The rotation of nearby M dwarfs, the ages of planetary systems, and implications for exoplanet discovery

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70% of all stars





Why M drearfs?

70% of all stars

Small size → find & characterize habitable planets





Why rotation?

Planetary system ages Exoplanet detection Exoplanet habitability

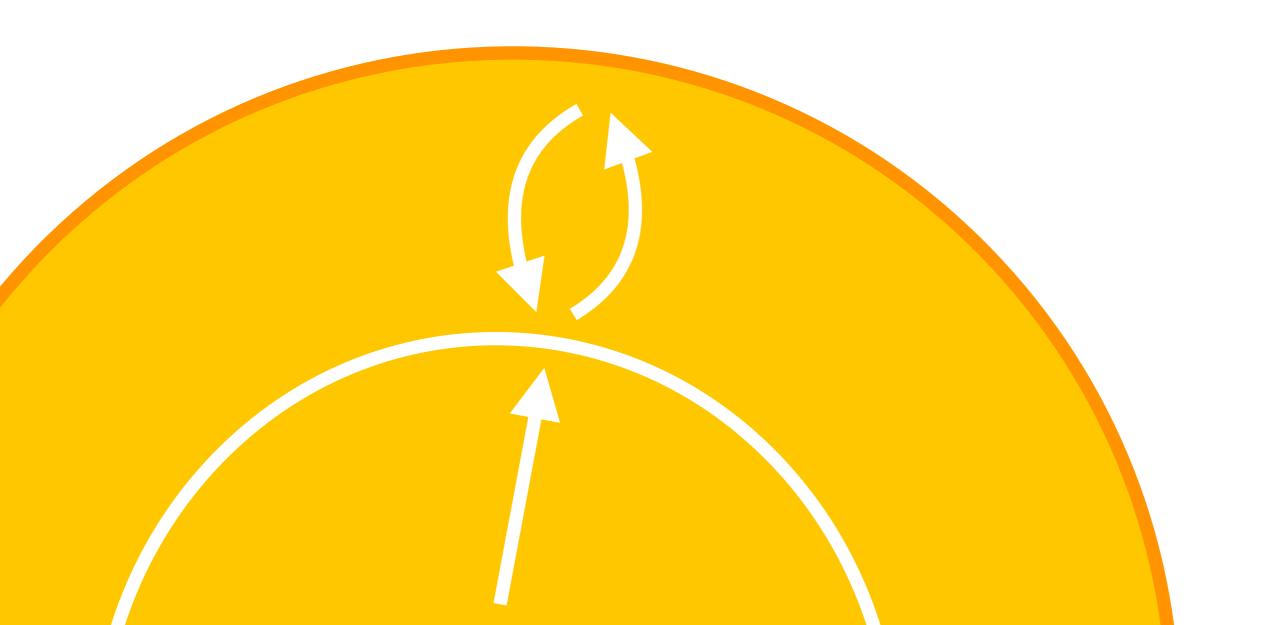
A need for observations New measurements from MEarth The age-rotation relation The impact on RV surveys

ERN et al. ApJ accepted arXiv: 1511.00957 | ERN et al. (submitted)

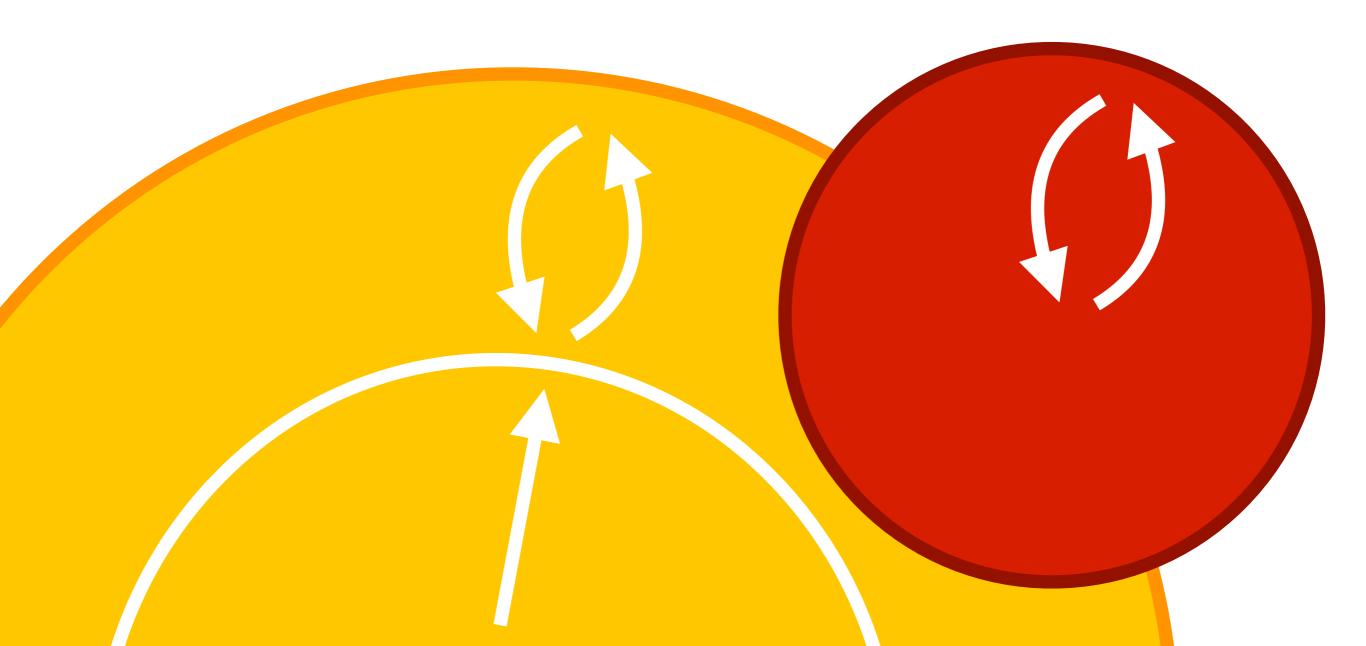
- A need for observations New measurements from MEarth The age-rotation relation The impact on RV surveys
- Low-mass, for the purposes of this talk: M4V-M5V (most M dwarfs) M*<0.3M_☉ (fully-convective)

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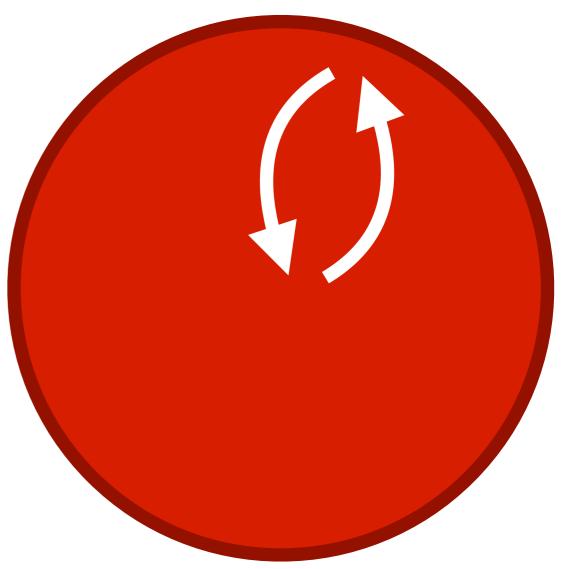
Detailed observations of the Sun Observations of stars young stellar clusters



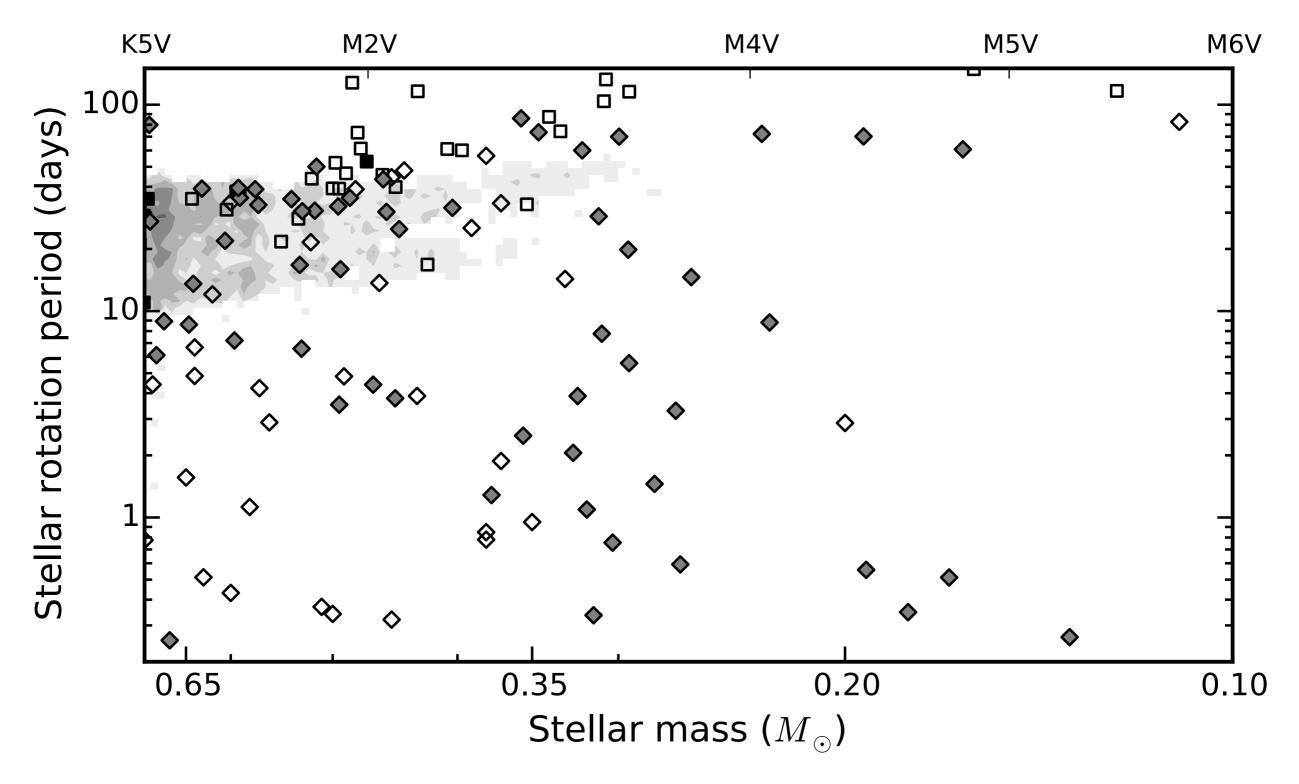
Non-solar magnetic dynamo Angular momentum evolution at field ages



A need for measurements of rotation periods & ages for field M dwarf stars

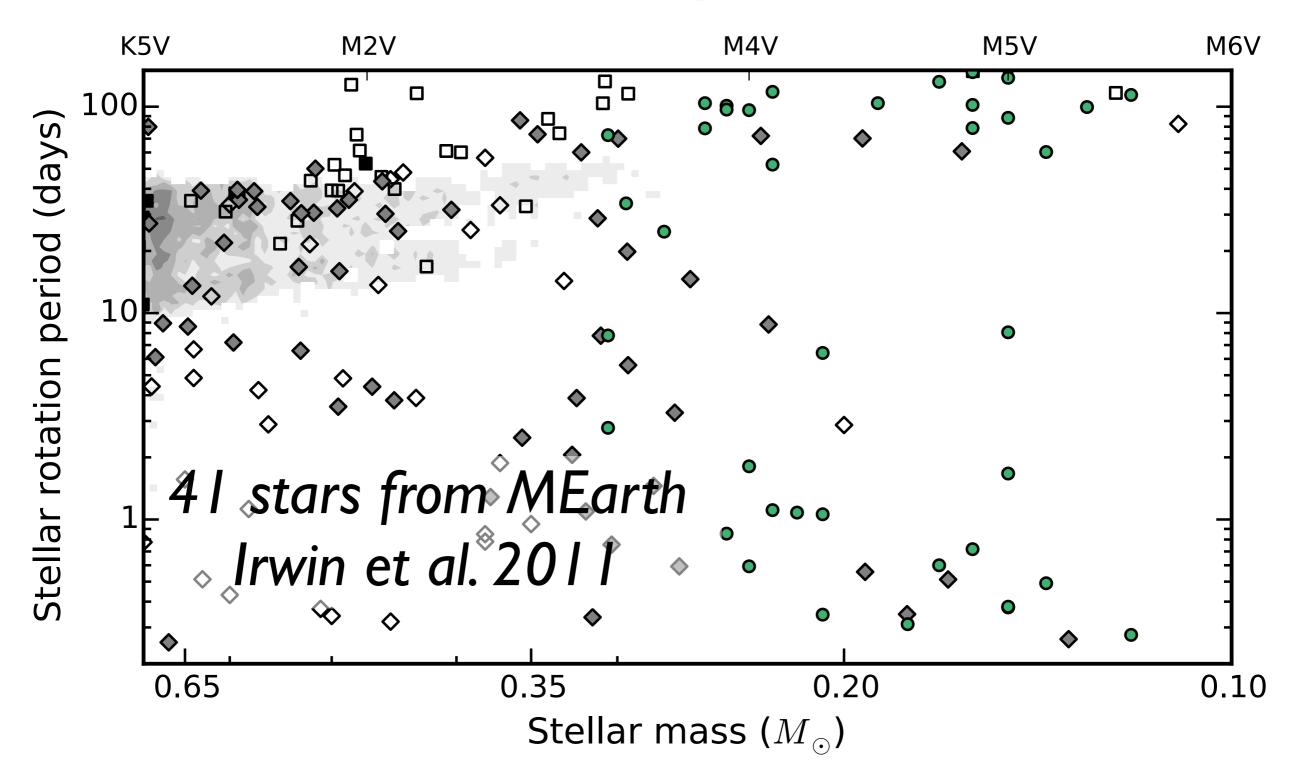


Rotation in field stars



Compilation c.f. Newton et al. (submitted)

Rotation in field stars



The MEarth Project a **transiting planet** survey

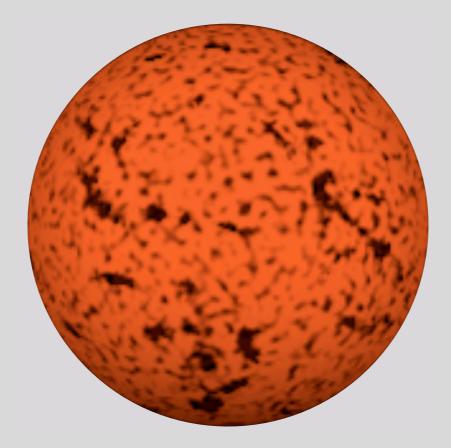
PI: D. Charbonneau — MEarth Team: J. Irwin, Z.K. Berta-Thompson, J. Dittmann, ERN

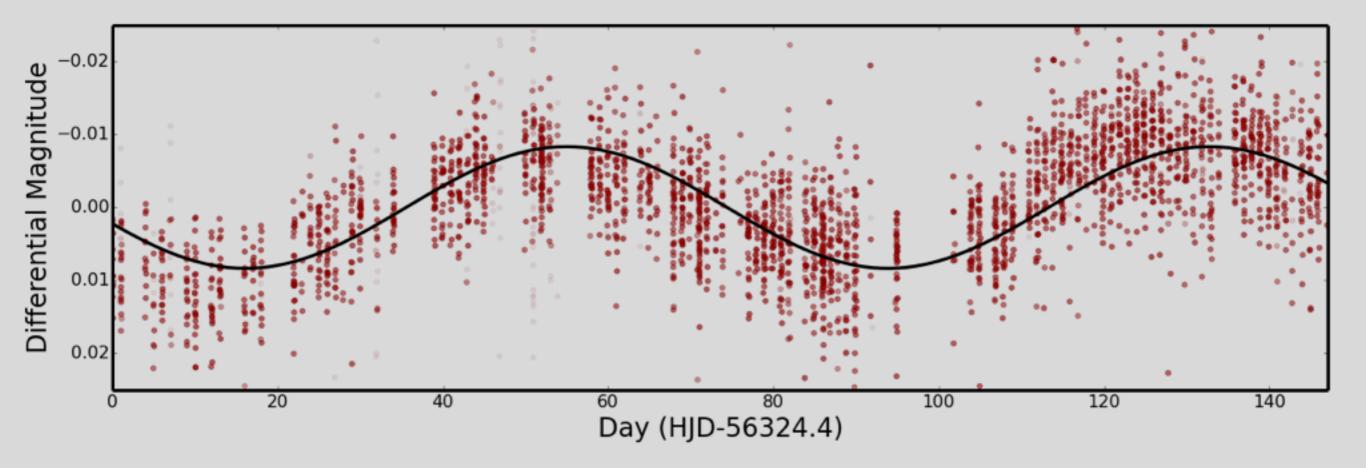
targeted survey focusing solely on mid-to-late M dwarfs

targeted survey focusing solely on mid-to-late M dwarfs

Lepine & Shara (2005) Proper motions > 0.15 as/yr Estimated distances < 33pc Estimated radii < 0.33R

see Nutzman & Charbonneau (2009)





Searched for photometric rotation periods in all 1886 M dwarfs ever observed by MEarth-North

High-cadence (20-30 min) Long time-baseline (months to years)

Sensitive to periods from 0.1 to 140 days



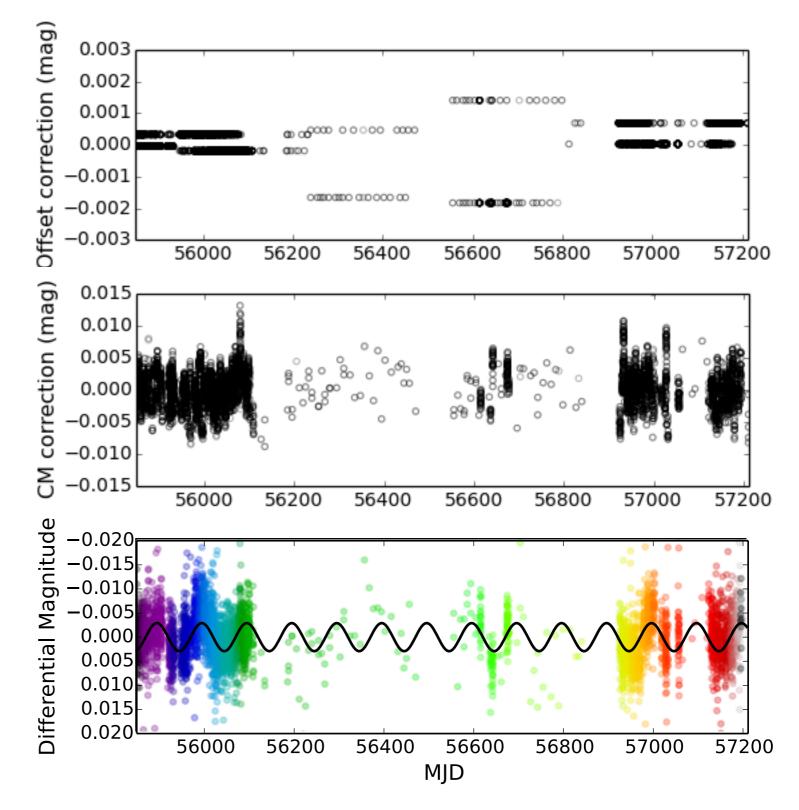
Simultaneously fit for systematics and stellar variability

Atmosphere

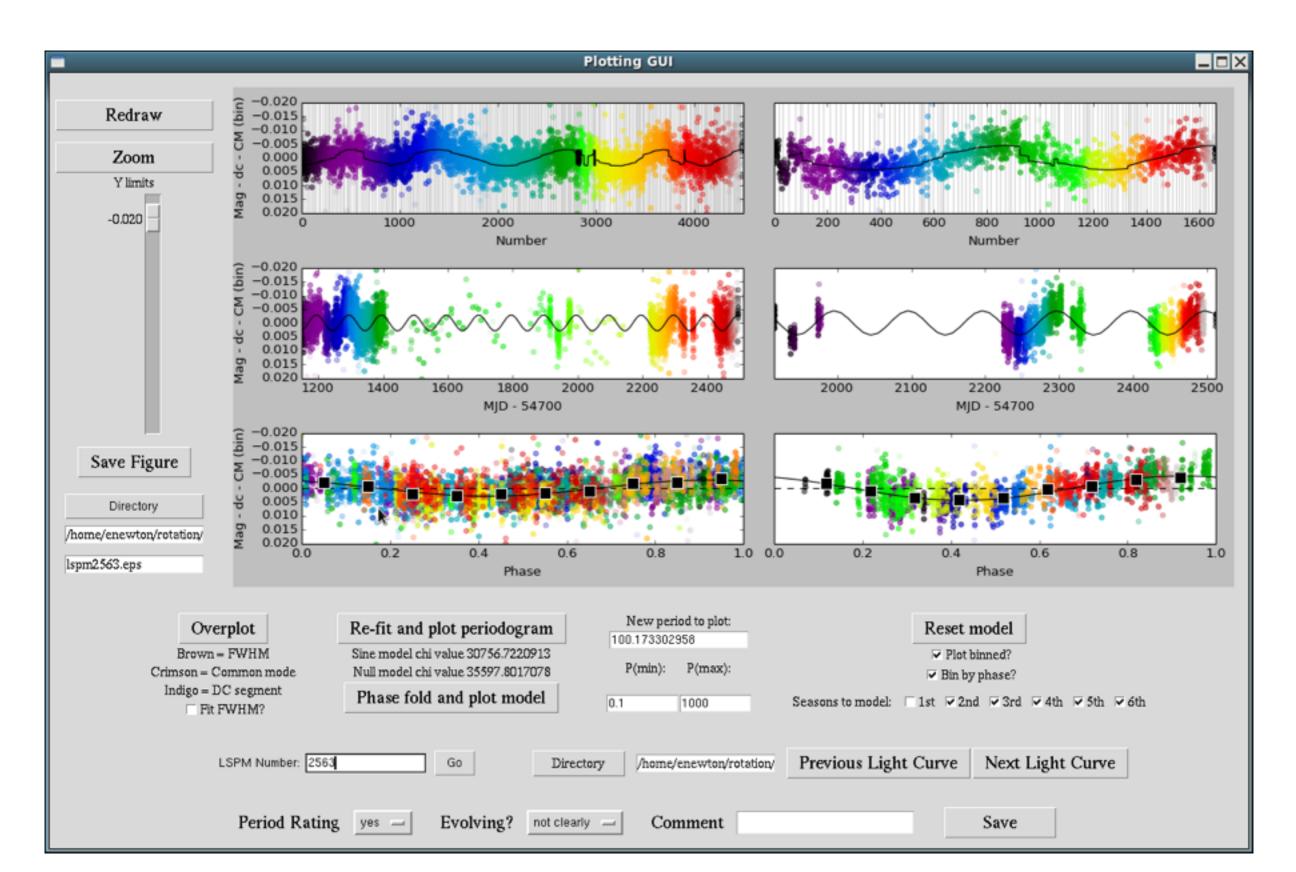
Instrumental

Astrophysical

following Irwin et al. (2006)

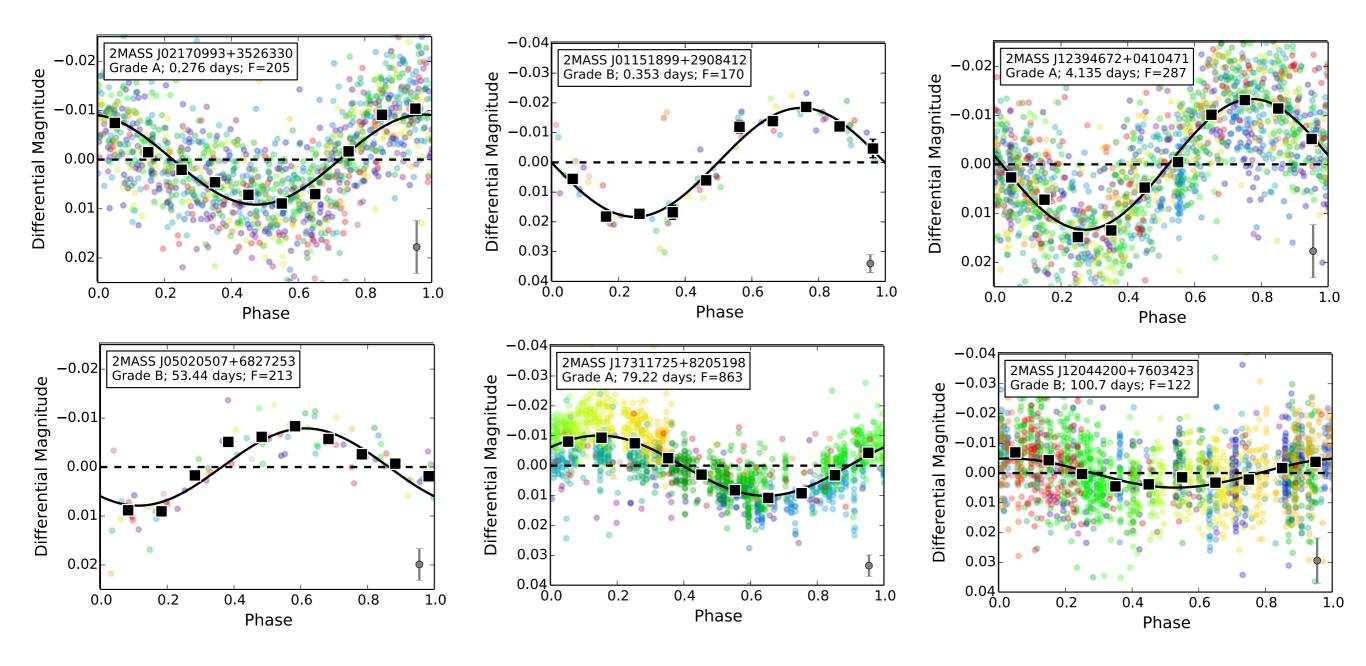


Examined each light curve by eye

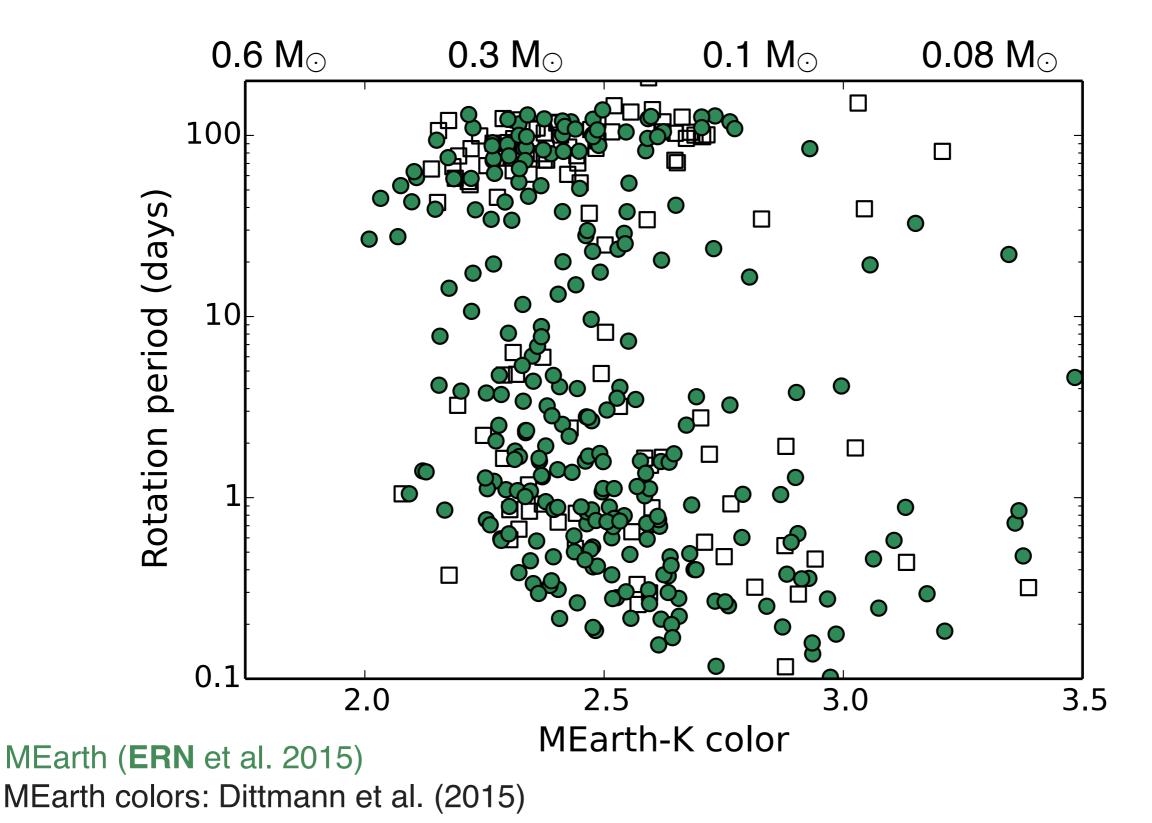


Developed a by-eye classification system for rotators and non-rotators

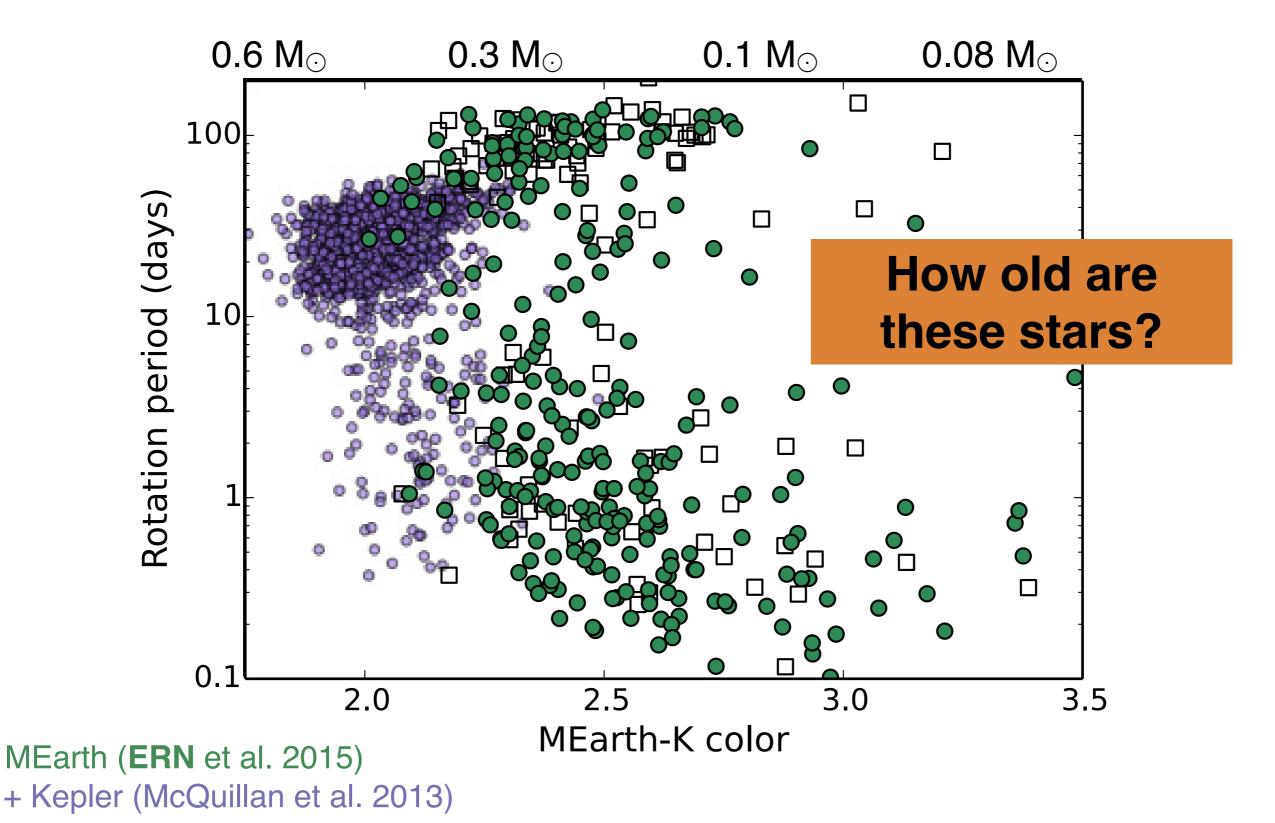
387 photometric rotation periods



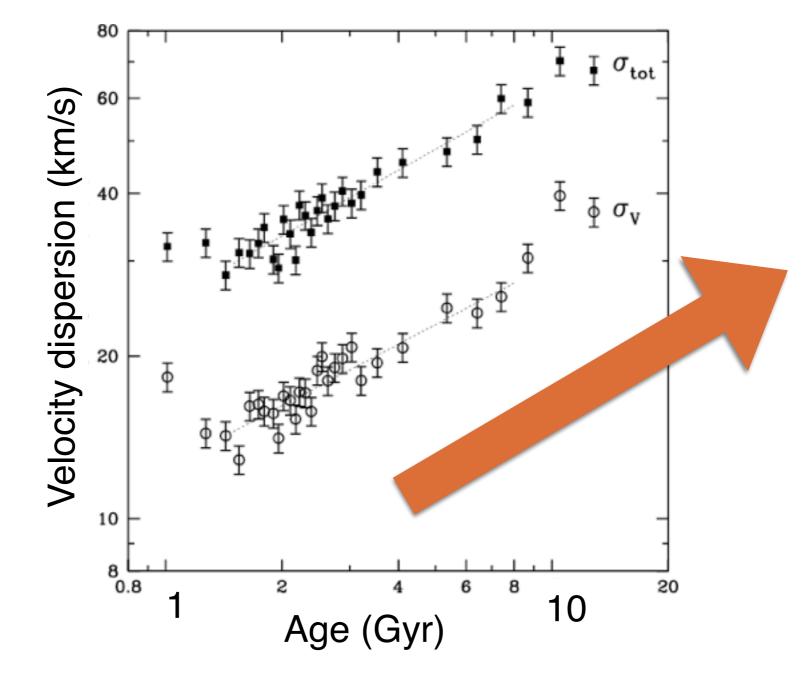
Mass-period relation



Mass-period relation

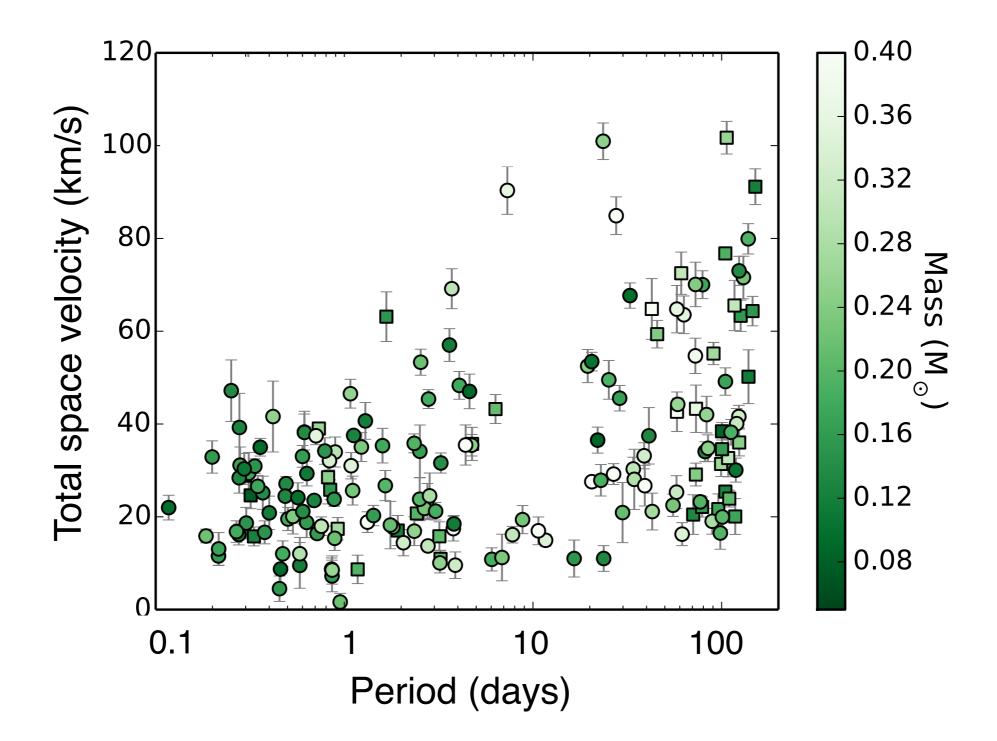


Galactic kinematics: The age-velocity relation

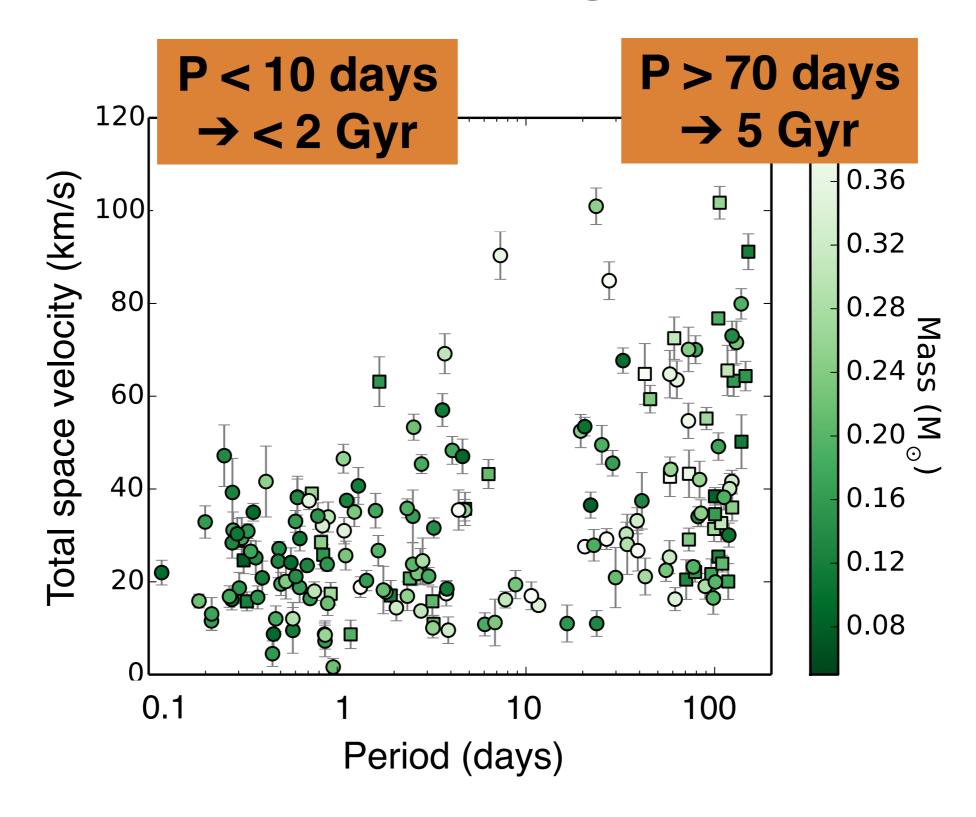


Holmberg et al. (2009)

The rotation-velocity relation



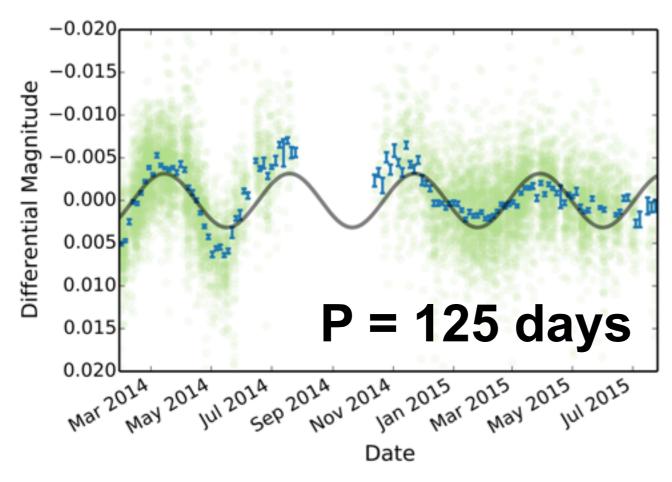
The rotation-age relation

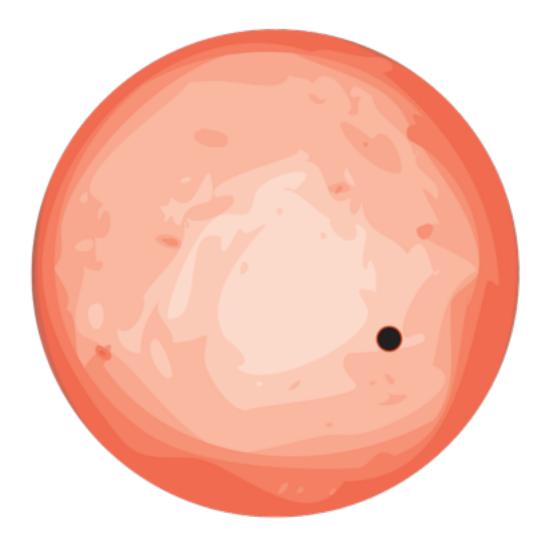


The implication for exoplanets

a rocky planet orbiting a nearby M dwarf







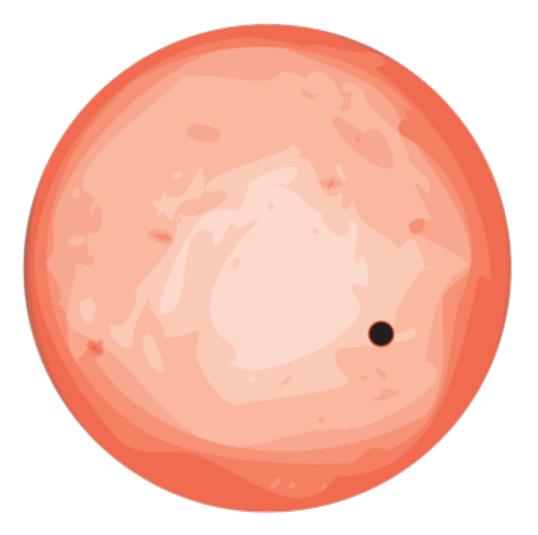
Berta-Thompson, Irwin, Charbonneau, **ERN** et al. (2015) *Nature* 527 204

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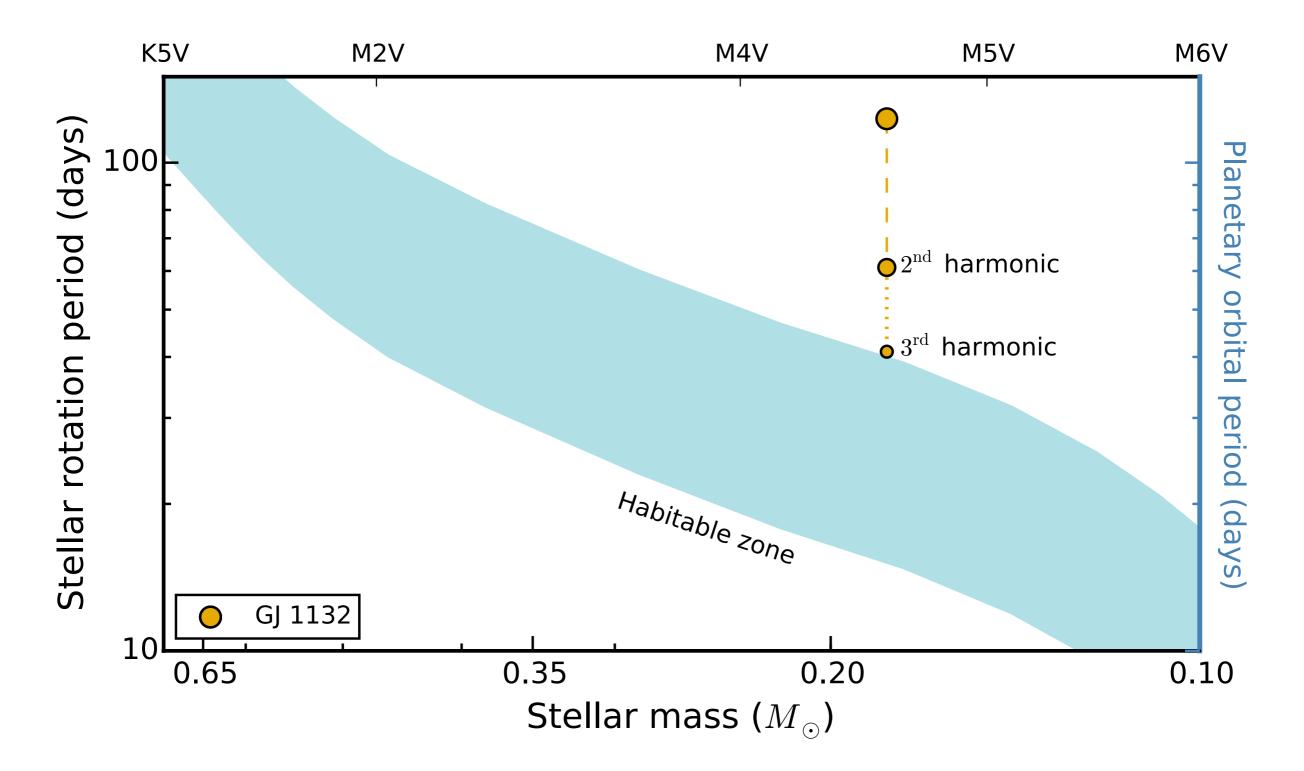
Excellent target for radial velocity surveys looking for habitable planets

GJ 1132



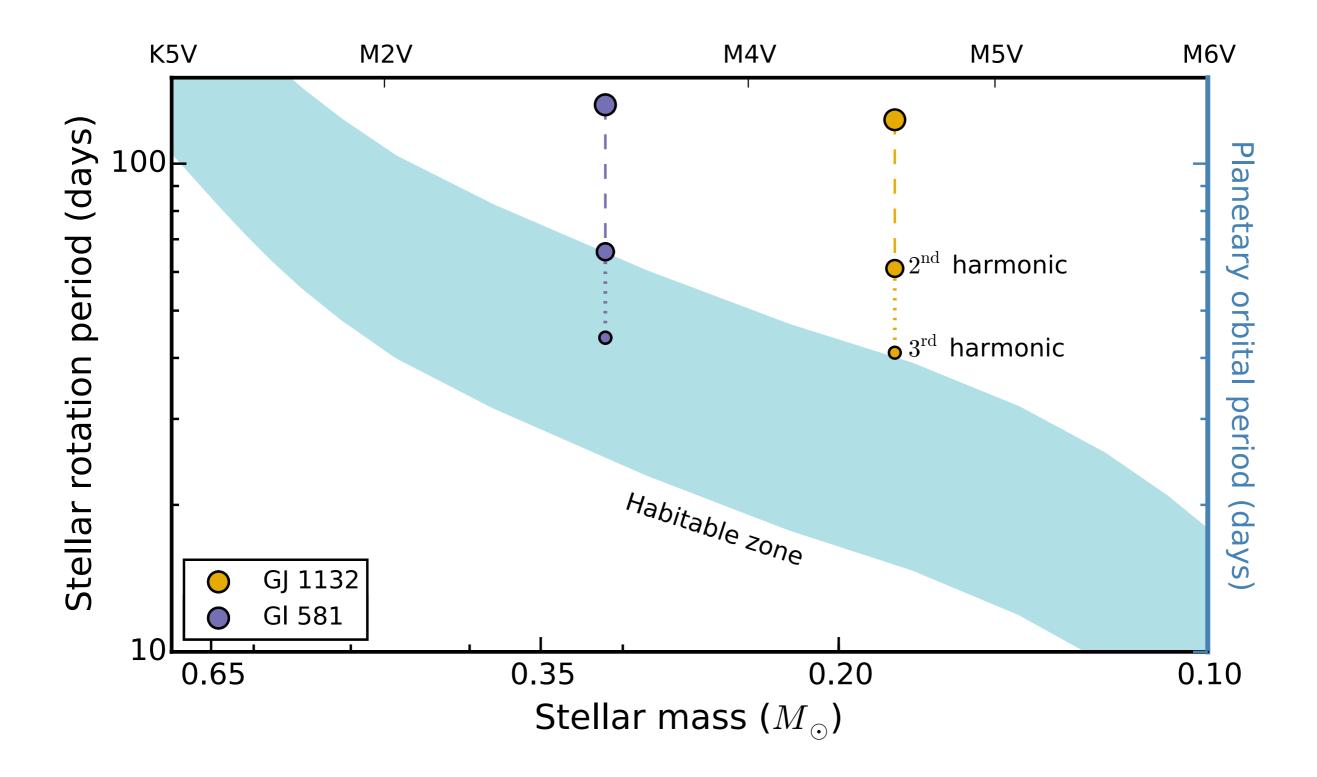
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Implications for RV Surveys

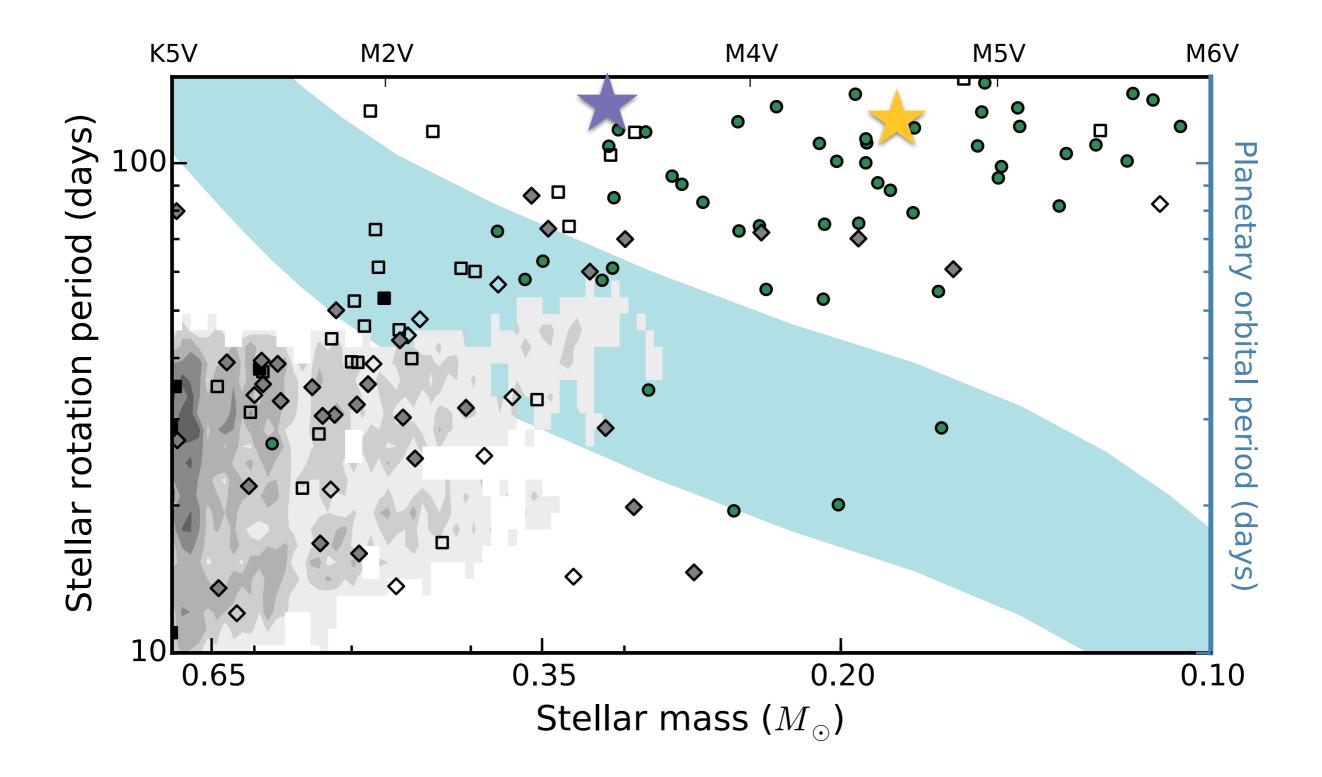


Habitable Zone, Kopparapu et al. (2013), moist to max greenhouse

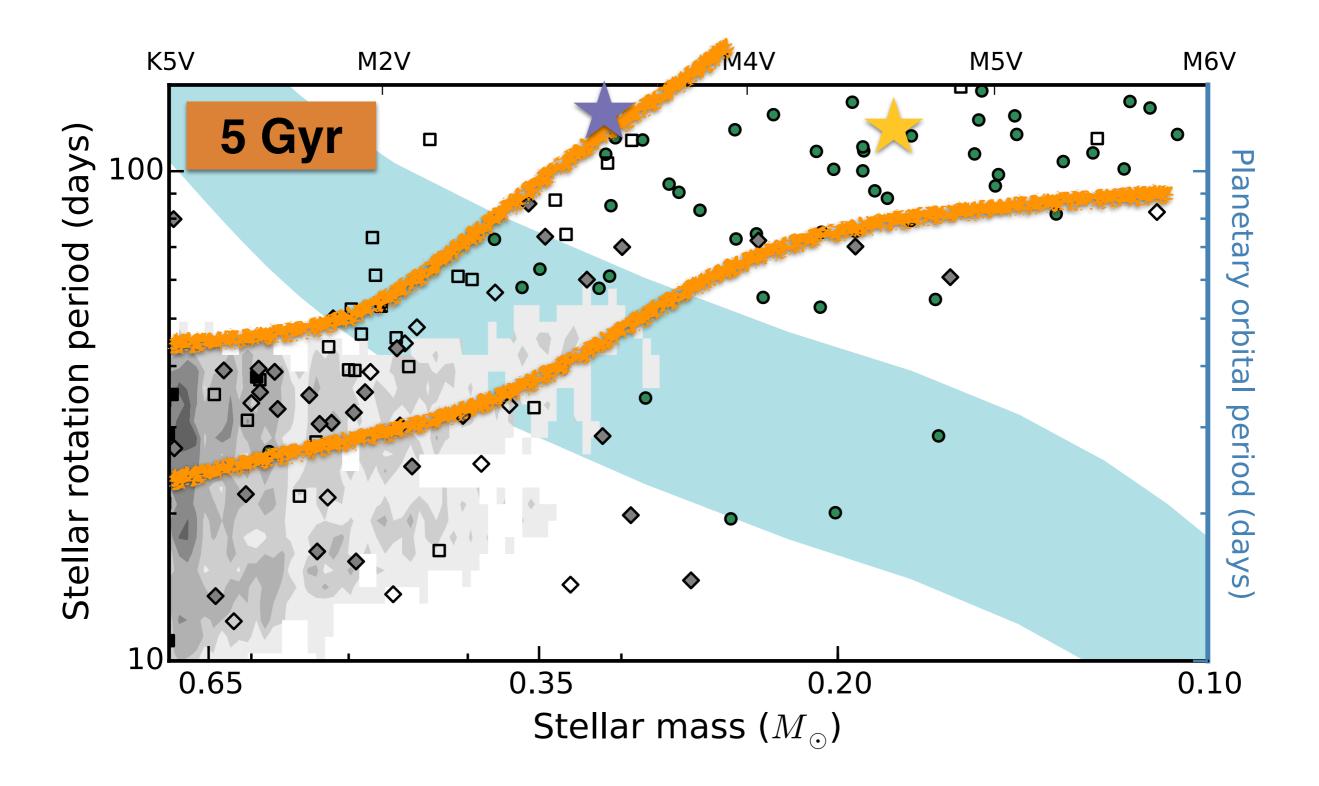
Implications for RV Surveys



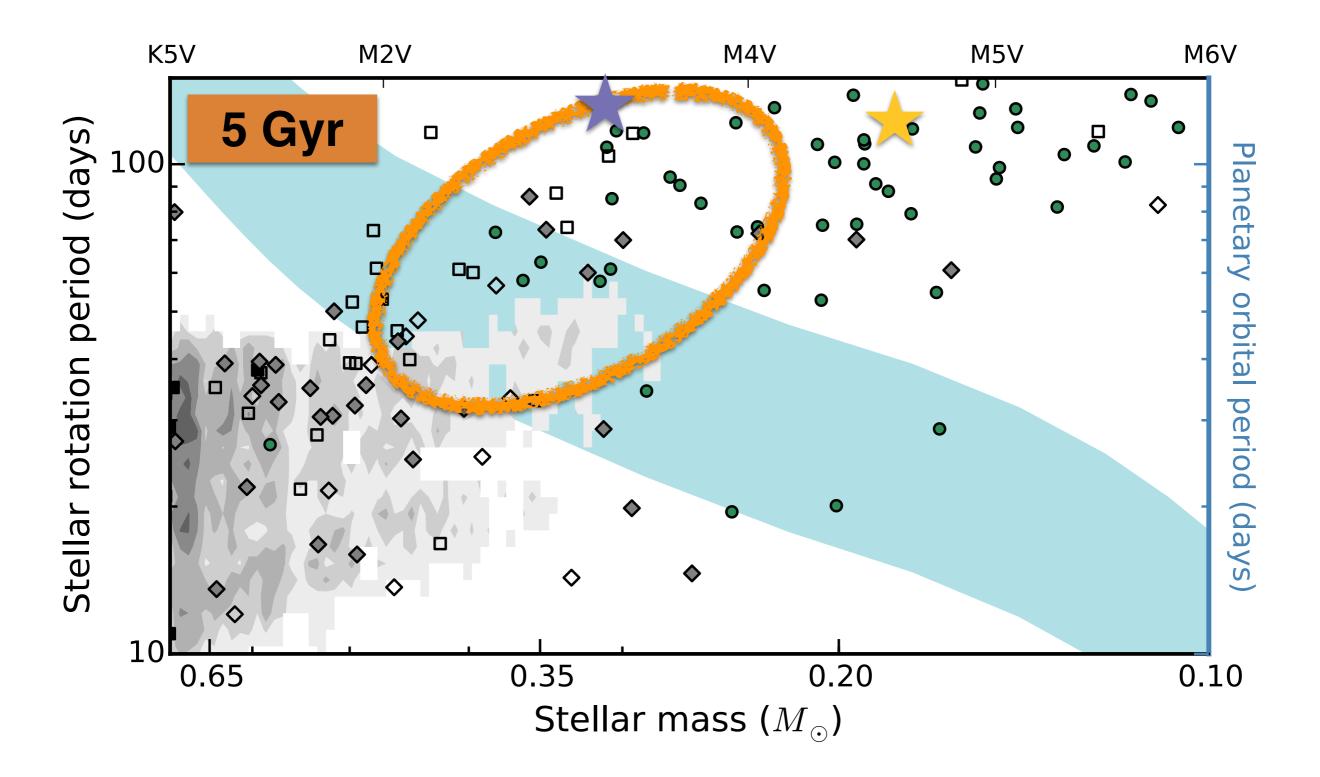
Implications for RV Surveys



Implications for RV Surveys



Implications for RV Surveys



Lessons from stellar rotation: The typical stellar rotation periods (or harmonics) of early M dwarfs coincide with

harmonics) of early M dwarfs coincide with the planetary habitable zone. On the other hand, mid M dwarfs have long rotation periods and close-in habitable zones, making them good targets for the discovery of habitable planets via radial velocities The nearby, Northern, mid M dwarfs

trigonometric parallaxes

Dittmann et al. (2014) ApJ 784 156

optical MEarth magnitudes

Dittmann et al. (2016) ApJ in press

radial velocities

Newton et al. (2014) AJ 147 20

stellar parameters from NIR spectra

Newton et al. (2015) ApJ 800 85

H-alpha activity measures

West et al. (2015) ApJ 812 3 & Newton et al. (in prep)

The rotation periods of nearby, low-mass stars

387 new rotation period measurements using photometry from MEarth

Long rotators have ages of about 5 Gyr using galactic kinematics

Mid-dMs are good targets for RV surveys considering stellar rotation & the planetary HZ

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ERN et al. (accepted to ApJ) arXiv: 1511.00957 & ERN et al. (submitted)

Acknowledgements

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Tools for NIR spectroscopy

github.com/ernewton/nirew github.com/ernewton/tellrv calculate equivalent widths estimate stellar properties measure radial velocities

MEarth data releases www.cfa.harvard.edu/MEarth/

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