Variability properties of the Gaia DR3 catalogue of galactic AGB stars

F. Jiménez-Esteban et al.

CAB / UNIR

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Variability in Gaia DR3 AGB star catalogue

Collaboration

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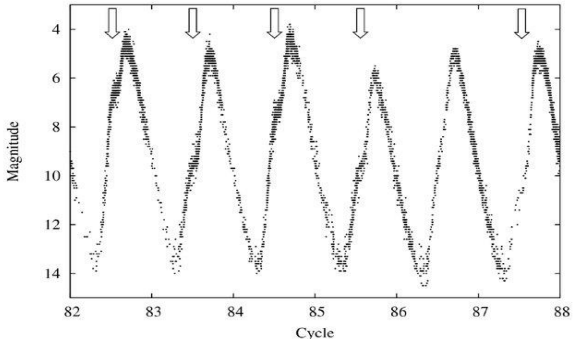
Variability in Gaia DR3 AGB star catalogue

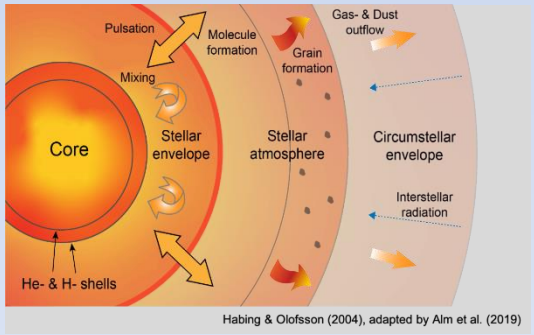
Asymptotic Giant Branch stars

- 90% of the stars pass through the AGB ($M_{MS} < 8\ M_{\odot}$)
- T_{eff} ~3,000 K
- L from 1000 up to >20,000 $L_{\odot}$
- Pulsating
  - P ~ 200 to >1,000 d
  - Amp of several mag in opt.
- Strong mass loss → Circumstellar shell

Willson & Templeton 2009



χ-Cyg Mira star



Habing & Olofsson (2004), adapted by Alm et al. (2019)

Extremely bright in the IR and often opaque in the visible light

Two flavours: O- and C-rich

AGB chemical evolutionary branches

Three evolutionary branches, based on Magellanic Clouds AGB studies:

a) $M_{MS} < 1.5\ M_{\odot}$ O-rich
Lower luminosity; Lower mass-loss; thinner CSE – no masers; lower P

b) $1.5\ M_{\odot} > M_{MS} < 3.5\ M_{\odot}$ C-rich (3^{rd} Dredge-up)
Intermediate properties

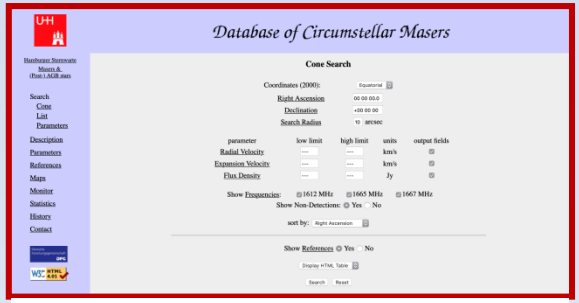
c) $M_{MS} > 3.5\ M_{\odot}$ O-rich (Hot Bottom Burning)
Higher luminosities; Higher mass-loss; thicker CSE – masers; longer P

Jiménez-Esteban et al. 2015 were not able to confirm this evolutionary scenario in an study of AGBs in the Galactic bulge.

The Catalogue of Gaia DR3 AGB stars

Starting Point

Suh 2021



Engels & Bunzel 2015; Engels 2022

- **O-rich OH maser-less sample** (lower mass): **~4500 O-rich without OH maser AGB star candidates** from a compilation of **IRAS sources** by Suh 2021
- **C-rich sample** (intermediate mass): **~ 3600 C-rich AGB star candidates** from a compilation of **IRAS sources** by Suh 2021
- **OH/IR** (higher mass): **~ 2800 O-rich AGB star candidates** from a compilation of **OH masers** from the literature by Engels & Bunzel 2015 and Engels 2022

Variability in Gaia DR3 AGB star catalogue

The Catalogue of Gaia DR3 AGB stars

Starting Point


THE ASTROPHYSICAL JOURNAL
SUPPLEMENT SERIES

A New Catalog of Asymptotic Giant Branch Stars in Our Galaxy

Kyung-Won Suh[1]

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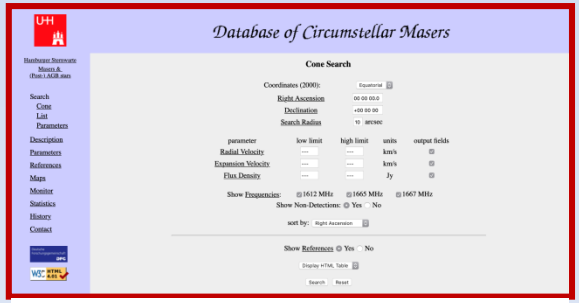
The Astrophysical Journal Supplement Series, Volume 256, Number 2

Citation Kyung-Won Suh 2021 *ApJS* **256** 43

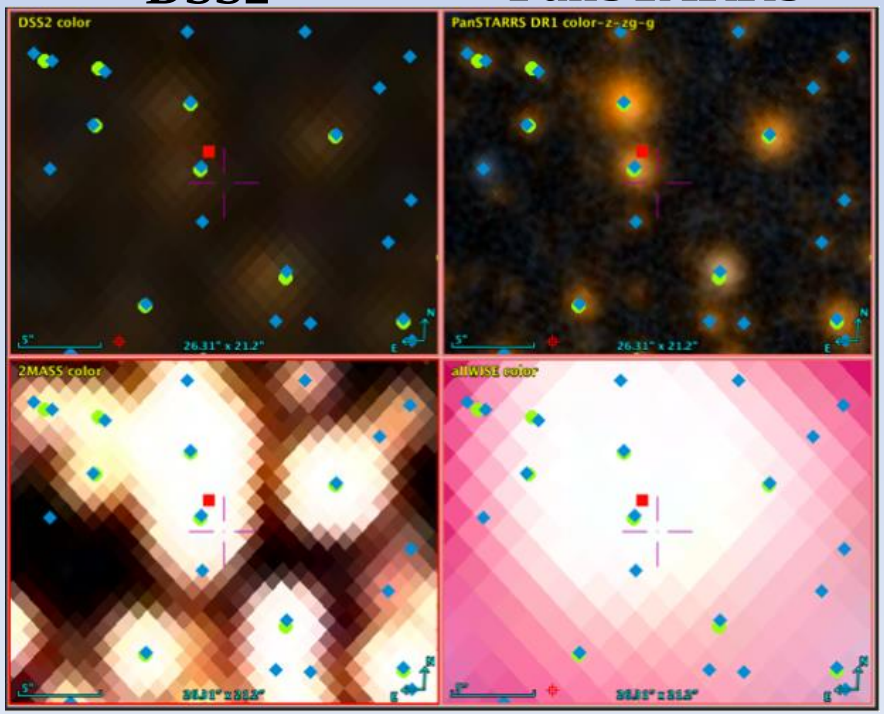
Suh 2021



Engels & Bunzel 2015; Engels 2022

The main difficulty is the high coordinate uncertainty

DSS2 **PanSTARRS**



2MASS **WISE**

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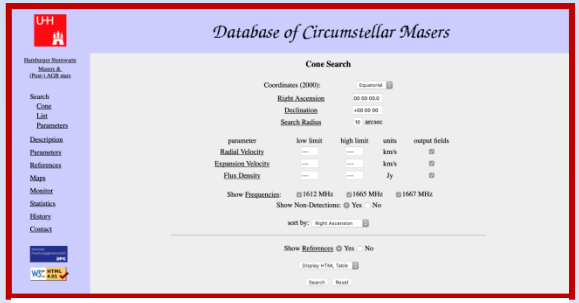

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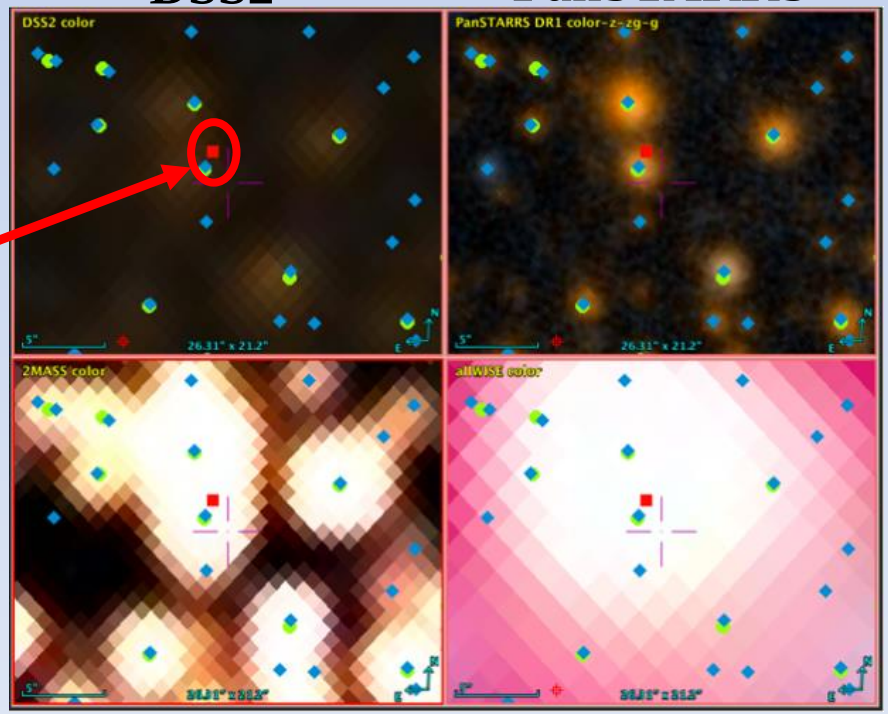

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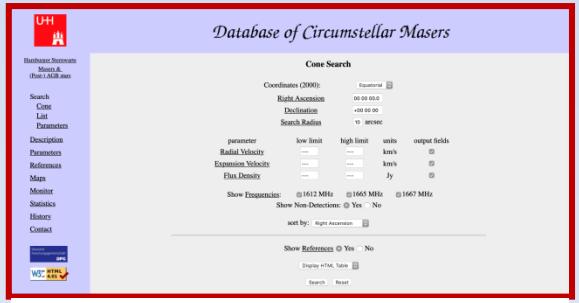

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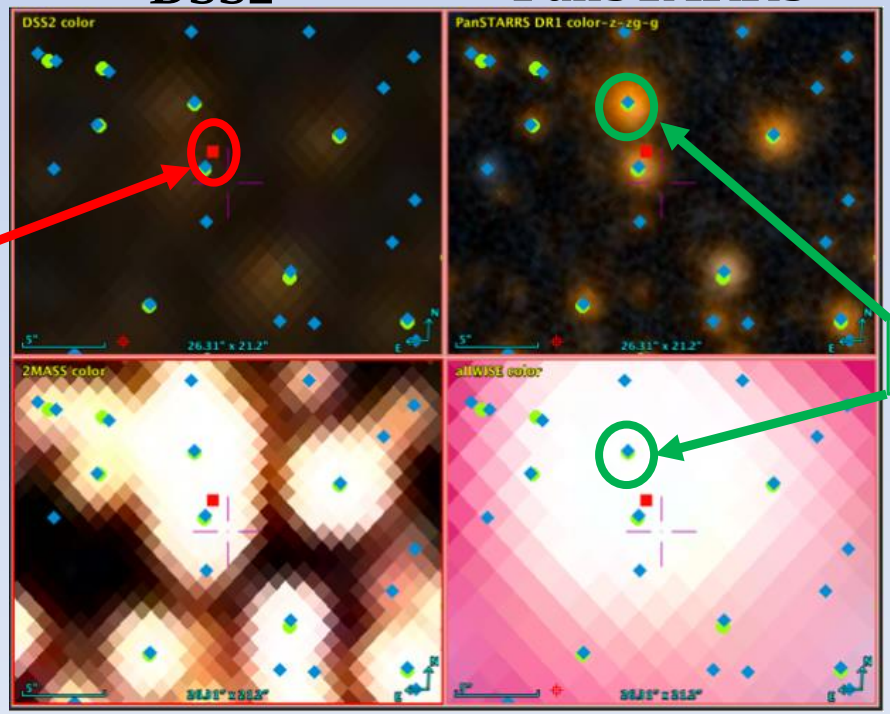

AGB

2MASS **WISE**

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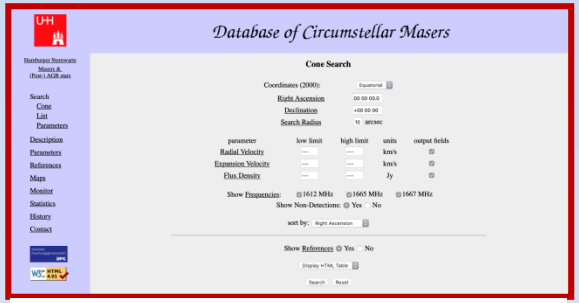
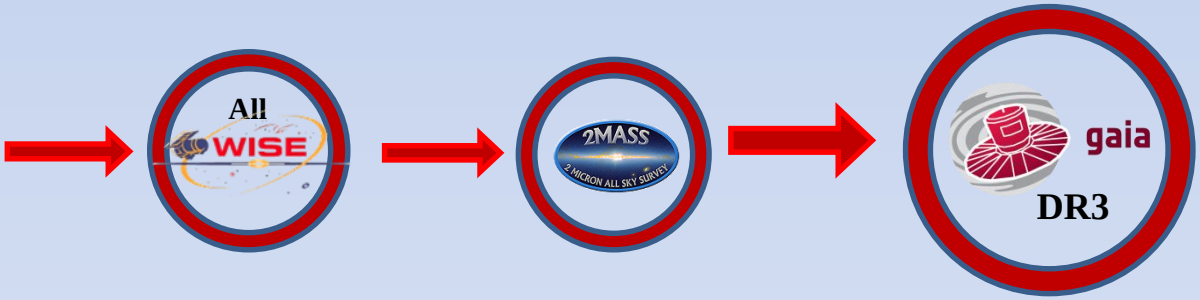


Engels & Bunzel 2015; Engels 2022

Refining coordinates in the IR



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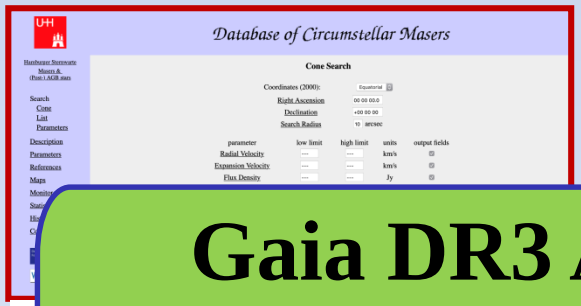
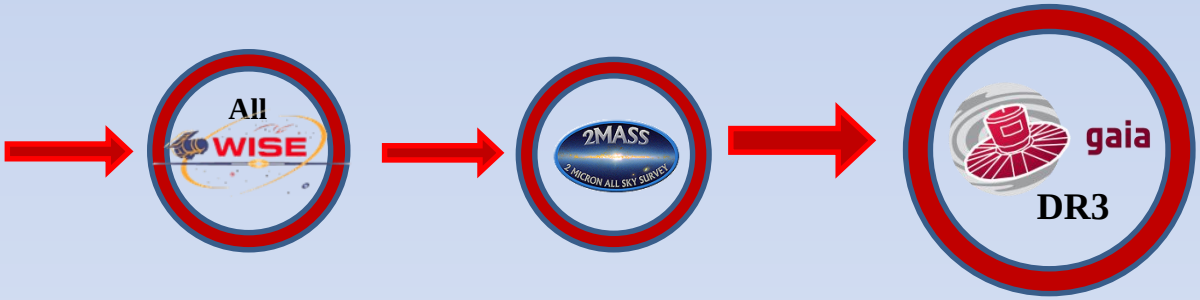

Database of Circumstellar Masers

Cone Search

Refining coordinates in the IR



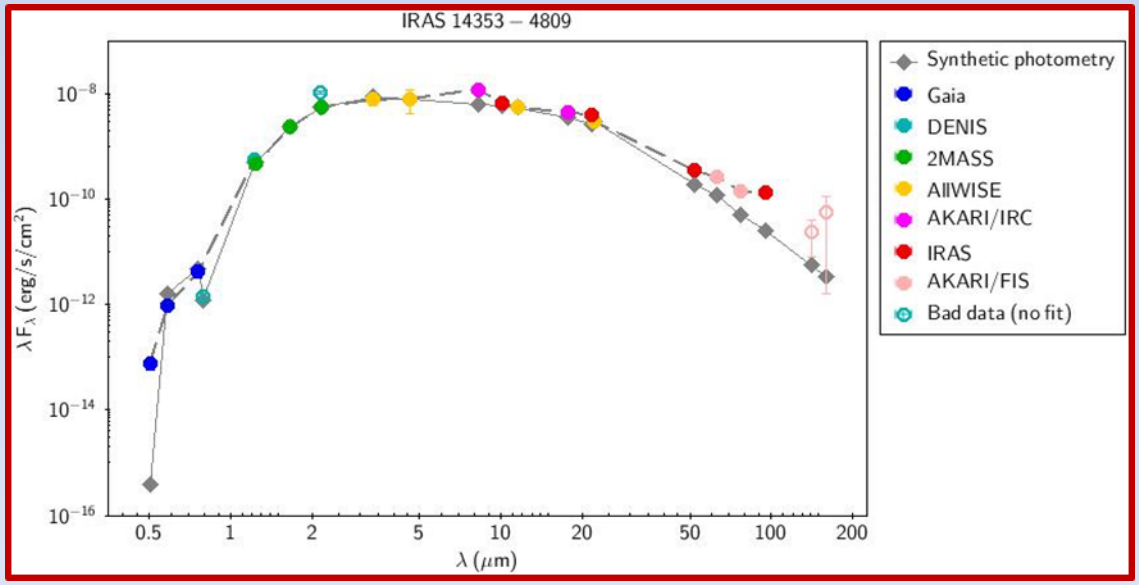
Gaia DR3 AGB candidates samples:

3740 (~85%) O-rich OH maser-less &

3233 (~90%) C-rich & 1487 (~55%) OH/IR

Enhancing the catalogue with the VO: luminosity

VOSA VO SED Analyzer



Physical parameters
from SED fitting to GRAMS models
(Sargent et al. 2011; Srinivasan et al. 2011)

↓

Bolometric flux

↓

- **$0 < \sigma_\pi/\pi < 0.2$**
- **astrom_ex_n <1.5**

Geometric distance
(Bailer-Jones et al. 2021)

↓

Luminosity

Variability in Gaia DR3 AGB star catalogue

Enhancing the catalogue with the VO: luminosity

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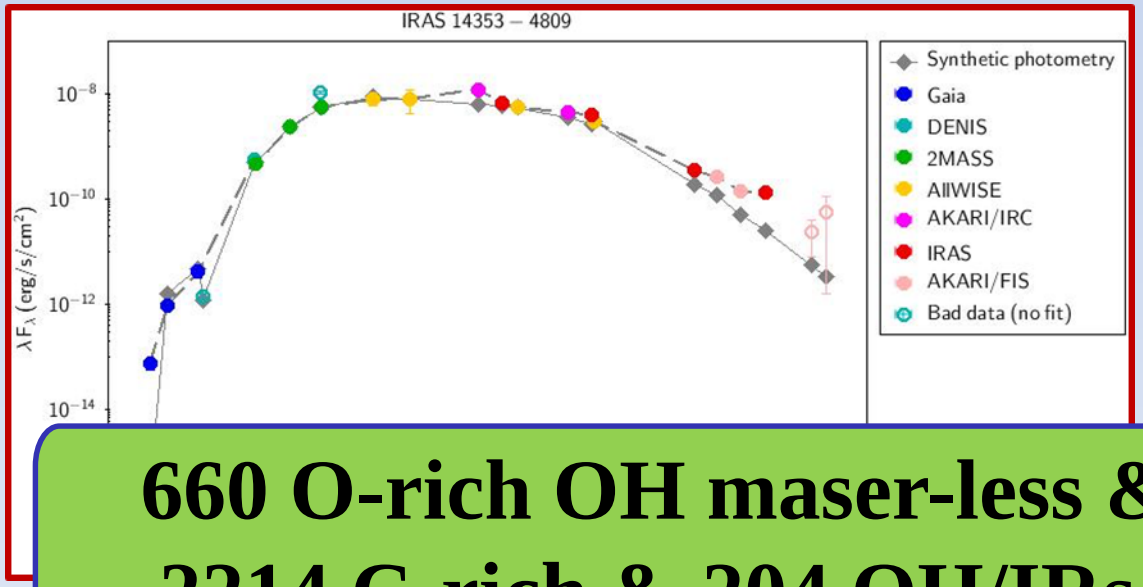

660 O-rich OH maser-less &
2214 C-rich & 204 OH/IRs

Physical parameters
from SED fitting to GRAMS models
(Sargent et al. 2011; Srinivasan et al. 2011)

Bolometric flux

- **$0 < \sigma_\pi/\pi < 0.2$**
- **astrom_ex_n <1.5**

Geometric distance
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uminosity

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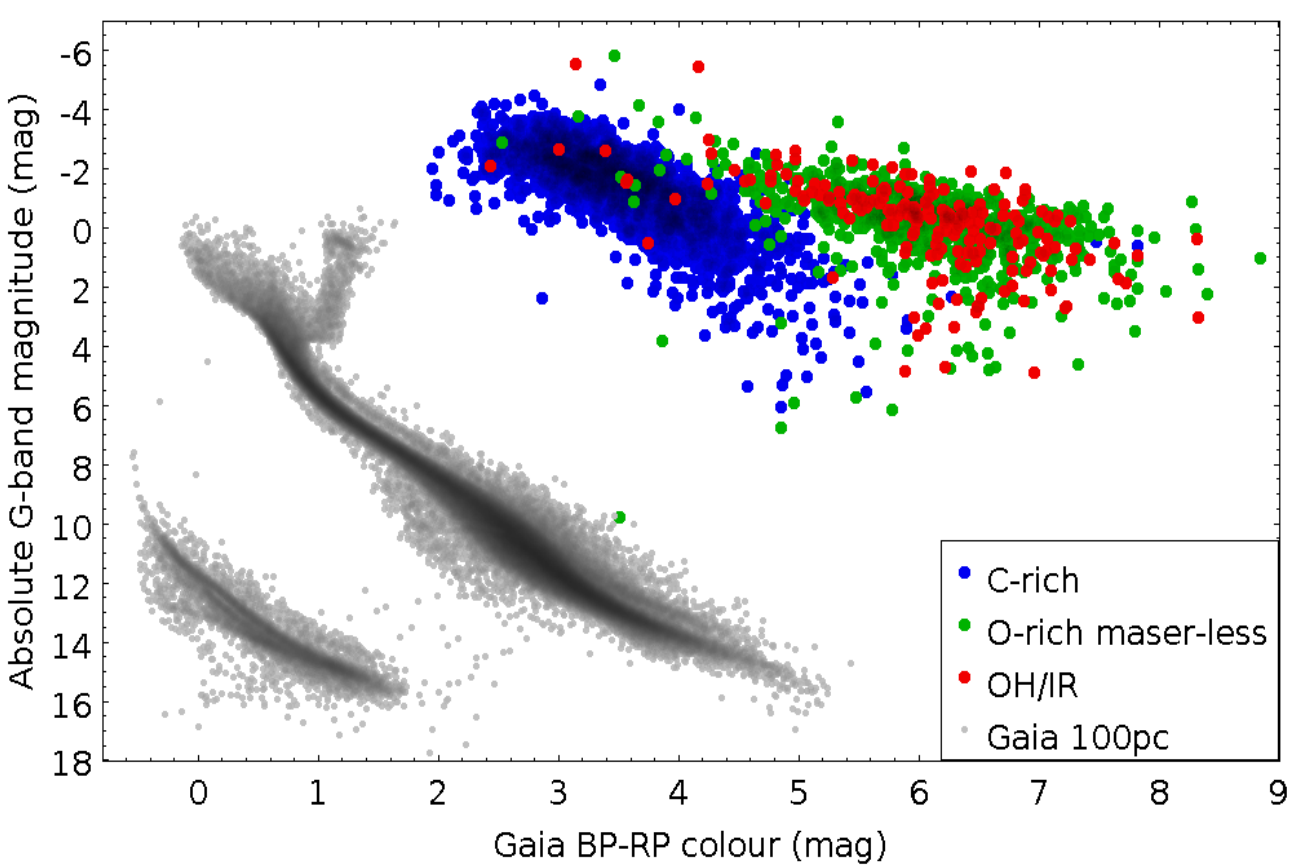
Variability in Gaia DR3 AGB star catalogue

The Gaia HR diagram

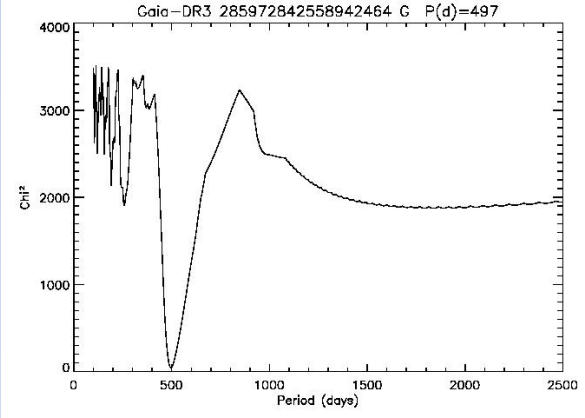


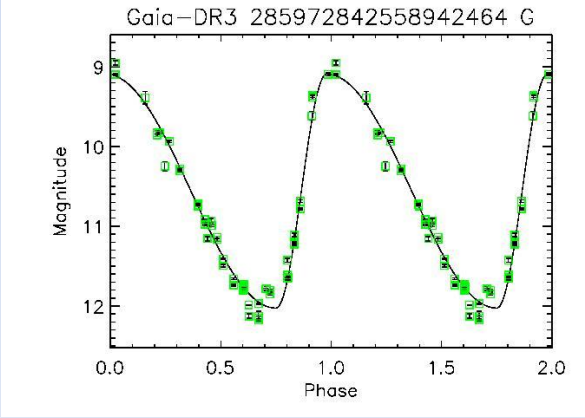
We built a clean sample of O-rich and C-rich AGB stars

O-rich OH maser-less and OH/IR stars occupy similar locus, while C-rich stars are well differentiated.

Enhancing the catalogue with variability properties

Gaia DR3 epoch photometry: G-band with a cut at 20% in flux error





Asymmetric cosine light curve model (Jiménez-Esteban et al. 2021)

$$m(t_i) = \overline{m} + \frac{A}{2} cos\left(2\pi\Omega(t_i)\right)$$

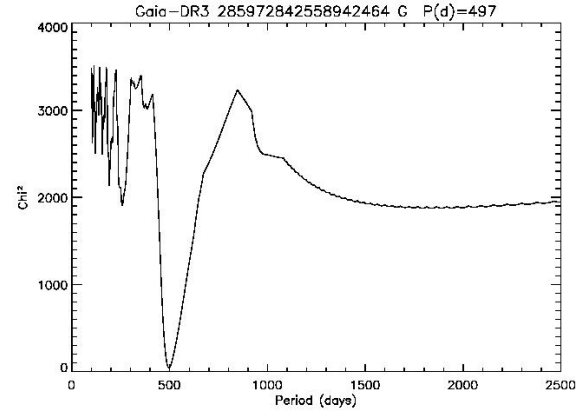
$$\Omega(t_i) = \begin{cases} \frac{t_i - t_0}{2Pf} & \text{when } 0 \leq \frac{t_i - t_0}{P} < f \\ \frac{t_i - t_0 - P}{2P(1-f)} + 1 & \text{when } f \leq \frac{t_i - t_0}{P} < 1 \end{cases}$$

rising branch { f < 0.5 → steeper
f > 0.5 → shallower

Variability in Gaia DR3 AGB star catalogue

Enhancing the catalogue with variability properties

Gaia DR3 epoch photometry: G-band with a cut at 20% in flux error



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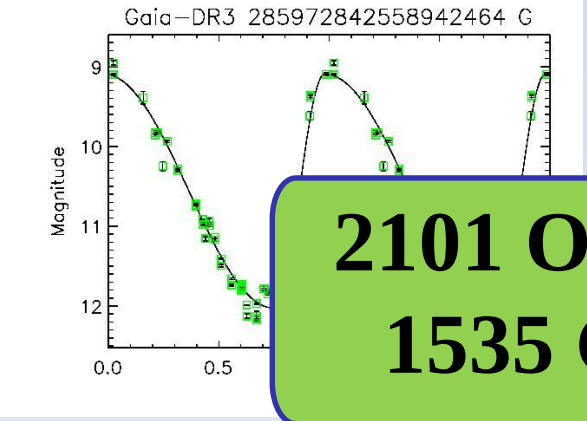

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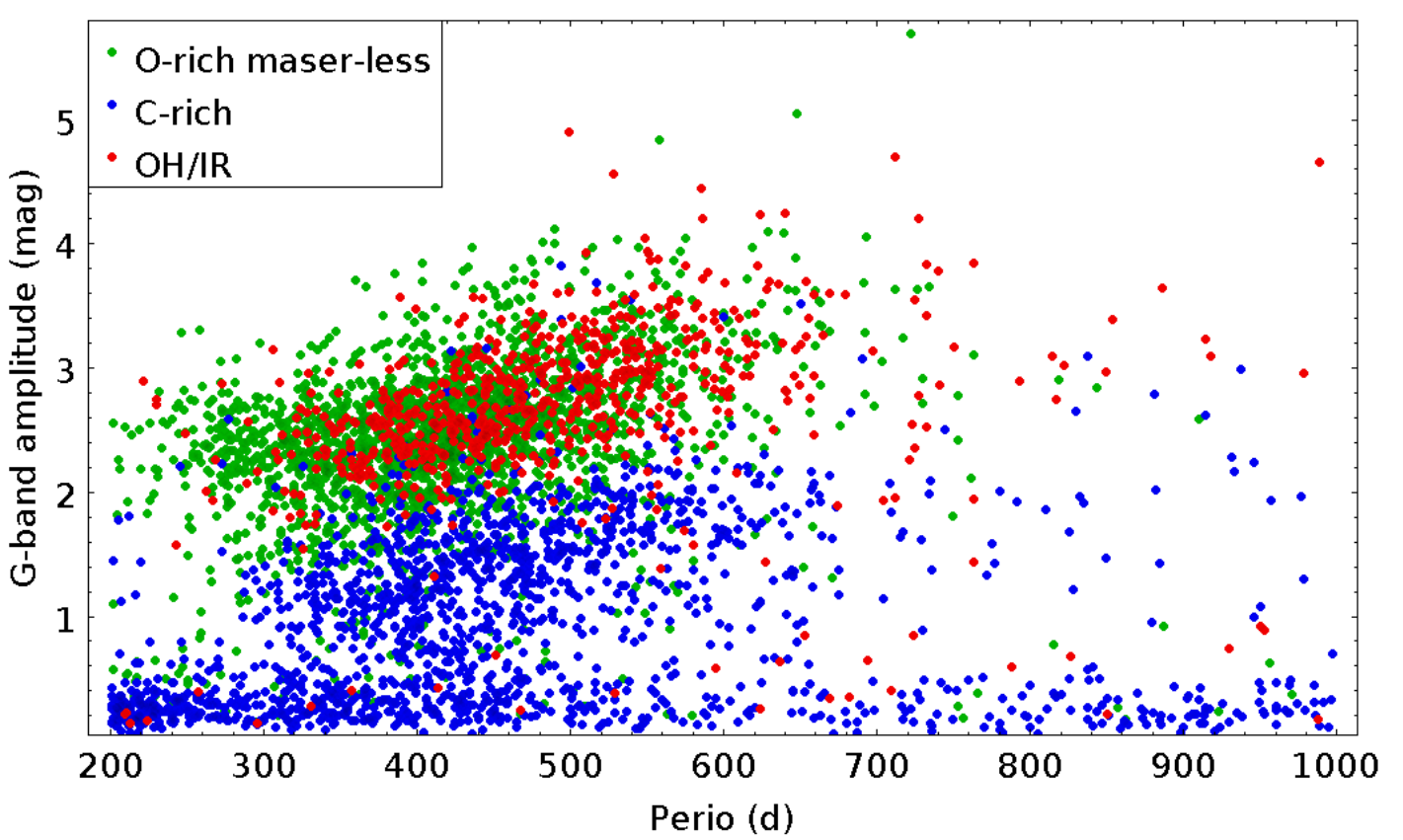
2101 O-rich OH maser-less &
1535 C-rich & 680 OH/IRs

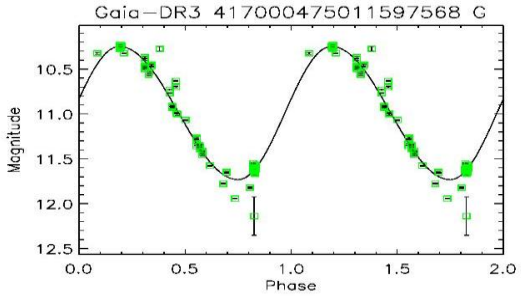
→ steeper
→ shallower

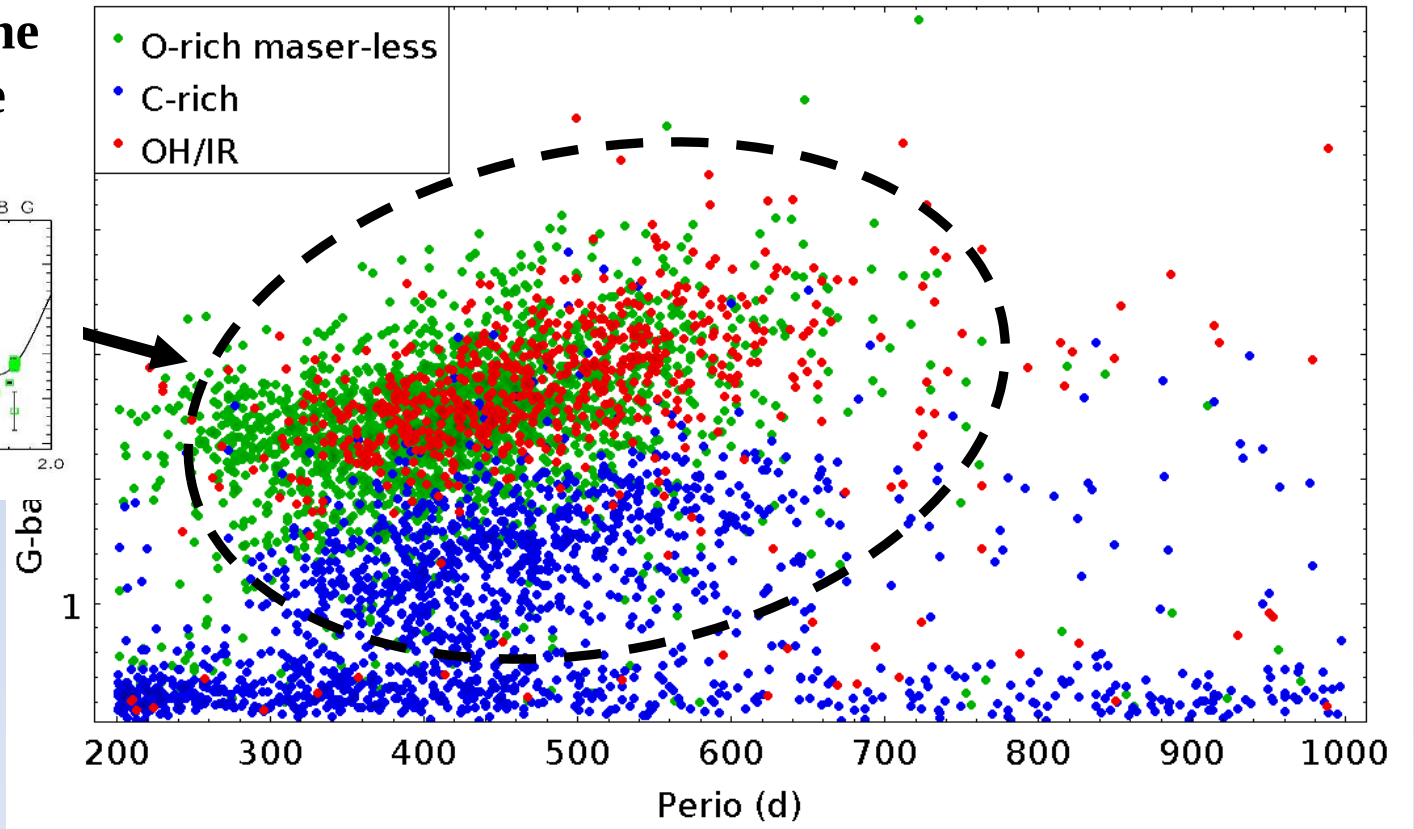
Enhancing the catalogue with variability properties



Enhancing the catalogue with variability properties

Almost all O-rich AGBs and 56% of the C-rich are Mira-like regular variables





Variability in Gaia DR3 AGB star catalogue

Enhancing the catalogue with variability properties

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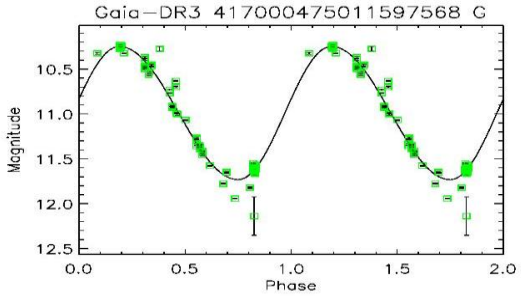
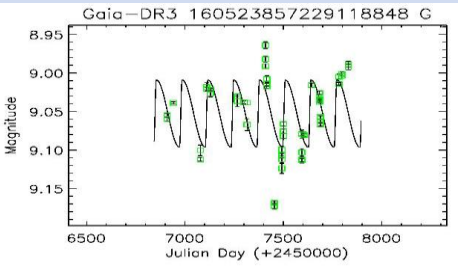
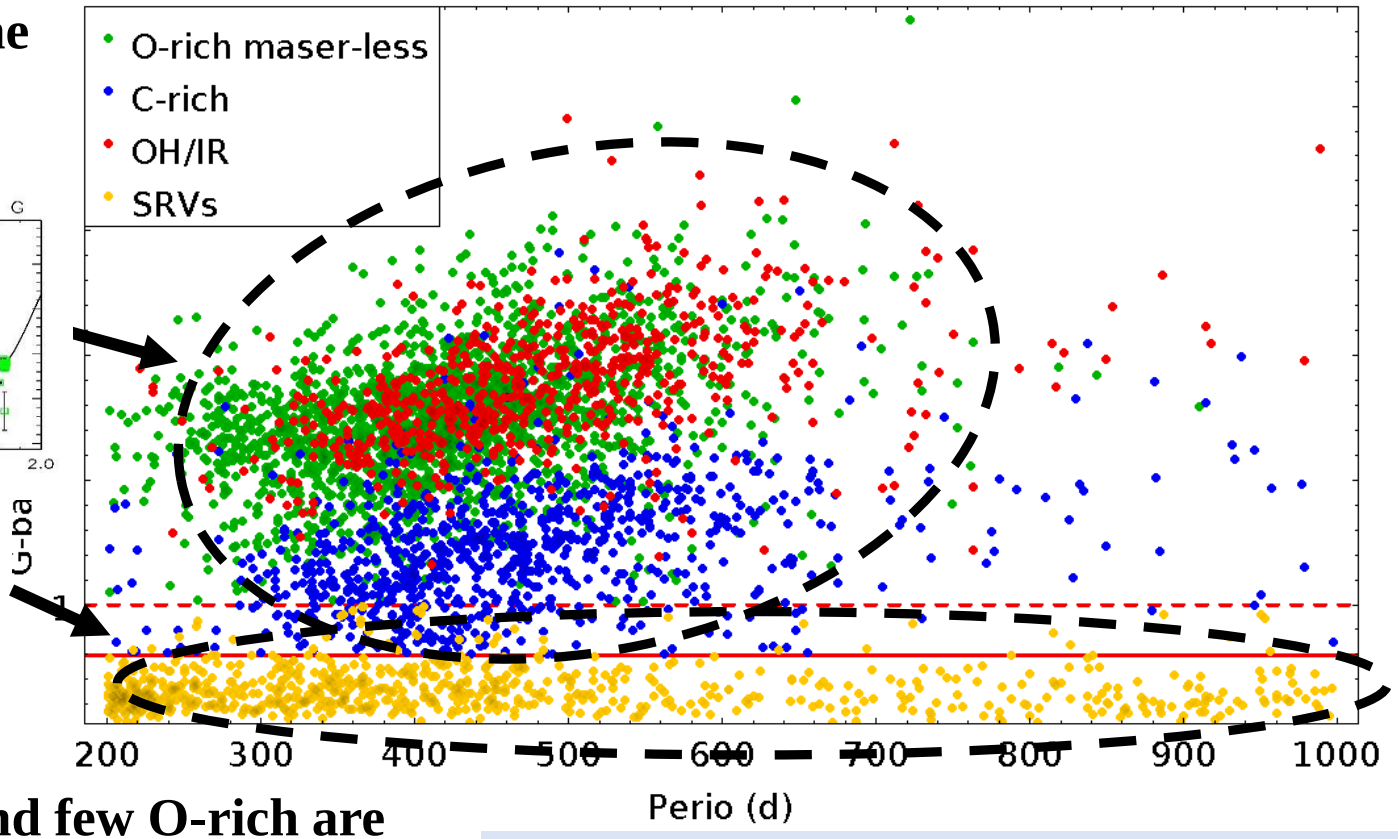


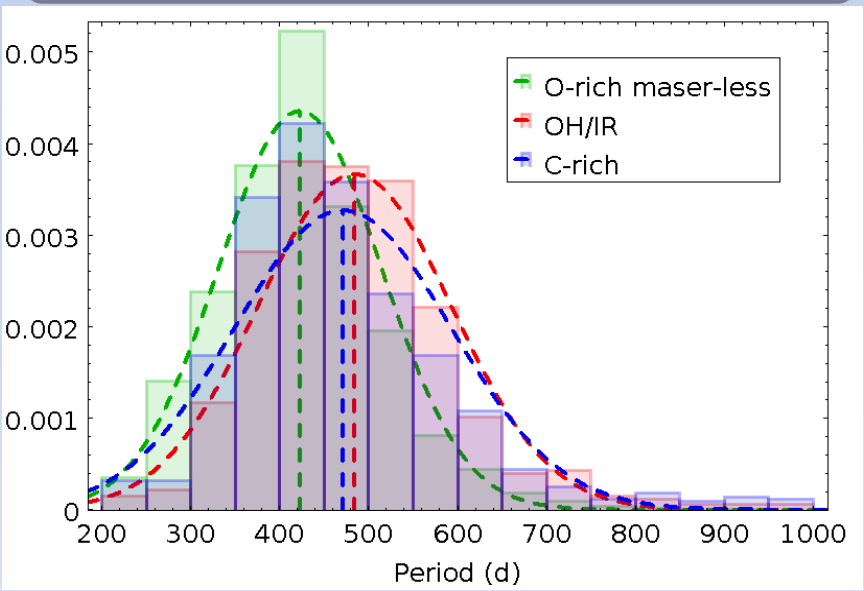


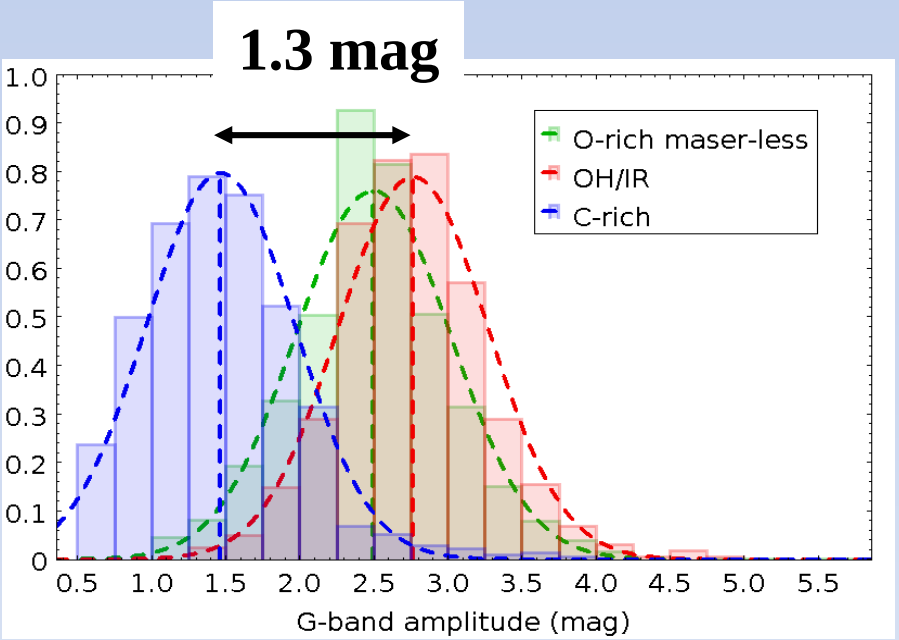


44% of the C-rich and few O-rich are Low-Amplitude Semiregular variables

Enhancing the catalogue with variability properties

Mira-like regular variables

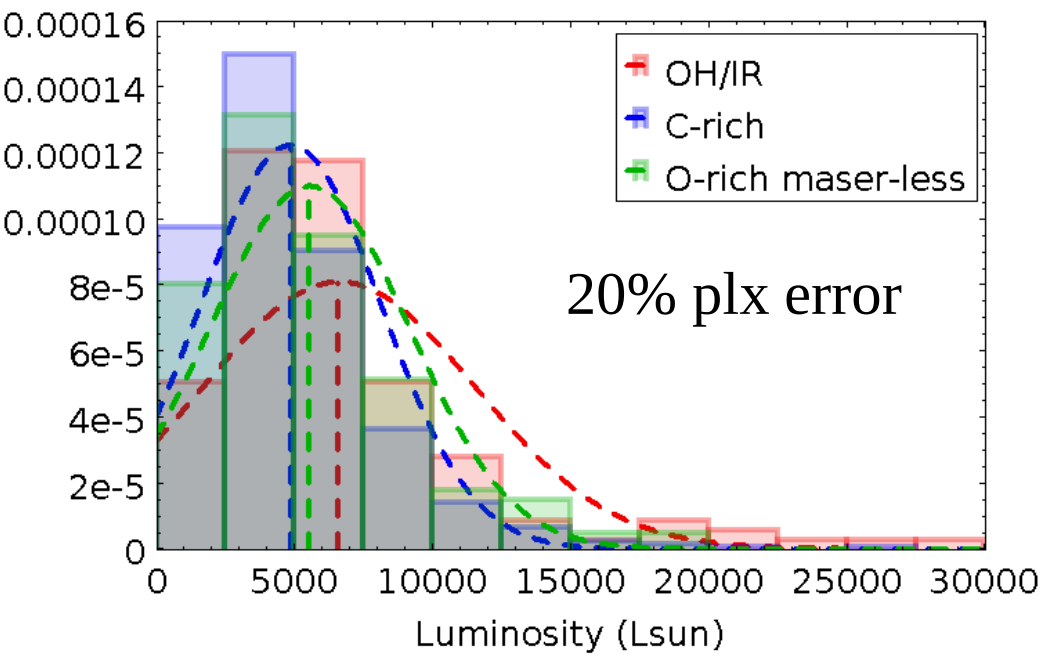




Period distributions are similar for the three samples,

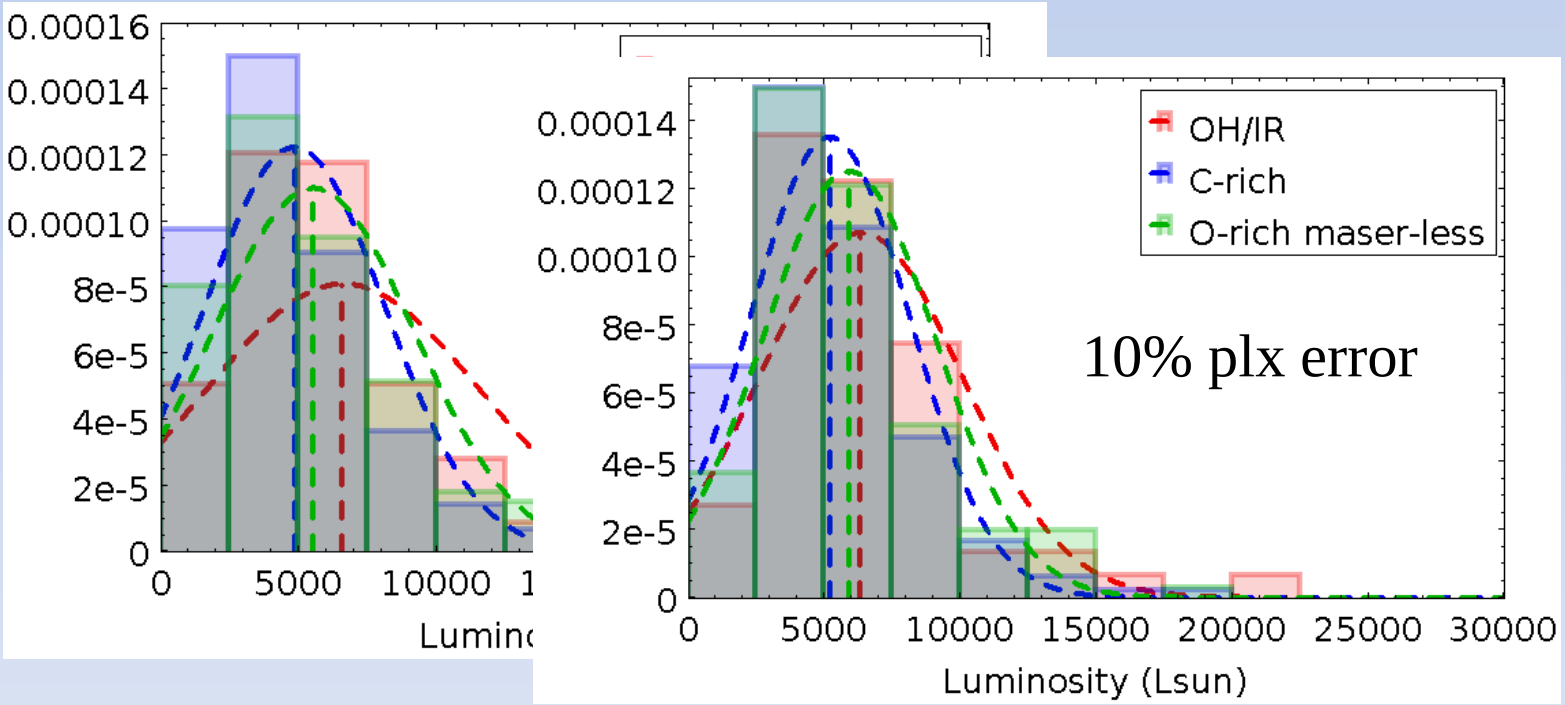
but the **amplitude is typically smaller for C-rich** AGB stars.

Luminosity of Mira-like regular variables



Luminosity distributions are very similar for all samples

Luminosity of Mira-like regular variables



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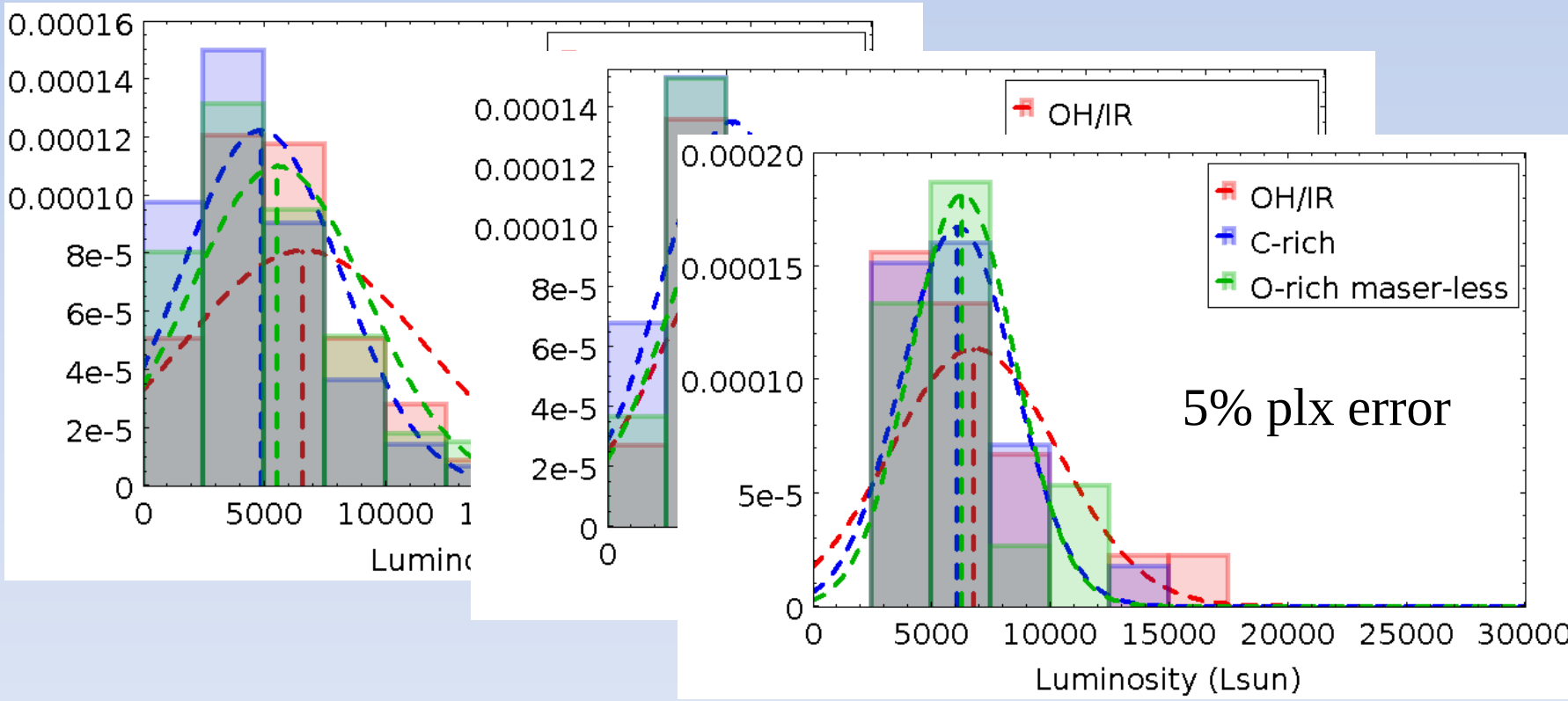

Luminosity distributions are very similar for all samples

Conclusions

- Using Gaia DR3 and the VO we have created a clean catalogue of galactic AGB stars with O-rich (both with and without OH maser emission) and C-rich chemistry.
- We obtained the luminosity from SED model fitting and Gaia parallaxes, and variability properties from Gaia light-curves.
- O-rich Gaia samples with and without OH maser emission show similar properties. C-rich sample only differs in Gaia colours and variability amplitude.
- We cannot confirm the 3 mass-range evolutionary scenario proposed from Magellanic Cloud AGB studies.

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Thanks!!