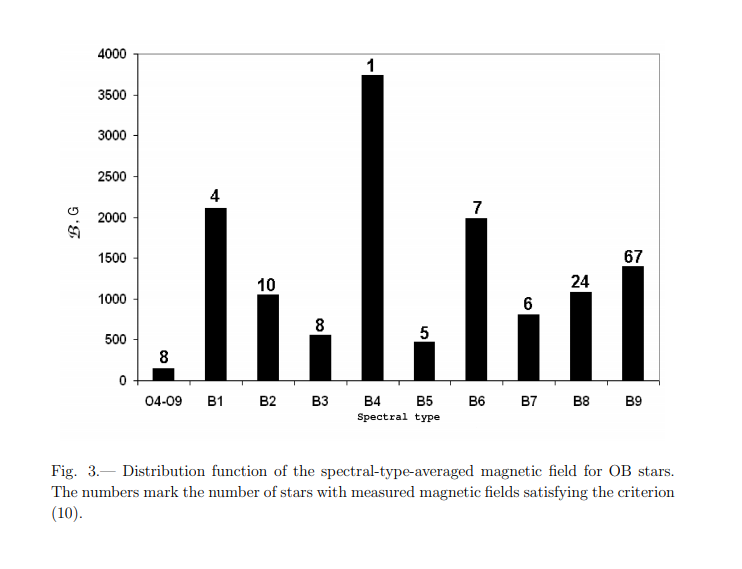
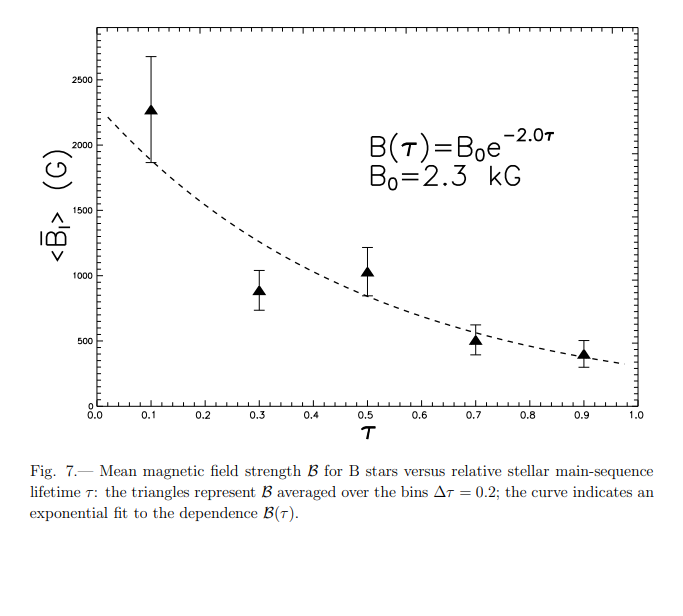
**Magnetism of O and B type star notes**



[1]

[1]



Fossil origin hypothesis [1]

* “Suggests that the stellar magnetic field of OBA stars at the present epoch is a fossil remnant of the magnetic field of the molecular cloud in which the star was formed” (Kholtygin et al., 2010)
* No correlation between mean magnetic field strength and projected rotational velocity of OB stars, consistent with the fossil origin hypothesis
* Over the main sequence lifetime of a B type star, its mean magnetic field strength can decrease by a factor of 5-7 (fig 7)

[2]

* Structurally simpler in high mass, hotter stars than in small cooler stars
* Frequently much stronger than the fields of cool stars
* They show stability of their large scale and smaller-scale structures on timescales of decades
* Characteristics show no clear correlation with stellar properties like age, mass or rotational velocity
* MiMeS project ~ 550 stars observed with approximately 65 stars showing evidence for magnetic fields and 30 of those 65 being identified as magnetic stars
* Of the approx. 90 O type stars in the sample previously unknown to host magnetic fields, 6 are found to be magnetic for an incidence of 7+-3%
* Of the approx. 430 B type stars in the sample previously unknown to host magnetic fields, 32 are found to be magnetic for an incidence of 7+-1%.
* The magnetic stars exhibit periodically variable longitudinal fields which corresponds to magnetic fields with dipole components.
* The strengths of these fields can range form several hundred gauss to tens of thousands of gauss
* General magnetic characteristics of B and O type stars are very similar

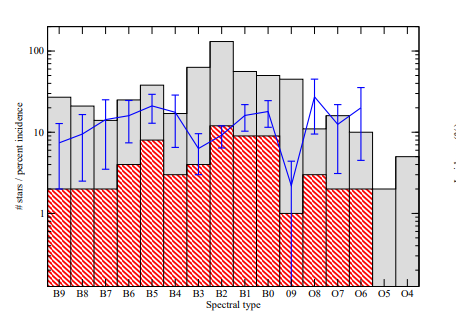
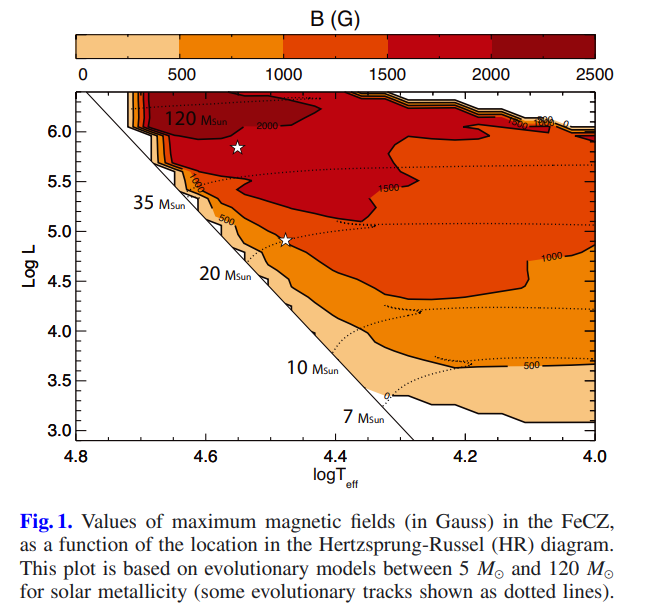
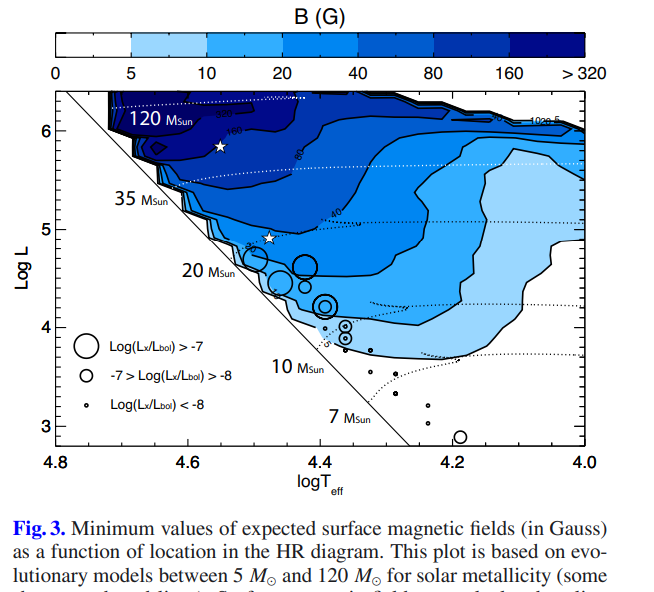


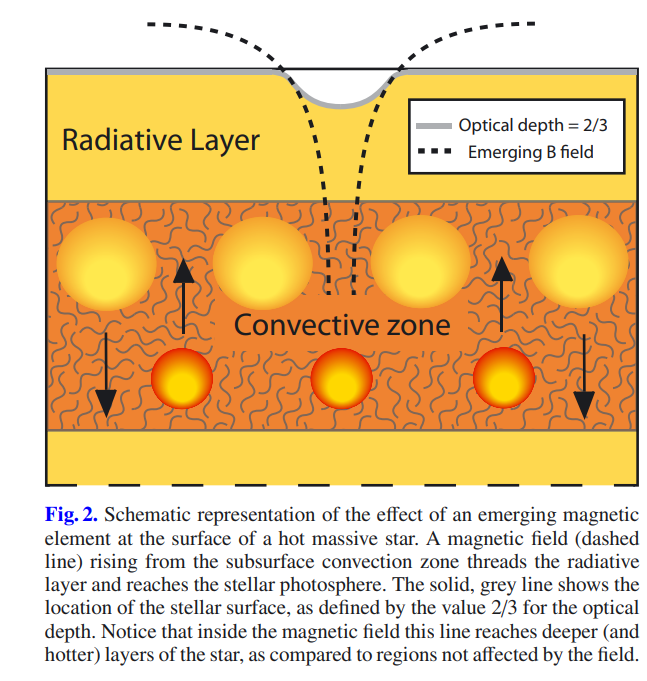
Figure 1: magnetic incidence as a function of spectral type

[3]

* A fraction between 5-10% of MS stars with radiative envelopes host detectable fields, regardless of spectral type according to Magnetism in Massive stars (MiMeS) and B fields in OB stars (BOB).
* Detection relies on the Zeeman effect (the splitting and polarisation of spectral lines produced by a B field)
* The topologies of magnetic massive stars are usually similar to those of Ap stars, oblique dipole and very stable over years
* Ap stars possess strong large-scaled organized B fields, all Ap stars are magnetic, observed field is always higher than 100 G for the longitudinal field (corresponds to a polar field of about 300 G)
* B fields of the order of kilogauss are considered strong fields, whereas fields n the order of hundred Gauss are considered weak fields
* The sun has an average B field strength of 1G, but sunspot areas can reach up to 3000G.
* Massive stars have a thin sun-surface convective layer; therefore, it is plausible that a dynamo process could operate in this zone. It is also plausible that this convective layer could reach the surface of the star
* It has been shown that increasing B-field strengths are found in increasing masses and towards the end of the MS [4]

[4]

* The iron convective zone (FeCZ) in O and B type stars contain very little mass due to low densities in the outer layers of the star.
* The transport of energy in the FeCZ by convective motions is inefficient, so radiative energy transport dominates and transports most of the total flux.
* This is due to the low density and convection being significantly super adiabatic.
* Convection zones close to the stellar surface of hot massive stars could lead to B fields being readily produced by dynamo action and reach the stellar surface via magnetic buoyancy, i.e. potential sunspots
* The FeCZ is a turbulent layer close to the stellar surface and as such could be a site of a small-scale dynamo ( small scale dynamos result in B-fields with correlation scale of order or smaller than the forcing scale)
* MS massive stars usually rotate rapidly, typical velocity of 150 km s-1, which could give B-fields up to 2kG which is supported by simulations of turbulent convection in the presence of rotation and shear
* Hence dynamo action in the FeCZ could depend on the stellar rotation and the shear profile, whilst the scale of the B-field is dependant on the type of dynamo action occurring.
* The dynamo could also be affected by a large-scale B-field penetrating upwards from the radiative zone below the FeCZ.
* [4] 



[1] Kholtygin, A., Fabrika, S., Drake, N., Bychkov, V., Bychkova, L., Chountonov, G., Burlakova, T. and Valyavin, G., 2010. Statistics of magnetic fields for OB stars. *Astronomy* Letters, [online] 36(5), pp.370-379. Available at: <https://arxiv.org/pdf/1005.3705.pdf> [Accessed 20 February 2021].

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[4] Cantiello, M. and Braithwaite, J., 2011. Magnetic spots on hot massive stars. *Astronomy & Astrophysics*, *534*, p.A140.