The curious case of the anti-correlation between the sub-100 au solar-type binary frequency and metallicity

see also Moe+ 2018, 2019

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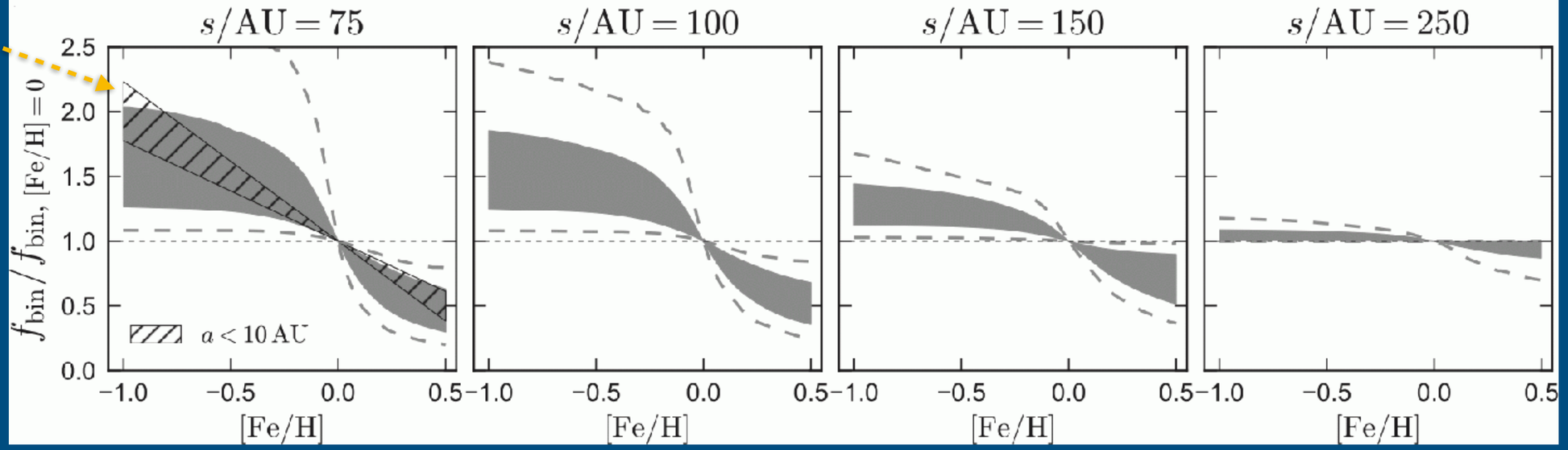
doi:10.1093/mnrasl/sly206

The wide binary fraction of solar-type stars: emergence of metallicity dependence at $a < 200$ au

~8400 binaries within 200 pc with spec. [Fe/H]
primary mass between 0.45 and 1.5 $M_\odot$

Kareem El-Badry [1★] and Hans-Walter Rix [2]



Binary frequency f_{bin} at fixed separations vs. stellar metallicity

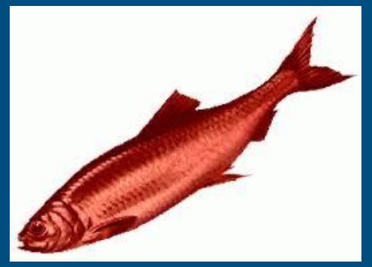
s ≥ 250 au => flat f_{bin} vs [Fe/H]

s ≤ 100 au => anti-correlation f_{bin} vs [Fe/H]

Anti-correlation of the sub-100 au G-dwarf binary frequency and metallicity

Puzzle: why do I call it “curious”?

1. **Is there a causation underlying the anti-correlation?**



or

2. **Does the metallicity act as a proxy for the formation time and formation environment?**

Anti-correlation of the sub-100 au G—dwarf binary frequency and metallicity

1. Causation

higher metallicity ~ higher (ISM) opacities:

a) external heating and ionisation fraction of molecular cloud cores are anti-correlated with metallicity

=> shorter ambipolar diffusion timescale

=> puzzles present by Alice Nucara, Henrik Beuther, Maria Jose Maureira, Arshia Jacob …

b)

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The statistical properties of stars and their dependence on metallicity

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SPH+RT+diffuse ISM model with simple H,C chemistry

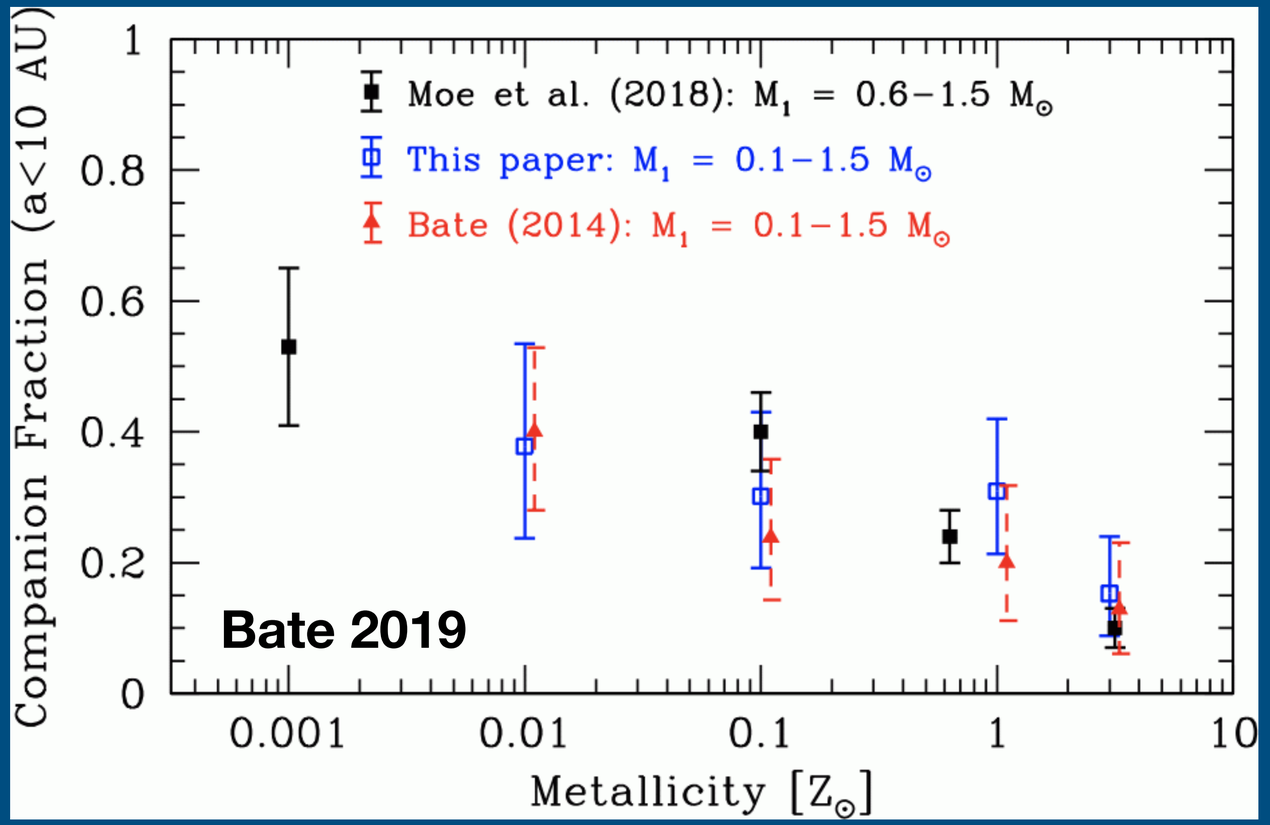
starting conditions:

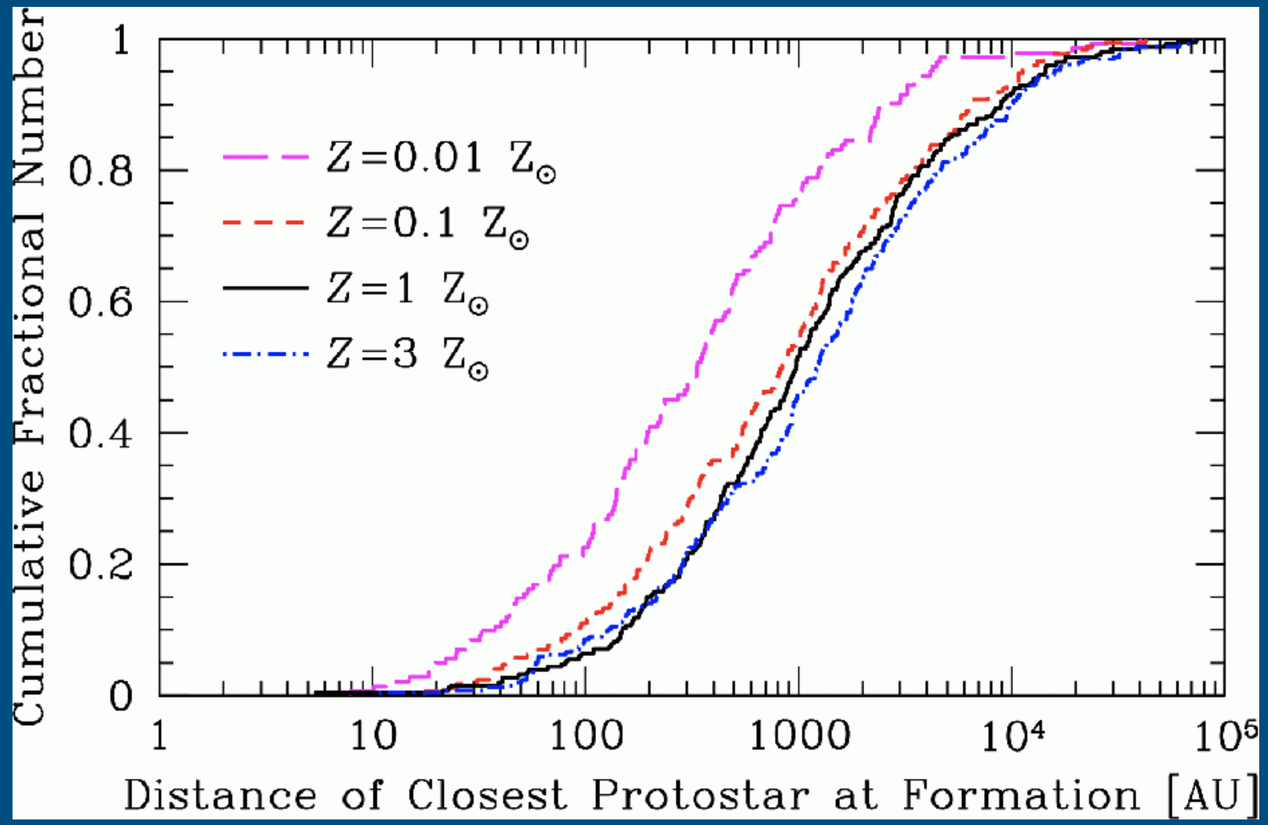
- 500 $M_\odot$ spherical molecular cloud of uniform density with r=0.4 pc
- Supersonic turbulence field
- Interstellar Radiation Field, dust and gas in respective thermal equilibria

Increased metallicity affects binary formation pathways:

i) reduced disk fragmentation

ii) longer collapse times, more time for close “binary” first hydrostatics cores to merge



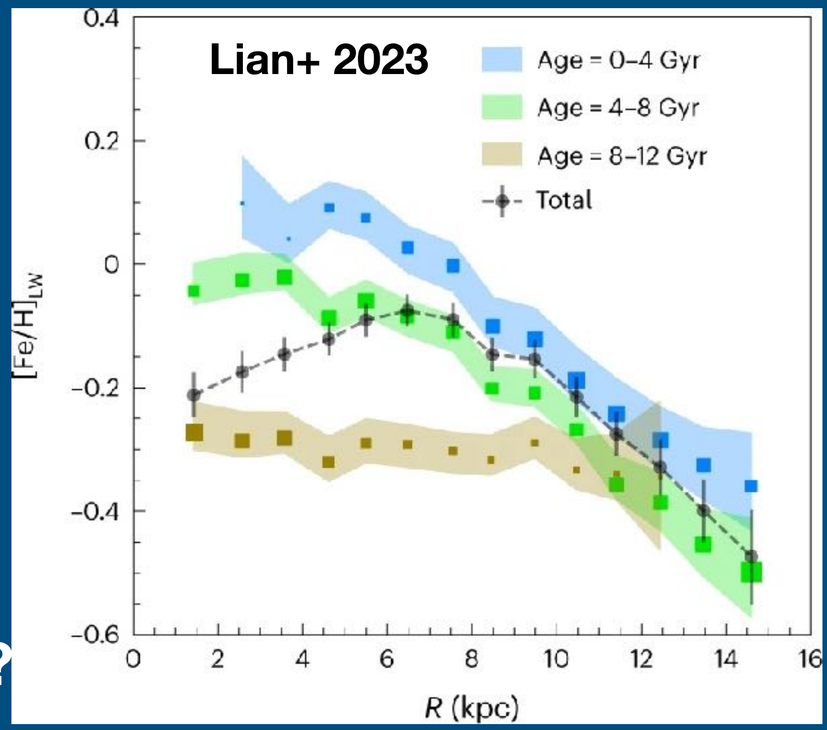


“With the exception of the close binary properties and the abundance of stellar mergers, we find no evidence for a strong dependence of stellar properties when varying the metallicity from 0.01 to 3 times the solar value.”

=> puzzle solved?

Anti-correlation of the sub-100 au G-dwarf binary frequency and metallicity

2. Metallicity as a proxy for age



lower metallicity ~ older age

=> higher fraction of baryonic mass in ISM, less in stars

=> Milky Way star formation history:

i) star formation rate

ii) stellar initial mass function ?

iii) older stars originate at different Galactocentric distances?

iv) halo vs thick disk vs thin disk stars?

v) lower-Z stars are slightly hotter (opacity of stellar atmospheres)

vi) Interstellar Radiation Field (SN rate, etc.)

<=> how does the formation environment affect cloud core fragmentation and binary formation?

<=> puzzles present by Thomas Henning: "environment is important", …

<=> what other astrophysics might be important?