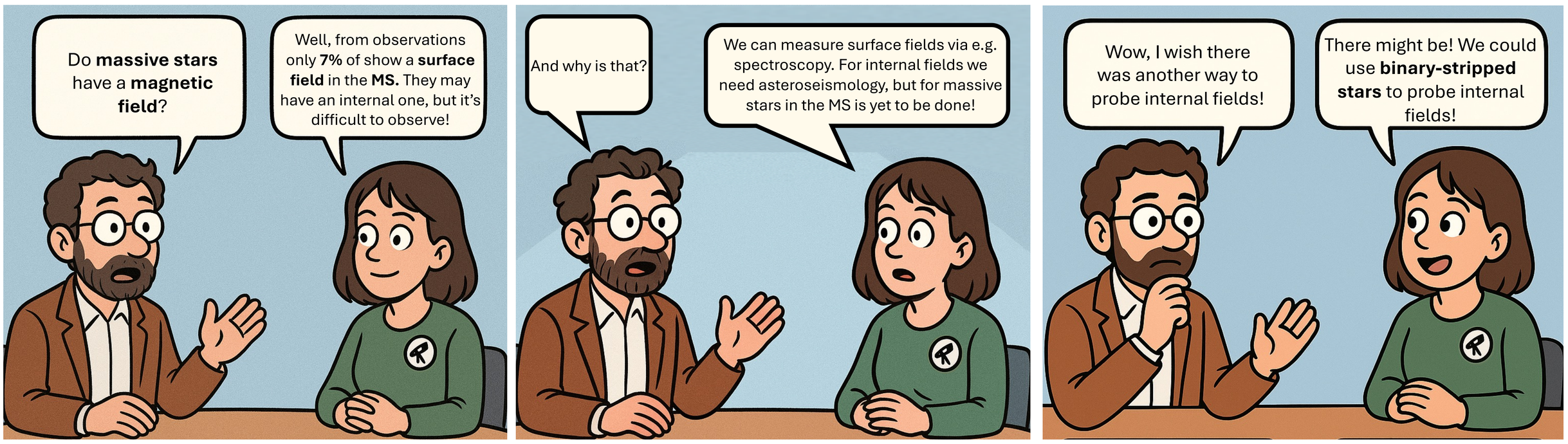
Magnetic fields in binary-stripped massive stars

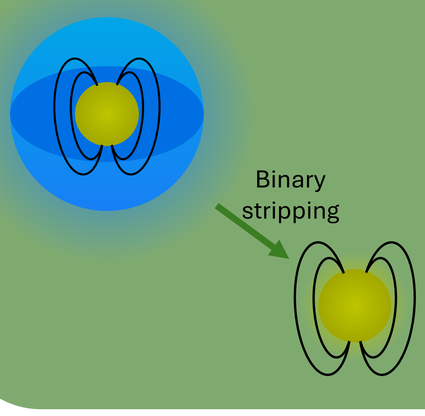
MAX-PLANCK-INSTITUT FÜR ASTROPHYSIK

Giovanni Stimamiglio, Jing-Ze Ma, Ylva Götberg, Selma E. de Mink (in prep.)



Cartoon generated by ChatGPT

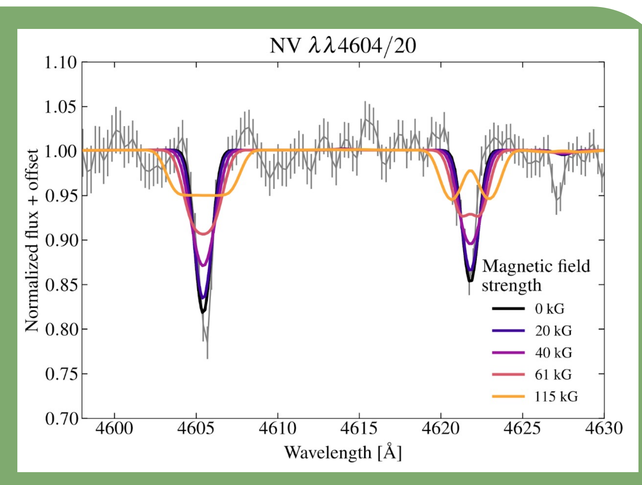
Binaries to the rescue!



A **binary-stripped He star** is a star that has lost its outer envelope due to binary interaction, leaving just the core.
Assuming the **internal field** survives the stripping, it would be **exposed**!

- Exposed field → apply **surface field detection techniques**
- **New observational sample** by Y. Götberg[1,2]
- Infer an **observational upper limit** for the field:

$$B_{upper} \sim 50 \text{ kG}$$

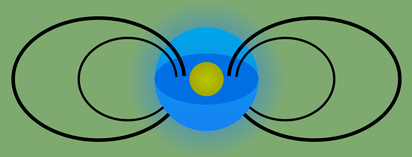


Methods

- We use the 1D stellar evolution code **MESA**[11,12] to generate a model of the observed system.
- We then apply **3 origin hypothesis** for the field and compare the result with the observational limit

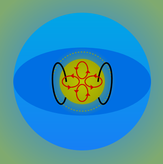
MESA

Fossil field



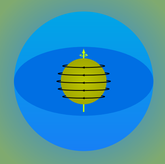
- **Large scale field** at ZAMS[3]
- **Poloidal** geometry → $B(r) = \mu_B r^{-x}$
- **Toroidal+poloidal** geometry[4,5]
- Test what **initial field** produces the limit and compare with obs. surveys

Convective core



- Field produced by **convective dynamo** in the core[6,7]
- **Equipartition**→ $\mathrm{B_{eq}} = \sqrt{4\pi\rho v_{conv}^2}$
- Compare **field after stripping** with observational upper limit

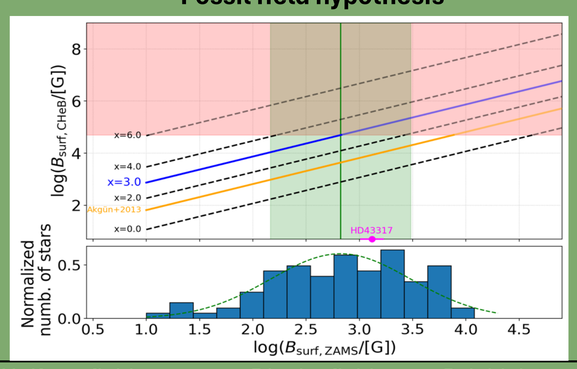
Rotational shear



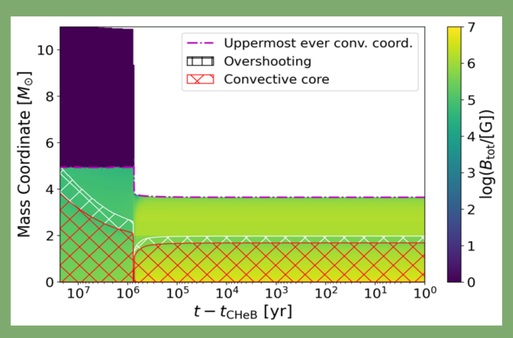
- Field produced by **rotational shear dynamo** due to differential rotation.
- Spruit[8,9] and Fuller[10] prescriptions
- Compare **field after stripping** with observational upper limit

Results

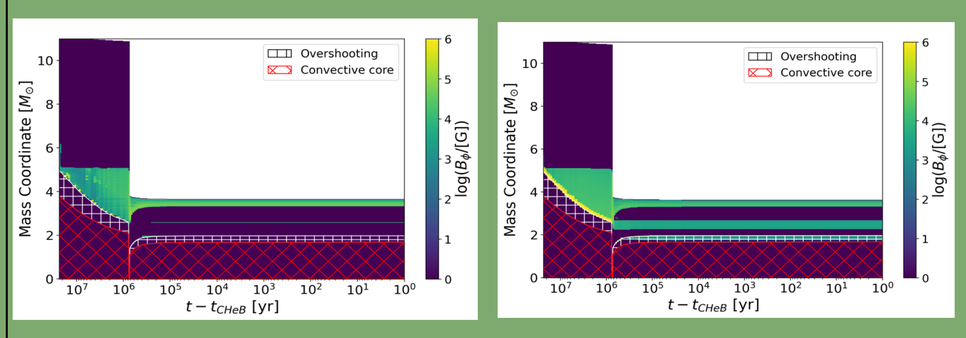
Fossil field hypothesis



Convective core hypothesis



Rotational shear hypothesis



	Uniform field ($x = 0$)	Dipolar field ($x = 3$)	Poloidal+torodial field configuration	Equipartition strength	Spruit dynamo	Fuller dynamo
Initial field [G]	4×10^4	6.7×10^2	8×10^3	N/A	N/A	N/A
Field after stripping [G]	*(limit)*	*(limit)*	*(limit)*	1×10^5 (excluded)	$\simeq 2\times10^4$	$\simeq 9\times10^3$

Conclusions

I. We **exclude** equipartition strength as predicted by convective core hypothesis → Equipartition not reached OR stronger field decay

II. Observations do **not** rule out Spruit and Fuller dynamos, though the obtained strengths are close to the limit → Deeper observations may lead to a detection or to useful constraints

III. Compared to observational surveys[13] for magnetic B-type stars in the MS, the fossil field yields estimates **below** the upper limit → Impossible to exclude a priori

Limitations and future directions

- Flux conservation assumed
- "Frozen" field assumption
- Observational limit from a single star

In light of the proximity of some of our findings with the observational limit, a **more precise observational constraint** could greatly improve our results.

References

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