Modelling of dipolar magnetic reversals for low mass stars

Anna Guseva[1], Charly Pinçon[2], and Ludovic Petitdemange[1]

[1]LERMA, l'Observatoire de Paris, France
[2]Université Paris-Saclay, Institut d'astrophysique spatiale, France

Magnetic fields can considerably influence all stages of stellar evolution, including accretion from protostellar discs and enhancement of momentum transport in evolved red giant stars, and are responsible for stellar magnetic activity. Recent spectropolarimetric observations of low-mass stars show that the large-scale dipolar component of their magnetic field can exhibit cyclic variations or reversals during which dipolar component changes its direction. In convective stellar envelopes, these fields are created through dynamo action - systematic stretching and twisting of magnetic field lines by helical convective vortices. It is yet however unclear how low-mass stars, with their high levels of small-scale induction as compared to dissipation, and relatively slow rotation compared to time scales of convective turbulence, are able to maintain coherent magnetic activity along with the growth of small-scale fluctuations of magnetic field.

In this work, we elucidate physical mechanisms that allow magnetic flux to accumulate at large scales in highly turbulent and at the same time strongly stratified models of stellar convection. In such models, a highly turbulent convective layer is formed at the surface while the deep flow interiors remain rotationally constrained. Our results show that small-scale magnetic field, generated by small-scale turbulence in the outer regions with low density, is systematically transported into more quiescent inner regions by global magnetic pumping mechanism. Consequently, the dipolarity of the field at the surface of the domain increases both with enhancement of turbulence and stratification. These unstable dipolar large-scale fields exhibit reversals which can be responsible for magnetic cyclic variations observed in low-mass stars.