

On the Relationship Between Stellar Rotation and Radius in Young Clusters

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Abstract. We have compiled data from the literature on rotational velocities and/or periods for > 1000 K & M stars in 10 young clusters ranging in age from Orion to the IC 1391/2602. These data show that most PMS stars < 3 Myr do not appear to spin up in response to contraction, but there is a suggestion of slight spinup by ~ 8 Myr. These results extend and reinforce our earlier study (Rebull et al. 2002), based on observations of ~ 300 stars in the Orion Flanking Fields, NGC 2264, and the Orion Nebula Cluster (ONC), which showed that the majority of PMS stars in these three groups apparently do not conserve stellar angular momentum as they contract, but instead evolve at nearly constant angular velocity. This result applies both to stars with and without near-IR $I-K$ excesses indicative of disks.

1. Introduction

When PMS stars first appear, they rotate well below breakup velocity, even though many are still accreting and in principle gaining angular momentum (J) from their disks. Models (e.g. Königl 1991) posit star-accretion disk interactions that lock PMS objects to near constant angular velocity (ω). When accretion ceases, models predict that stars should spin up in response to contraction (conserving stellar J). Rotation periods (P) and/or projected rotational velocities ($v \sin i$) are now available for a large number of stars and enable tests of these predictions. Rebull et al. (2002) show that for PMS stars in Orion and NGC 2264, there is no evidence of the expected spinup in rotational velocity as stars approach the ZAMS!

2. Observations, Analysis, & Discussion

Rotational information (P or $v \sin i$, with V , I , and spectral types) was retrieved from > 85 papers in the literature, for > 1000 stars in Orion, TW Hya, Cha, ρ Oph, NGC 2264, Tau-Aur, Lupus, η Cha, IC 2391, and IC 2602. The present

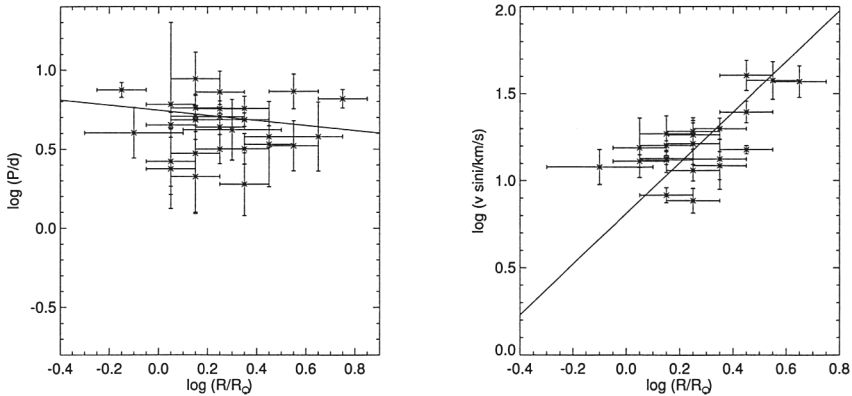


Figure 1. Mean rotational data from K5–M2 cluster stars in the literature. Each point is a mean P or $v \sin i$ over the indicated range in $\log R$. The data are consistent with constant P and decreasing v as the stars contract, as expected for evolution at constant angular velocity. The best-fit line on the left has slope -0.16 ± 0.09 and on the right, 1.45 ± 0.29 .

discussion is limited to types K5–M2 (effectively a cut in mass) to limit mass & age effects across clusters. We calculated stellar radii (R) from position in a dereddened CMD. If stellar $J \propto MvR$ conserved, $P \propto R^2$, or $v \propto 1/R$. The figure instead suggests that stars evolve at nearly constant P and that v decreases nearly linearly with R , e.g. that stars LOSE J throughout much of their approach to the ZAMS. The only hint of a turnup in v and a decrease in P occurs for stars with $\log R/R_{\odot} < 0.0$ or an age $> \sim 8$ Myr.

Crucial to this conclusion is the ability to obtain R , which we estimate to have an intrinsic typical uncertainty of 0.05 dex (Rebull et al. 2002). Comparing results across studies introduces a mix of selection effects and biases. Complete studies of P and $v \sin i$ (especially for clusters $> \sim 5$ Myr) are desperately needed!

3. Acknowledgements

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References

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