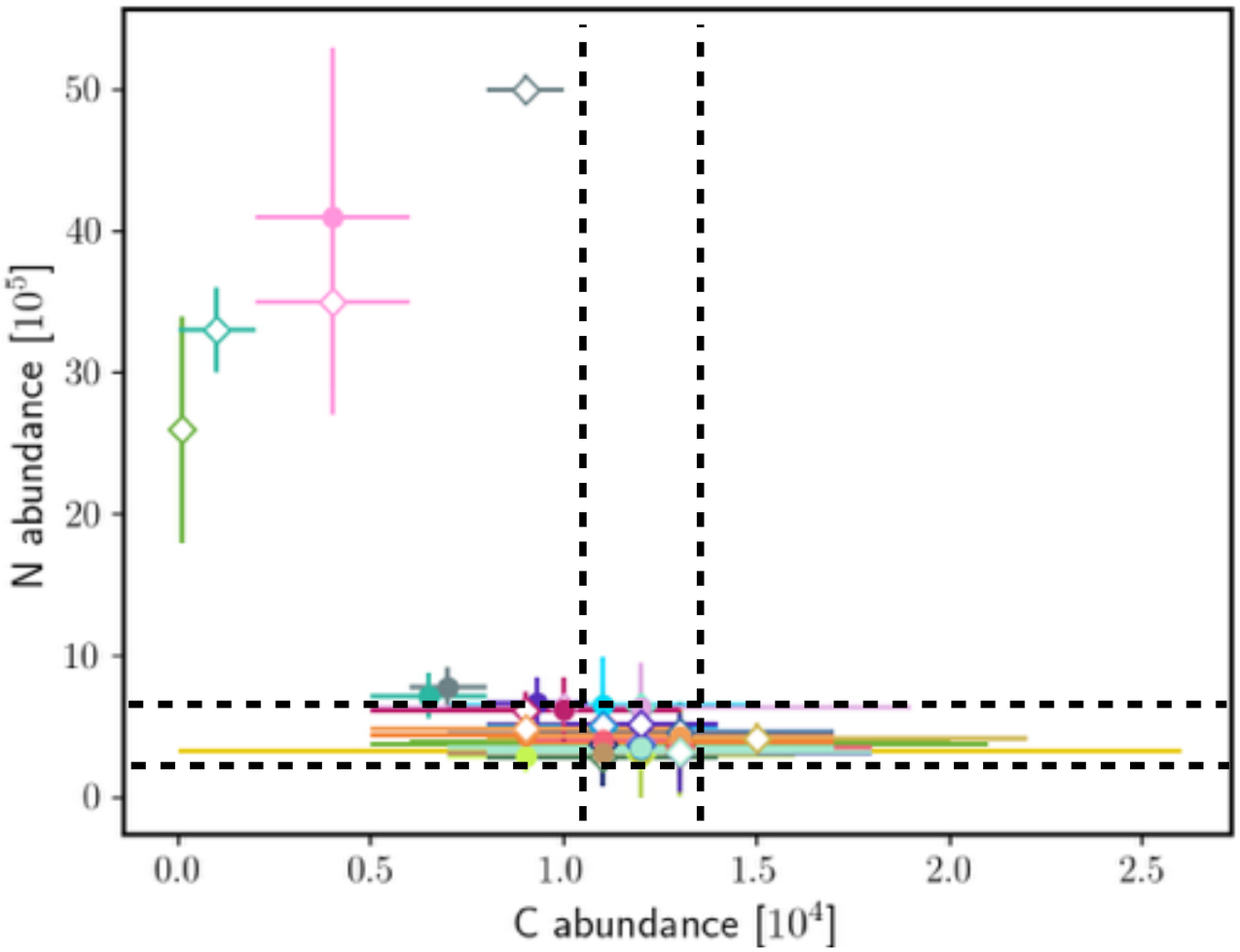
SYNCHRONISATION



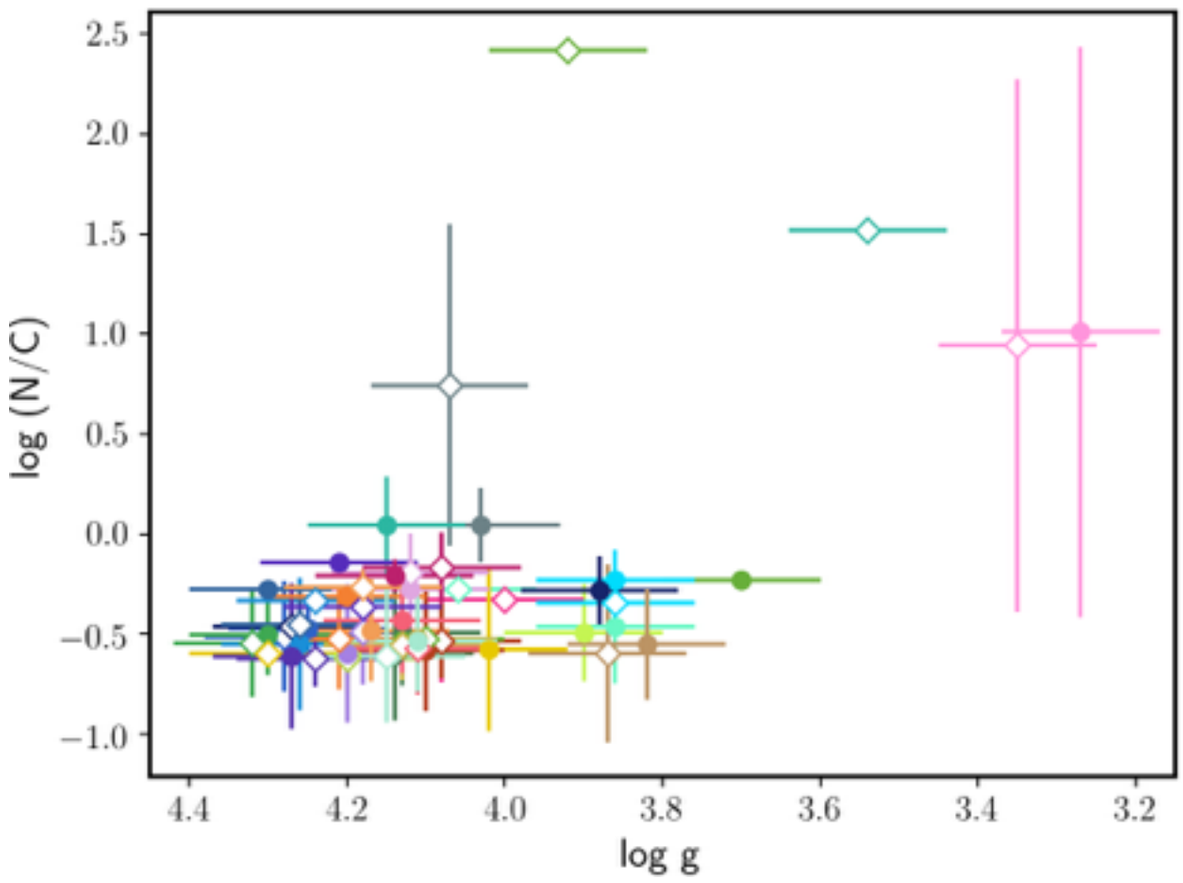
SYNCHRONISATION



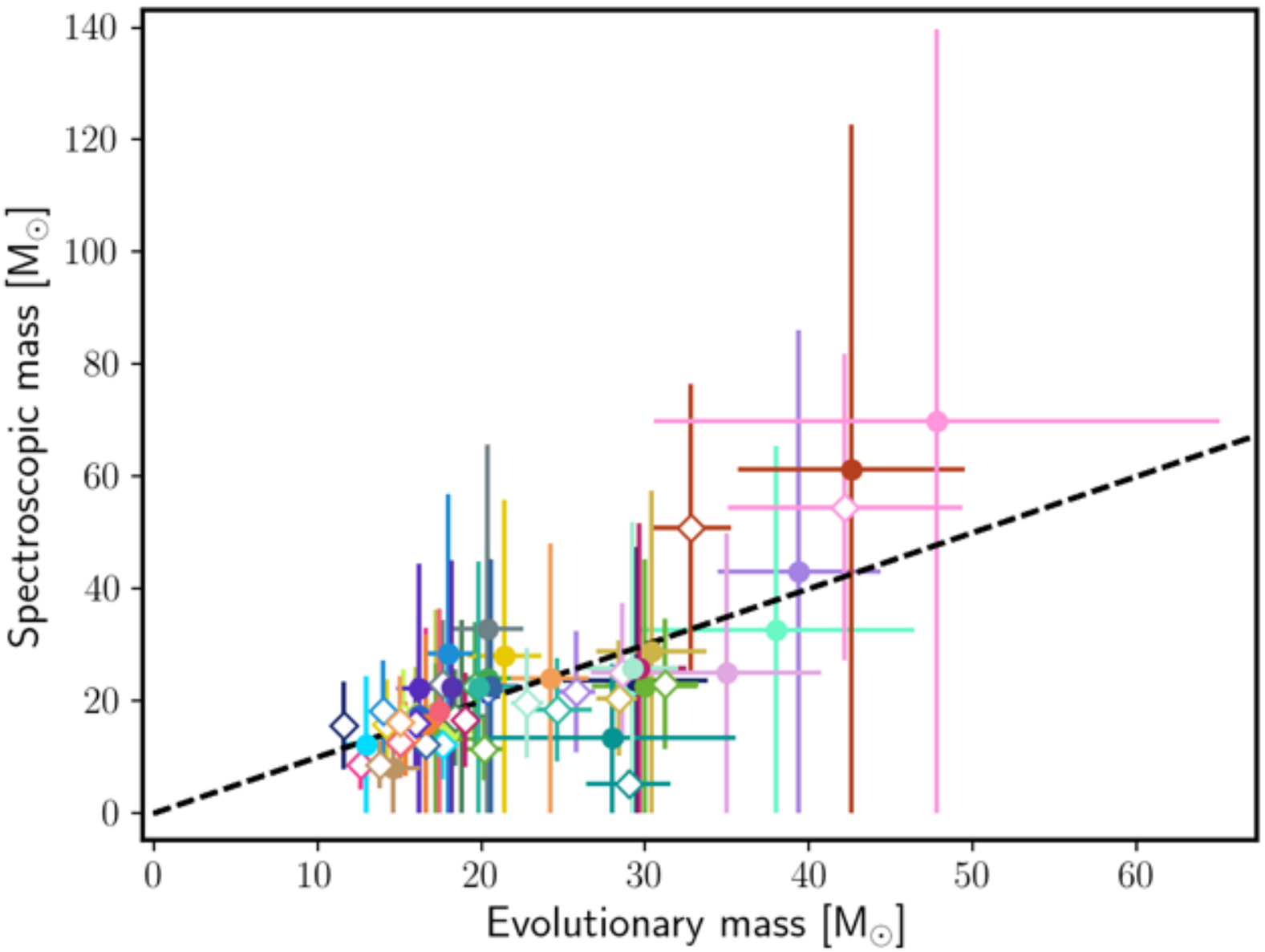
SURFACE ABUNDANCES



No line to derive the oxygen surface abundance



MASS DISCREPANCY



Compare:

- ★ Spectroscopic masses to dynamical masses
- ★ Evolutionary masses to dynamical masses

→ Test binary evolutionary tracks

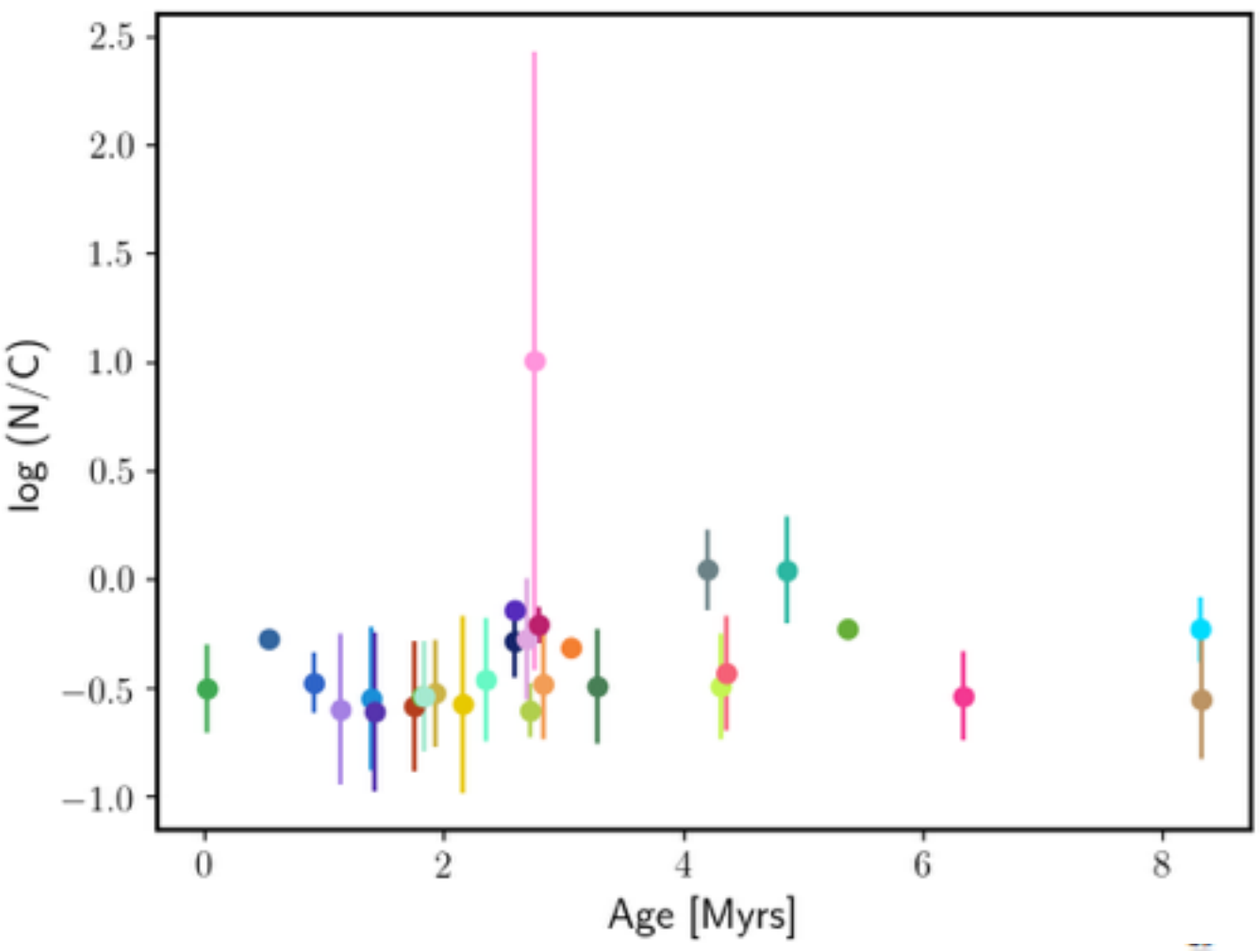
Conclusion (and take away message…) :

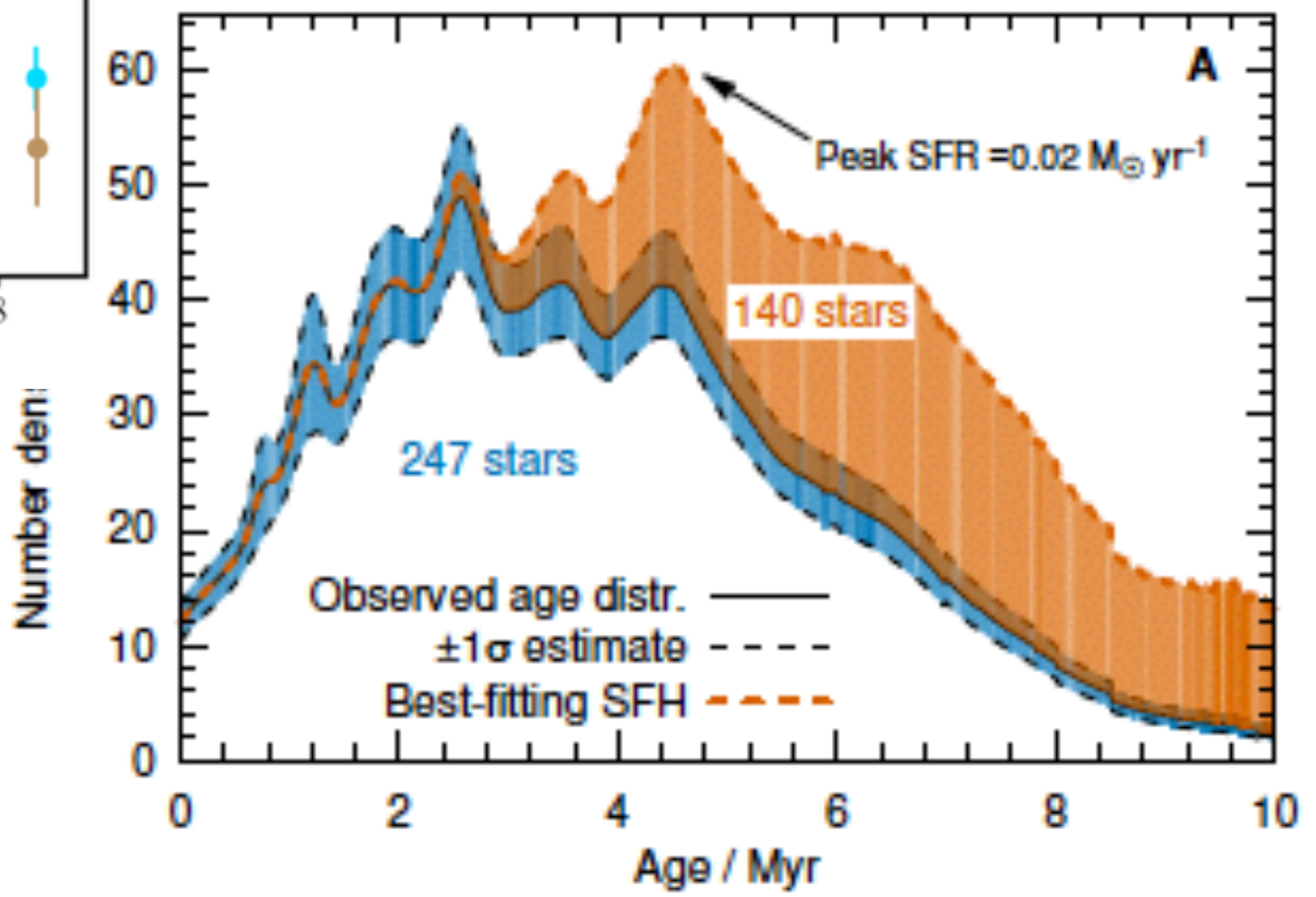
- 3 (and probably 5) systems out of 31 present clues of binary interactions
- Up to now, no mass discrepancy is observed in binaries without interactions
- The effect of tides on chemical mixing is limited, whereas the mass transfer leads to the appearance of chemically processed material at the surface

Future project:

- Project to study the interactions in massive eclipsing binary systems in the Galaxy, LMC and SMC is ongoing, and the results will be (normally) provided soon…

THANK YOU


log (N/C)
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
0
2
4
6
8
Age [Myrs]


A
Peak SFR =0.02 M⊙ yr⁻¹
140 stars
247 stars
Observed age distr.
±1σ estimate
Best-fitting SFH
Number den
60
50
40
30
20
10
0
0
2
4
6
8
10
Age / Myr