PHYS6013 Midterm Report: A Machine Leanring Approach to Cool Star Spin-Down

Ely Doodson,[1,2????,3???]⋆ Cecilia Garraffo,[2,3] Pavlos Protopapas[3] and Jeremy J. Drake[2]

[1]*School of Physics and Astronomy, University of Southampton, Southampton, SO17 1BJ, United Kingdom*
[2]*Harvard-Smithsonian Center for Astrophysics, 60 Garden St, Cambridge, MA 02138, United States*
[3]*Institute for Applied Computational Science, Harvard University, Cambridge, MA 02138, United States*

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ABSTRACT

Observations of young open clusters have shown a bimodal distribution in the rotation periods of cool stars. This bi-modality stems from stars having fast or slow rotation periods. The evolution of this trend through time suggests a fast transition from fast to slow rotating. Our current understanding of cool star spin down, through magnetic braking, accounts for the slow-rotators branch, while the fast rotators remain somewhat of a mystery.

Our goal is to build a predictive probabilistic spin-down model that links the period of a starat any given mass and age. We use machine learning to predict the age at which each star transitions from fast to slow-rotation. Using a graphical model we translate the distribution of initial periods into a rotation period probability distribution for a given mass and age.

Key words: keyword1 – keyword2 – keyword3

1 INTRODUCTION

Stars are born from the collapse of clouds made of dust and gas. This cloud, though being made up of many molecules with their own random velocities, can be said to have an overall spin which, when the star collapses, will be the axis of rotation when the star is born. However, this spin rate is not constant and will descrease over a stars lifetime, assuming no companion or outside influence.

Cool stars are classified as having a conventive envelope, meaning the outer-most layer of the star is moving. Due to this movement, ionic material in the star is allowed to generate massive magnetic fields which stretch in orders of stellar radii. Ejected stellar material travels along these lines, forming large arms which effectively co-rotate with the star. When material at the end of these arms breaks free, the loss in angular momentum (AM) is much grater than it would have been if the same material was lost at the stars surface. This loss in AM causes the star to lessen its rotational period and spin down. This is called *magnetic breaking* and is a very effecient way for the star to spin down.

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Stars born spinning, Over time they spin down with a mechanism. First pointed out by skumanich(feed back mechqnism so they converge(Faster they spin the LESS??? they lose), however fast branch escape thix for long period of time) and studied further for hopes of a gyrochronological model. Magnetic breaking modeled and used as a method of spin down by Garraffo et al. 2017. Linked to magnetic field complexity. Dipole causes large arms that make for an effecient spin down. Viewing open clusters one can see the fast, slow and transitional rotators. Some evolution between the two that is UNKNOWN(?).

2 METHODS AND OBSERVATIONS

2.1 Data Reduction

Collected from various papers stated in CITE BOOK, plus personal findings and unpublished data. Each cluster in different photometry and no one fits all conversion. Used MIST tracks to interpolate a mass from the given ages of the stars.

FIGURE OF ALL CLUSTERS REDUCED MERGE CLUSTERS?

2.1.1 M37 shift?

Perhaps due to metalicity

2.2 Unsupervised Clustering?

Initial attempt to seperate the fast and slow rotators however problematic due to it not being a "two group" problem. Transitional stars need to be considered, otherwise subjecting the transition to a dirac delta.

2.3 Polynomial Ridge Regression

slow rotators fit using a polynomial fit of order 4. Sigmoid function overlapped and optimised to change poly term on and off at switch point.

⋆ E-mail: ely.doodson@cfa.harvard.edu

FIGURE OF CURRENT FIT

2.4 Initial Period and other parameters

Expand of the effect initial period and perhaps metalicity. Other parameters could allow for deeper understanding of the "overlap" sections of the open clusters

FIGURE OF HOW INTIAL PERIOD CAUSES MULTIPLE LINES TO OVERLAP AND MAKE THE TRANSITION "BLURRY"

3 FUTURE WORK?

Since there is overlap, 1 polynomial fit will give poor predictive results and without inital period is not purely deterministic to the degree we want. To remedy this a probabilistic model will be built that can be used to sample and generate a synthetic population of stars at a given age and a range of masses.

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APPENDIX A: SOME EXTRA MATERIAL

If you want to present additional material which would interrupt the flow of the main paper, it can be placed in an Appendix which appears after the list of references.

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