OPTIMIZING EXOPLANET TRANSIT SEARCHES

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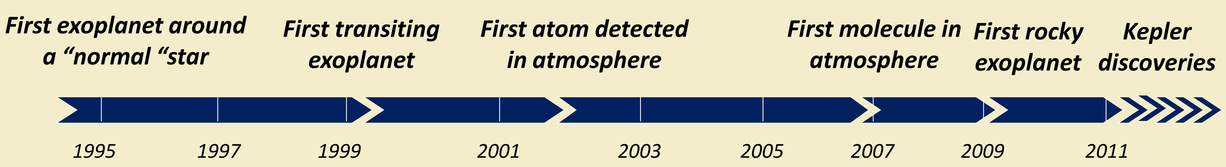
Exoplanet searches using the transit technique are providing new findings at a fast pace. Most exoplanet transit detection programs that are currently underway are focused on large catalogs of stars with no pre-selection. This necessarily makes such surveys quite inefficient, because large amounts of data are processed for a relatively low transiting planet yield. In this work we investigate a method to increase the efficiency of a targeted exoplanet search with the transit technique by preselecting a subset of candidates from large catalogs of stars. Assuming spin-orbit alignment, this can be done by considering stars that have higher probability to be oriented nearly equator-on (inclination close to 90º). We use activity-rotation velocity relations for low-mass stars to study the dependence of the position in the activity-*v*sin*i* diagram on the stellar axis inclination. We compose a catalog of G-, K-, and M-type main sequence simulated stars using isochrones, an isotropic inclination distribution and empirical relations to obtain their rotation periods and activity indexes. Then the activity-*v*sin*i* diagram is filled and statistics are applied to trace the areas containing the higher ratio of stars with inclinations above 80º. A similar statistics is applied to stars from real catalogs with $\log(R'_{HK})$ and *v*sin*i* data to find their probability of being equator-on. We present the method used to generate the simulated star catalog and the subsequent statistics to find the highly inclined stars from real catalogs using the activity-*v*sin*i* diagram. Several catalogs from the literature are analyzed and a subsample of stars with the highest probability of being equator-on is presented. Assuming spin-orbit alignment, the efficiency of an exoplanet transit search in the resulting subsample of probably highly inclined stars is estimated to be two to three times higher than with a global search considering no pre-selection.

Exoplanets: a recent field



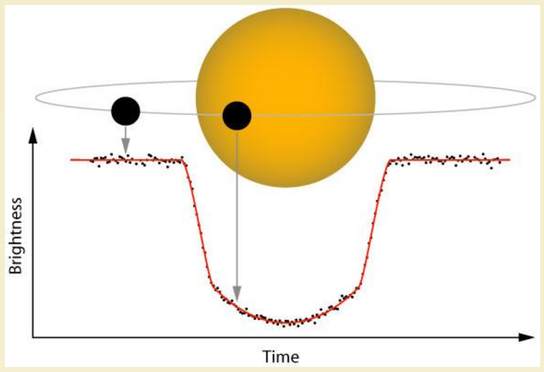
Currently…

Detection of big planets in close orbits → Detection of small (Earth-like) planets
Characterization of big planet's athmospheres

Near future…

Detection and characterization of habitable super-Earths → Detection of life!

Exoplanet transits



The transits of an exoplanet on the stellar disc yields a monochromatic signature in the light curve easily measurable.

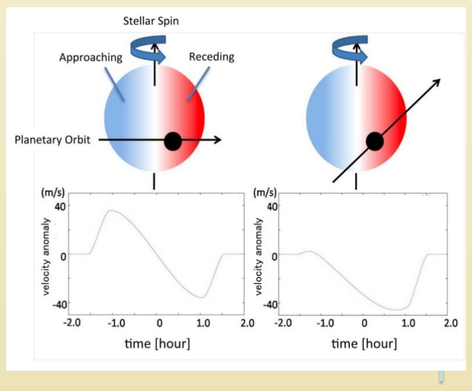
The depth and duration of the eclipse in the light curve allows to derive planet radius and orbit inclination.
The period is known through the repetition of transits.

About 30% of the known exoplanets have been discovered with the transit technique

Transits occur at inclinations ~90º

OUR AIM is to contribute to the transit detection efforts by selecting stars being equator-on oriented

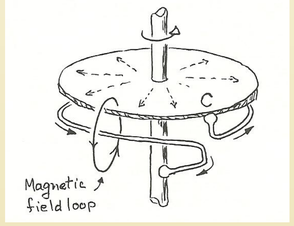
Spin-orbit orientation

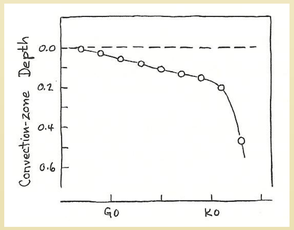


Spin-orbit angle projection in the plane of the sky can be measured thorugh the Rossiter-McLaughlin effect in radial velocity curves:

- Kepler is finding lots of multiple aligned systems.
- From 45 measurements made in hot-Jupiters, 20 are significantly misaligned!

Activity – rotation relations for low mass stars



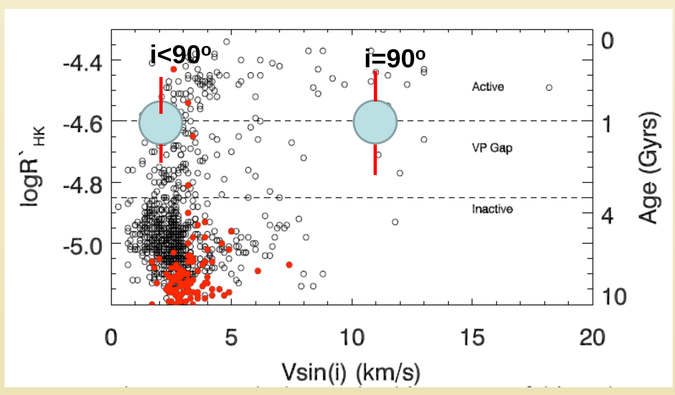


Fast rotation → Dynamo effect → Highmagnetic activity

V_{rot} ↔ Spectral type

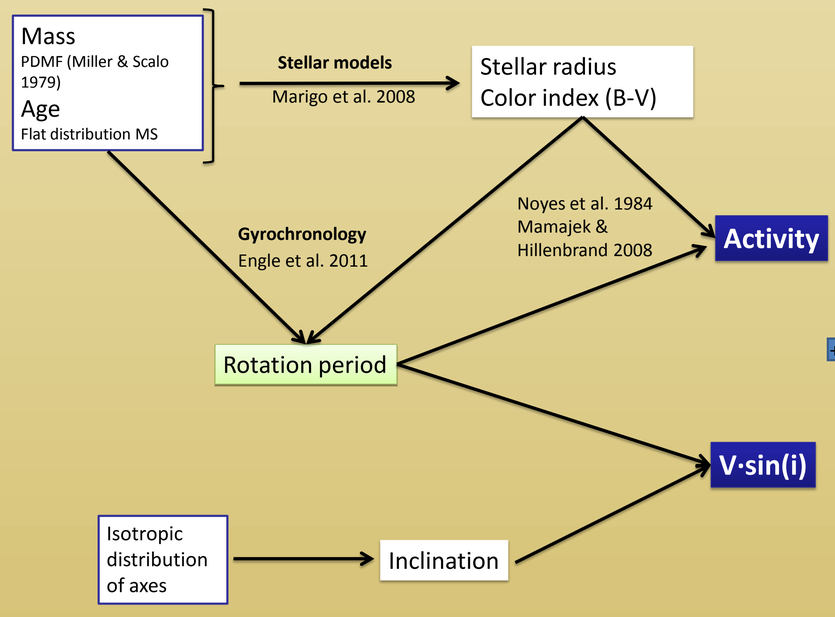
Spectral type ↔ Chromospheric activity

Chromospheric activity ↔ V_{rot}

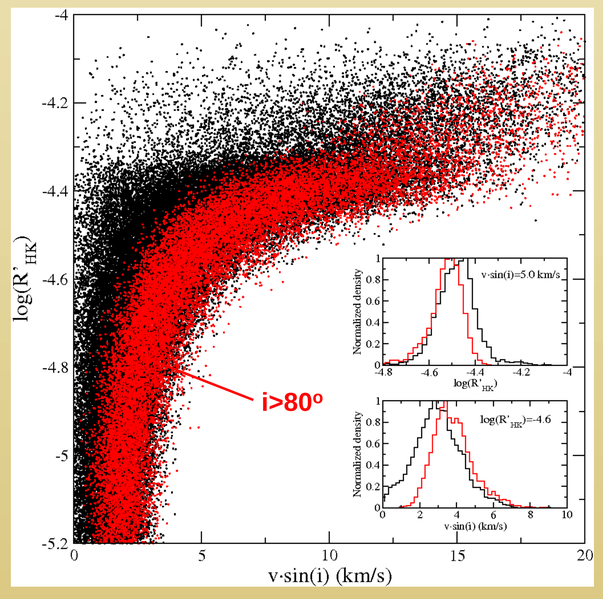


Simulated samples of GKM dwarfs

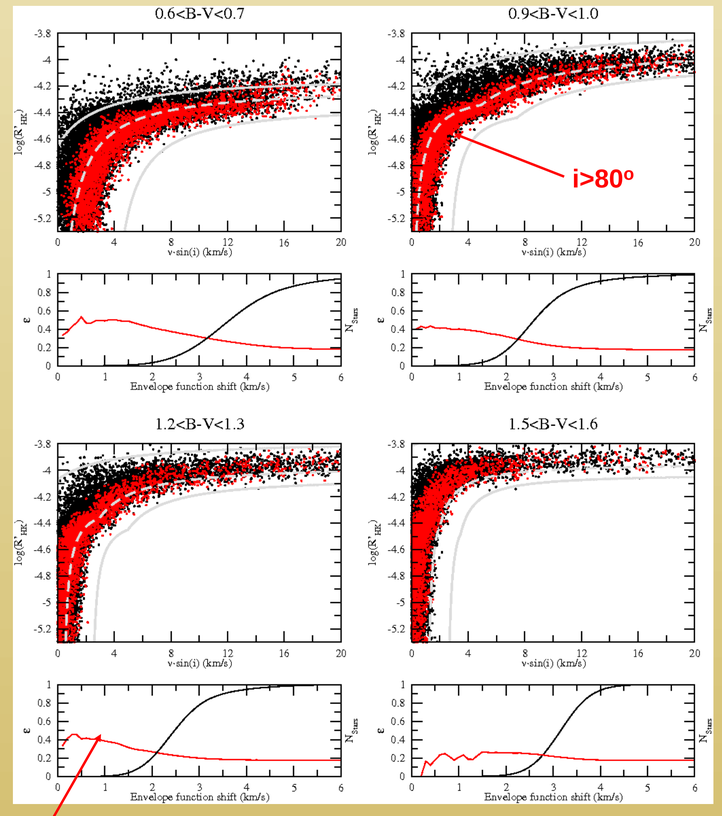
Simulating Activity & Vsini



+ observational errors



Stars with high inclination are in the (red) envelope region at the right hand of the total distribution.
For a given $\log(R'_{HK})$, stars are expected to have a very similar equatorial velocity in terms of the rotation and activity evolution assumptions, and so *v*sin*i* are mainly caused by different axis projections.



$$\epsilon_\alpha = \frac{N_{i>\alpha}}{N_T}$$

Efficiency = probability for a star in a given location of the diagram to have an inclination angle above α.

ε=0.173 for random distribution of orientations.

The preselection of stars with high probability of having high inclination axis enhances the success rate of an exoplanet transit search by a factor 2-3.

Related papers

Brown, D. J. A., et al., MNRAS, 423, 1503
Herrero, E., Ribas, I., Jordi, C., Guinan, E.F., Engle, S.G., 2012, A&A 537, A147
Mamajek, E. E., Hillenbrand, L. A., 2008, ApJ, 647, 1264
Marigo, P. ,et al, 2008, A&A, 482, 883
Noyes, R. W., Hartmann, L. W., Baliunas, S. L., et al. 1984, ApJ, 279, 763

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