Magnetic braking of stellar cores in red giants and supergiants

Andre Maeder and Georges Meynet

Geneva Observatory, Geneva University

Magnetic configurations, stable on the long term, appear to exist in various evolutionary phases, from Main-Sequence stars to white dwarfs and neutron stars. The large scale ordered nature of these fields, often approximately dipolar, and their scaling according to the flux conservation scenario favor the model of a fossil field Duez et al. (2010). We make some first estimates of the magnetic coupling between the stellar cores and the outer layers in red giants and supergiants. Analytical expressions of the truncation radius of the field coupling are established for a convective envelope and for a rotating radiative zone with horizontal turbulence. The timescales of the internal exchanges of angular momentum are considered.

Numerical estimates are made on the basis of recent model grids. The direct magnetic coupling of the core to the extended convective envelope of red giants and supergiants appears unlikely. However, we find that the intermediate radiative zone is fully coupled to the core during the He-burning and later phases. This coupling is able to produce a strong spin down of the core of red giants and supergiants, also leading to relatively slowly rotating stellar remnants, like white dwarfs and pulsars. Some angular momentum is also transferred to the outer convective envelope of red giants and supergiants during the He-burning phase and later.

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Email: georges.meynet@unige.ch