An Empirical Daisy Chain Method for Determining Wide Binary Star Ages Based on Cluster Data

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DAISY CHAINS

- "Daisy chains" are lines of constant age created by using wide stellar binary pairs. Components with similar rotation period and color are linked to empirically trace a line of constant age in a plot of rotation period vs. color index.
- Any star within a "daisy chain" that is a member of a cluster of known age can be used to define a line of known age for that includes non-cluster stars in a plot of rotation period vs. color index.
- In principle, this approach can be used to empirically determine the age of a single star or the ages of a binary pair from their location in the rotation vs. color plot and the nearest "gyrochrone" (line of constant known age).

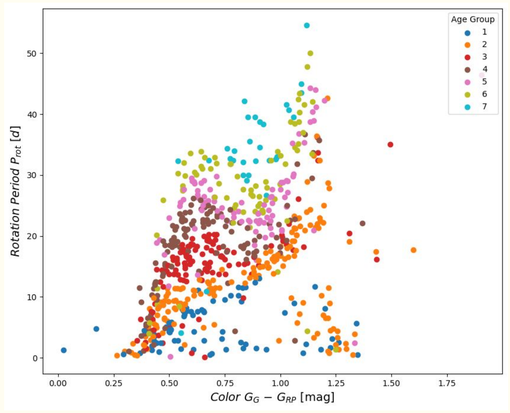

Figure 1: A plot of rotation period vs. Gaia G_G-G_{RP} color index for wide binaries in Gruner (2023). Age groups are identified by color. We used this sample to construct "daisy chains," some of which can be calibrated to cluster ages, thereby permitting the interpolation of ages for stars that are not members of clusters.

ABSTRACT

Determining the age of any star is one of the most difficult challenges in astrophysics. Gyrochronology is the observed correlation between a star's period of rotation and its age. We are using wide stellar binary pairs in an attempt to calibrate the rotation-age relation. Components in each pair are the same age and so, should have rotation rates periods commensurate with the gyrochronology paradigm. We are experimenting with a "daisy chain" method, which has the potential to map a band of constant age across the plot of rotation period vs. color index, a proxy for age, using wide binary pairs. Preliminary results suggest the approach can establish a net pattern along a band of constant age, known as a "gyrochrone". Once tied to absolute ages defined by star clusters, the approach may provide age estimates for single field stars.

GYROCHRONES

- "Gyrochrones" are lines of constant age that can be traced by "daisy chaining" pairs of stars known to have similar ages across a plot of rotation period vs. color index.
- The age corresponding to a particular gyrochrone can be assigned if any star within it is a member of a cluster with previously known age.
- Gyrochrones that do not contain a cluster member still trace out a line of constant age that can be interpolated from adjacent lines of known age.

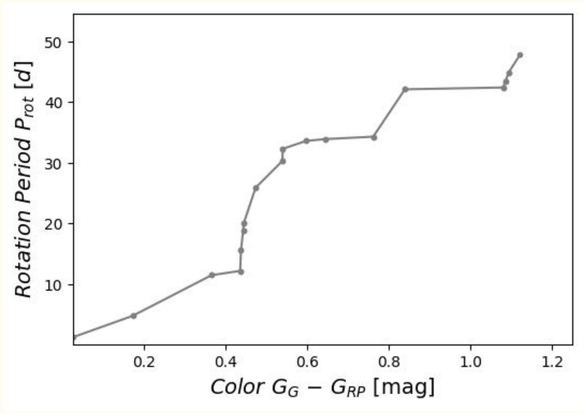

Figure 2: This graph shows a single daisy chain traced by adjacent wide binary components of similar rotation period and color index that defines a single age group. Stars used to trace this "isochrone" were selected from the sample in Fig. 1. This empirical isochrone does not exhibit an expected upward curvature of the "delayed spin-down" phenomenon noted by Curtis et al. (2020) as it is under the 1 Gyr cutoff. Using this method, it is hoped that older isochrones can be traced to show the phenomenon of "delayed spin-down".

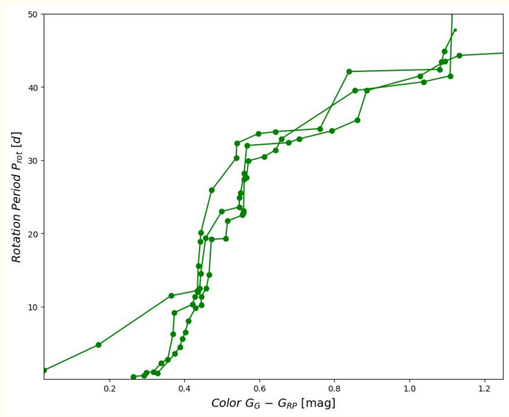

Figure 3: Example of a gyrochrone for stars of ages between 1.0-2.5 Gyr selected from Gruner (2023). The scatter shown puts together 3 separate "daisy chains" to form a net pattern upon which the center should be representative of a line of constant age defined by the absolute ages of a star cluster.

CONCLUSIONS

- The "daisy chain" approach to tracing lines of constant age may permit gyrochronology to be extended to the determination of ages for stars that are not members of clusters.
- Tying the empirical gyrochrones traced by the "daisy chain" method to as many cluster ages as possible will permit improved age determinations for single field stars.

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