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The various scenarios for the equatorward migration of sunspots

The profile of the differential rotation together with the sign of the alpha-effect determine the dynamo wave direction. In early models the dynamo wave often lead to a poleward migration of the activity belts. Flux transport by the meridional flow or the effect of the surface shear layer are possible solutions. The role of boundaries on the properties of mean field dynamos is shown for various properties of the corona. A new dynamo of Babcock-Leighton type also leads to the correct equatorward migration by the non-linear relation between flux density and rise time.

Various corona rotations and diffusivities

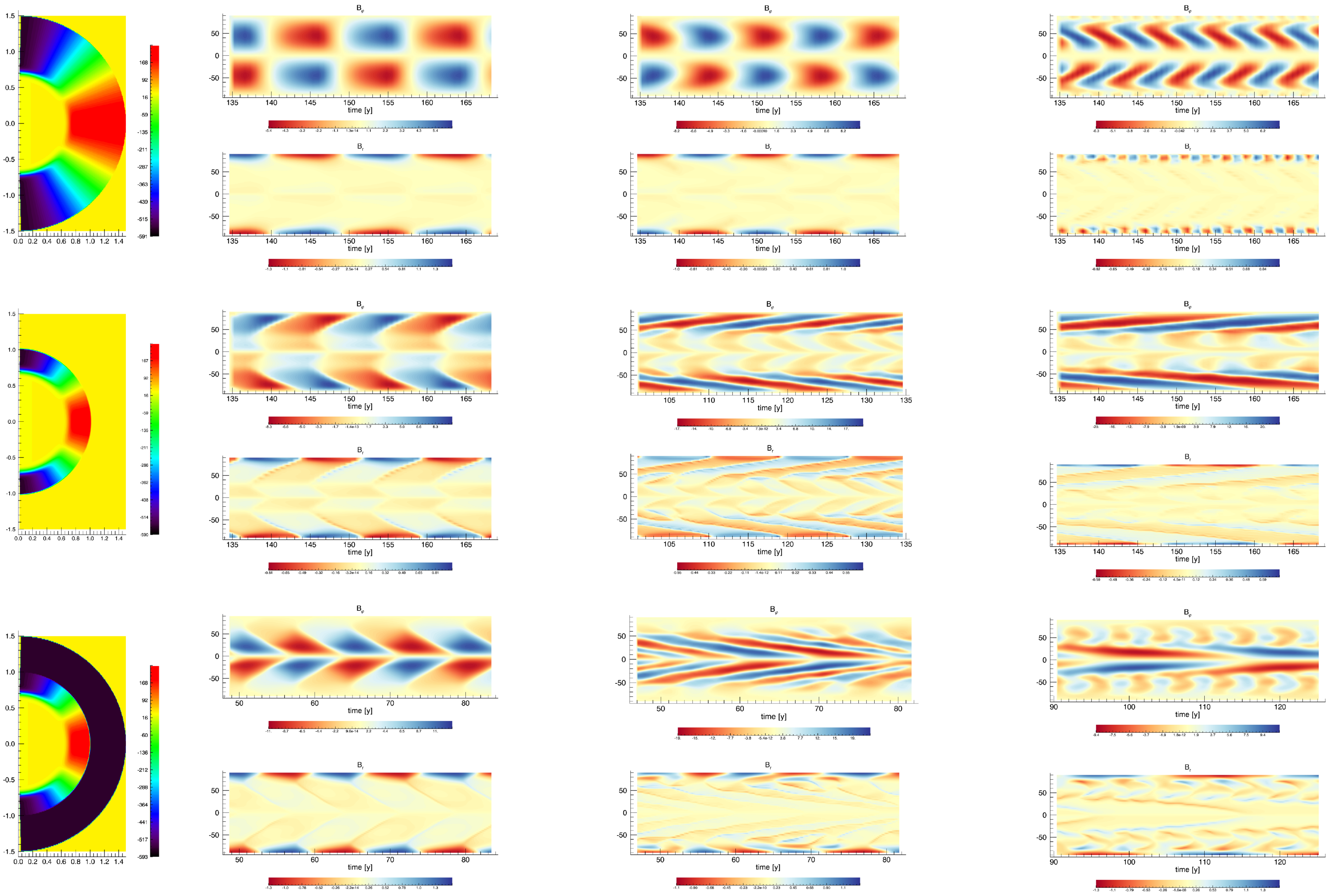
Solar rotation law in the convection zone. Constant diffusivity $\eta_* = 5 \cdot 10^{11} cm^2/s$ within the convection zone. No meridional circulation included. Simple isotropic alpha-effect within the convection zone and

$\eta_{corona} = 10\, \eta_*$ | $\eta_{corona} = \eta_*$ | $\eta_{corona} = 0.1\, \eta_*$

Corona rotates with stellar surface Ω

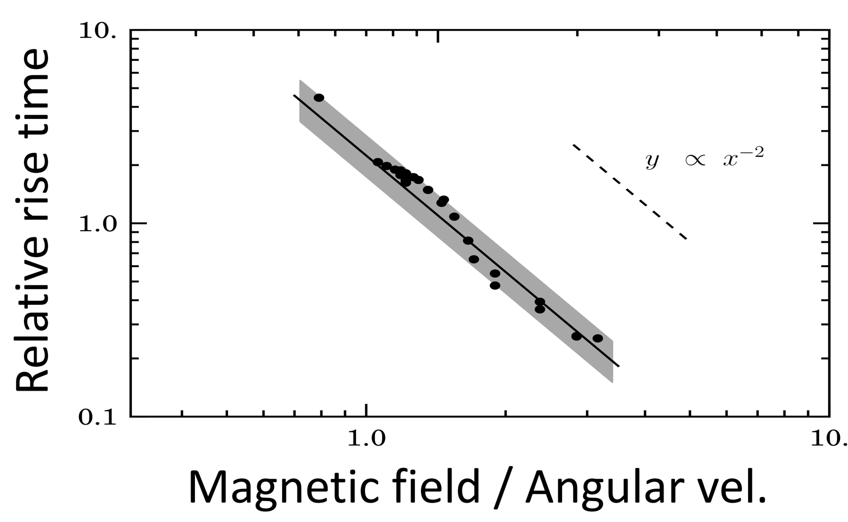
Corona rotates with core Ω

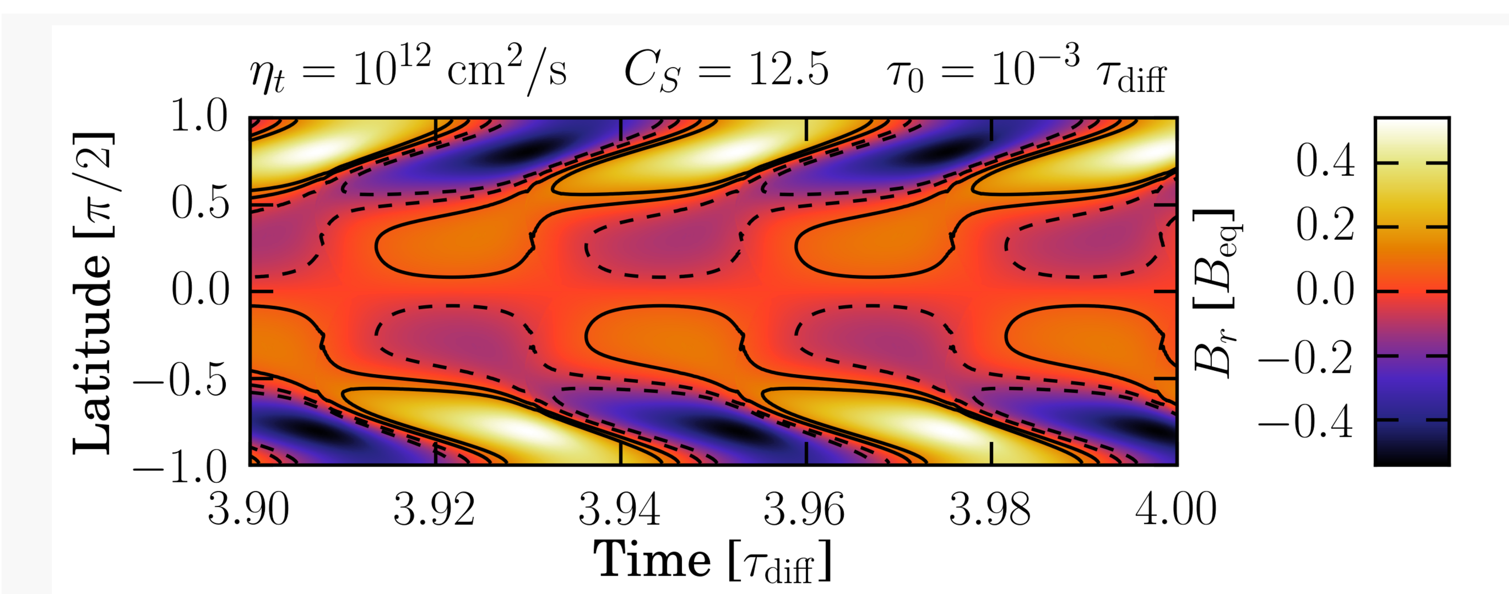
Corona rotates with polar Ω



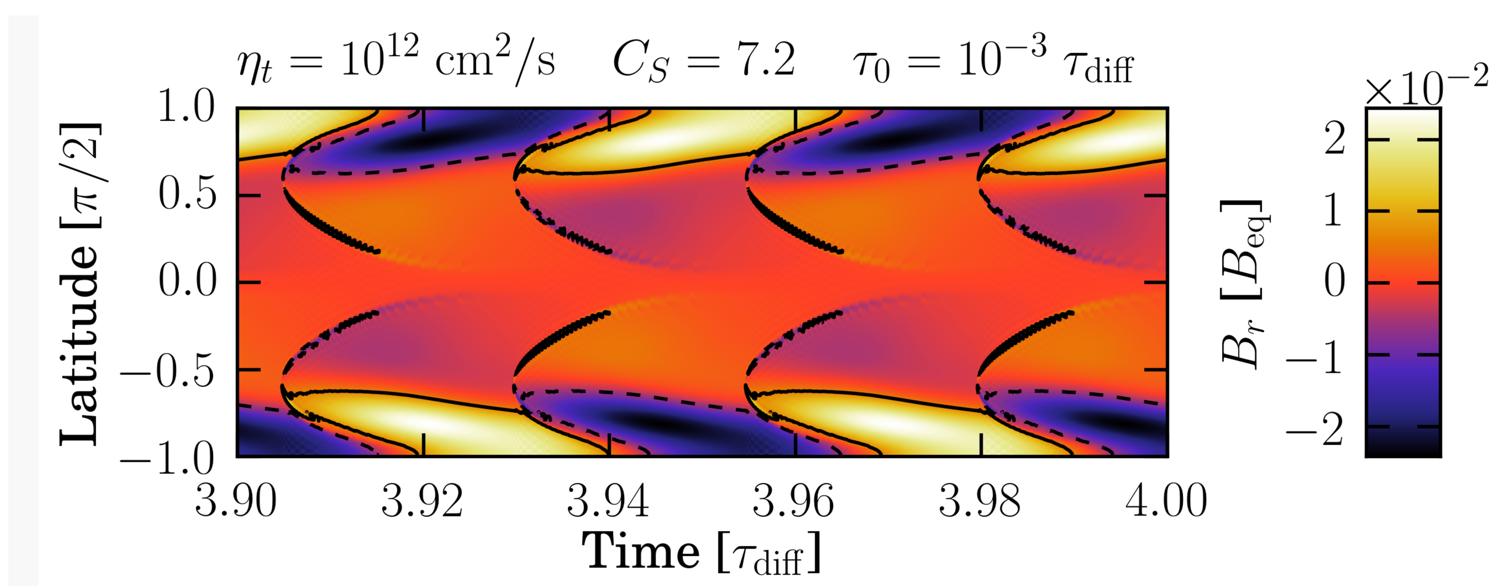
A dynamo with field dependent memory effect

Magnetic flux tubes have a finite rise time scaling with rotation period of the star and the ratio between buoyant force and Coriolis force modified by the magnetic tension. For the sun we have $\tau_{delay} = \tau_0/\sin(\theta) \; |B_\varphi/B_{eq}|^q$. It is a non-local α-effect in space and time, where the non locality depends on the field strength in a non-linear way for q between -0.91 and -2.0. The toroidal flux can accumulate at the surface during the cycle. It is an under critical regime, which leads to the equatorial migration at low latitudes. This system automatically saturates for strong fields, where the accumulation of flux is impossible because of the fast rise time.





Standard Babcock-Leighton model



Subcritical Babcock-Leighton model