The Art of Modelling Stars in the 21st Century
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The evolution of 'the moment of inertia' of stars

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Abstract. Observations of the rotation periods of cool open cluster stars display a distinctive dichotomy when plotted against stellar mass/color. Other measures of stellar activity are also known to be dependent on stellar mass and structure, especially the onset and characteristics of convection zones. One proposal for understanding the observed rotation period dichotomy suggested dependencies on the moment of inertia of either the whole star or that of only the outer convection zone (Barnes 2003).

The moment of inertia of stars with the mass between 0.1Msun and 3.0Msun have been calculated using a version of Yale Stellar evolution code (aka YREC). Each star has been evolved from stellar birthline to the onset of the core He burning. For easy comparison to observations, we have calculated the isochrones of these quantities as well as the convective turnover time, of interest to the activity community.

Keywords. stars: interiors stars: evolution

1. Introduction

The stellar rotation rate is the prime parameter determining the level of stellar magnetic activity. The activity level responds to changes in the stellar rotation rate that are the result of the loss of angular momentum through the magnetized stellar wind, and of evolutionary changes in the moment of inertia; both of these effects may also affect the internal differential rotation. Because of the evolutionary changes in the stellar interior, reflected in radial expansion or contraction and associated changes in density, the moment of inertia of the star changes with time. The magnetic brake applies directly to the top of the convective envelope. Therefore, it is of interest to study the moment of inertia of radiative interior and of the convective envelope separately.

The historical impetus for the belief in a connection between stellar structure and rotation-activity goes back to the work of Schatzman (1962) and Kraft (1967). This work suggested that the presence (absence) of a surface convection zone is the determinant of whether (or not) stars can spin down over time. Using rotation periods rather than the $v \sin i$ measurements, we can test whether this point in the theoretical models does indeed coincide exactly with the change in rotation. Consequently, we have been working on how to relate the best models of cool stars we can generate to the best rotation-activity datasets we can assemble. This paper is about the modeling component of this project. A comparison of the observation with these models will be presented elsewhere (Barnes & Kim 2008 in preparation).

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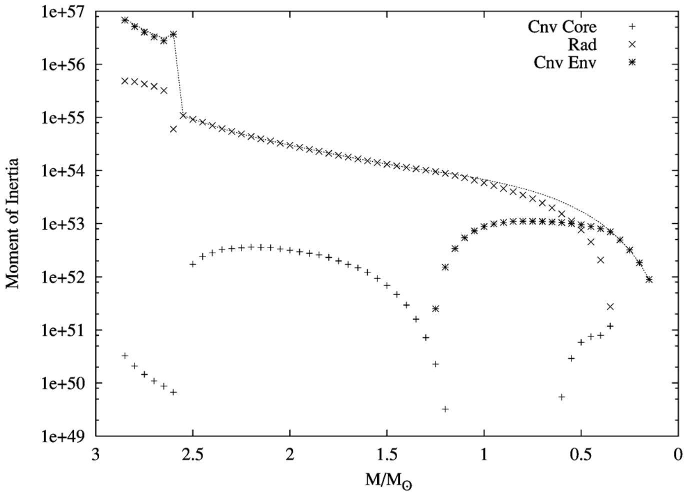

Figure 1. The isochrone of the moment of inertia for $500Myr$

2. Computation

All models used in this paper have been constructed using a version of the Yale Rotating Stellar Evolution Code (YREC; Demarque *et al.* 2007). A series of stellar models with masses ranging from 0.1 to $3.0M_\odot$ have been evolved from the stellar birth line (Palla & Stahler 1993), to the onset of the core Helium burning. Along the evolution, the moments of inertia are computed for the radiative interior and for the convective envelope and for the convective core separately, as well as the total value. Also, the convective turnover timescale has been calculated within the mixing length scheme. And the 500Myr isochrone is shown in Figure 1.

3. Summary

The moment of inertia of radiative interior and of the convective envelope as well as the total moment of inertia of a star have been computed along evolutionary tracks. Other characteristic parameters of the convection, for example the convective turnover time scale, have been calculated. This series of computations form the database, to be compared with observation to study a connection between stellar structure and rotation-activity.

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