

Title: On the numerical treatment of short timescale angular momentum transport in stellar evolution codes: The example of the Tayler-Spruit dynamo

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Abstract: Traditionally, the transport of angular momentum in stellar radiative zones (RZ) has been modelled as a competition between angular momentum advection via meridional circulation and the diffusion of angular velocity through shear-induced turbulence. However, the angular velocity profiles obtained using this model do not match the observations. For example, the expected radial shear in the solar RZ contradicts the results of helioseismic inversions, which indicate almost rigid rotation. In more evolved stars, radial differential rotation is measured to be much smaller than that predicted by classical angular momentum transport. These discrepancies suggest the need to consider additional mechanisms that transport angular momentum on much shorter timescales. One of the most promising candidates is diffusion of angular velocity induced by the Taylor–Spruit dynamo. Previous studies have demonstrated that TS dynamo is an efficient transport mechanism, though insufficient to reproduce the observations. However, we demonstrate that many of these earlier results are not numerically converged. Stellar evolution codes commonly rely on large timesteps, which are suitable for following the evolution of structures but lead to numerical errors when modelling MHD instabilities acting on much shorter timescales. In particular, we demonstrate the significant effect that temporal and spatial resolution have on the resulting rotation profiles. To overcome these limitations, we adopt a modified numerical strategy that allows for a more accurate treatment of these processes, which could change conclusions regarding the efficiency of MHD-induced transport processes.