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Survival of fossil fields during the pre-main sequence evolution of intermediate-mass stars

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Chemically peculiar Ap/Bp stars host strong magnetic fields in the range of 200 G to 30 kG. Here we discuss their possible origin in terms of fossil fields from the interstellar medium and their survival during protostellar evolution.

The origin of strong magnetic fields in chemically peculiar Ap/Bp-type stars is still controversial. A possibly important origin involves fossil magnetic fields from the interstellar medium, which however need to survive the protostellar evolution of the star (Braithwaite & Spruit, 2017). During the convective phase, this is very difficult, and the magnetic field is likely to be efficiently dissipated, unless the magnetic energy is at least comparable to the convective energy and thus able to efficiently suppress convection (Moss, 2003).

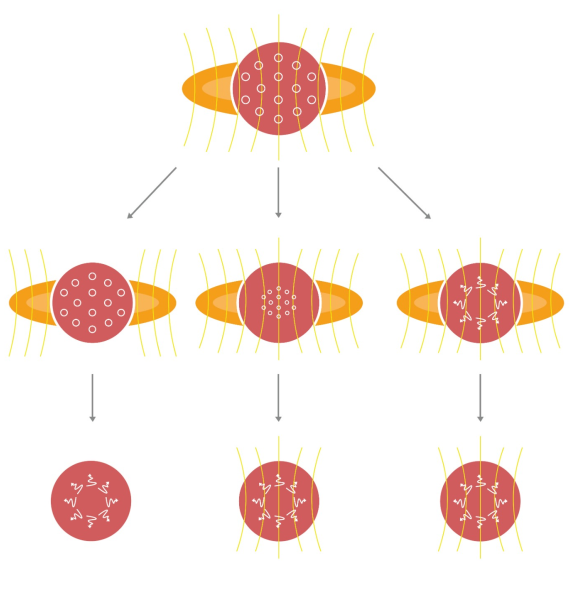

Figure 1. Possible evolutionary pathways of a convective protostar with a magnetic field. Left: Dissipation by convection. Middle: Magnetic field suppresses convection. Right: Protostars becomes radiative and magnetic field survives. Figure from Schleicher et al. (2023).

A possible alternative has been sketched by Dudorov & Tutukov (1990). If protostars become radiative during their evolution, then at least the mass accreted during the later phase of the protostellar evolution is likely to remain magnetised, inheriting and maintaining the magnetic field from the interstellar medium. Protostellar evolution models by Palla & Stahler (1991) indeed have shown that protostars exposed to constant accretion rates

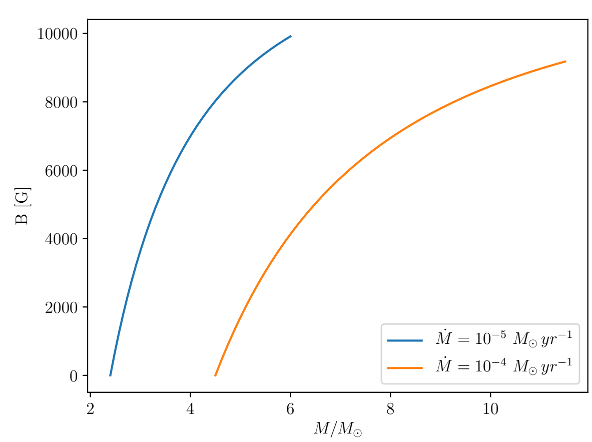

Figure 2. Expected magnetic field strength as a function of stellar mass considering the evolutionary models of Palla & Stahler (1991). Figure from Schleicher et al. (2023).

of $\sim 10^{-5}$ $M_\odot$ yr^{-1} become radiative after reaching a mass of about 2.4 $M_\odot$. The pathways are summarized in Figure 1, and an estimate of the field strength that could be obtained from the Palla & Stahler (1991) models is given in Figure 2 as a function of stellar mass.

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