Kinematics in the solar neighbourhood

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CARMENES input catalogue of M dwarfs

VII. Kinematics in the solar neighbourhood

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ABSTRACT

Aims. Our goal is to kinematically describe the M dwarfs of the CARMENES input catalogue and to identify young stars in the sample, which will help in the characterization of the targets of the exoplanet survey.
Methods. We compile spectral types, proper motions and distances for **2218** M dwarfs, and radial velocities for **2187** M dwarfs. We use the public code `SteParKin` to derive their Galactic space velocities, which served us to identify members in the different Galactic populations and young stellar kinematic groups. We complement these results with other available codes and an exhaustive analysis of M-dwarf rotation-activity relations (rotational periods and velocities, Hα, X-rays, and ultraviolet emission) for 2037 M dwarfs. We define five rotation-activity-spectral type relations that young (<600 Ma) sources satisfy.
Results. We associate 284 likely members in young stellar kinematic groups with rotation-activity features and provide xxx young candidates. Furthermore, we identify 180 very active M including four high velocity stars belonging to the old populations of the Galaxy. We conclude that combining kinematics and rotation-activity information is the most advantageous and confident way to properly identify young M dwarfs.

Key words. stars: kinematics and dynamics – stars: late-type – stars: low mass – Galaxy: solar neighborhood – Galaxy: clusters and associations: general

1. Introduction

Tables A1, A2, A3 need to be updated.

M dwarfs constitute over two-thirds of the main sequence population in the solar neighbourhood (Henry et al. 2006; Bochanski et al. 2010). Because of their abundance, they become excellent targets to broadly study the formation and evolution processes involving stellar objects at the bottom of the main-sequence in the Herzsprung-Russell diagram. In addition, M dwarfs are prime targets for planet hunting. Their low masses and small radii (between 0.6 and ~0.1 $M_\odot$, and 0.6 and ~0.1 $R_\odot$ during the main sequence (Reid et al. 1995; Schweitzer et al. 2019), present a huge advantage when detecting potentially habitable Earth-sized planets with the radial-velocity method (e.g., Mayor et al. 2009; Wright et al. 2016; Astudillo-Defru et al. 2017; Dreizler et al. 2020; Zechmeister et al. 2019). The characteristics of the host stars strongly determinates the habitability of the detected planets (Tarter et al. 2007).

In the M dwarf regime, early and mid M dwarfs present convective envelopes and radiative cores. For lower masses, the existence of a convective zone allows dynamo generation of magnetic flux. This magnetic field is observed through the emission of the Hα atomic line at 6562.8 Å coming from the stellar chromosphere (Hawley et al. 1996; West et al. 2004; Jeffers et al. 2018; Schöfer et al. 2019). It is also closely connected to the stellar corona, where the heated plasma is trapped producing radiation in the X-rays domain (Güdel 2004). There is also an intimate relation between chromosphetic and coronal activity with rotation (Noyes et al. 1984; Pizzolato et al. 2003), showing that rapid rotators present higher levels of magnetic activity (e.g., Stelzer et al. 2016). Additionally, a positive relation has been found between coronal and chromospherically active stars with ultraviolet (UV) emission (Walkowicz & Hawley 2009; Stelzer et al. 2013; Pineda et al. 2020).

The presence of surface magnetic fields yields the occurrence of flares in the stellar surface as a consequence of magnetic

- 2218 – SpT, α, δ, μ, d
- 2187 – RVs
- 1581 – RVs single

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- 2187 – RVs

- SteParKin (update of Montes et al. 2001): UVW
    - Stellar populations: H, TD, TD-D, D (YD)
    - SKGs

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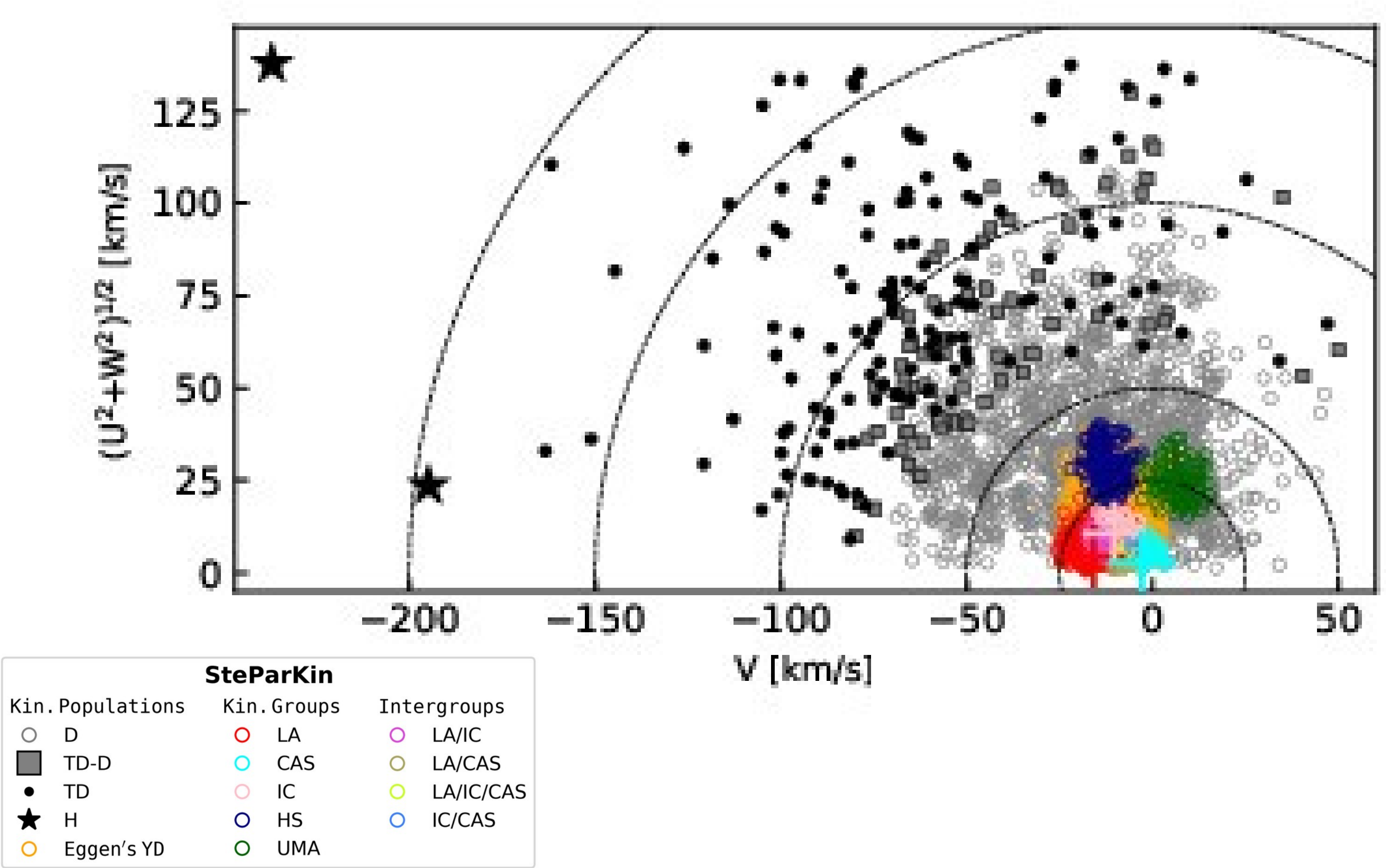

Stellar population (Acronym)	From 2187 Num.
Young disc (YD)	713
Thin disc (D)	1245
Thick-thin disc (TD-D)	78
Thick disc (TD)	149
Halo (H)	2

- SteParKin: UVW
  - Stellar populations: H, TD, TD-D, D
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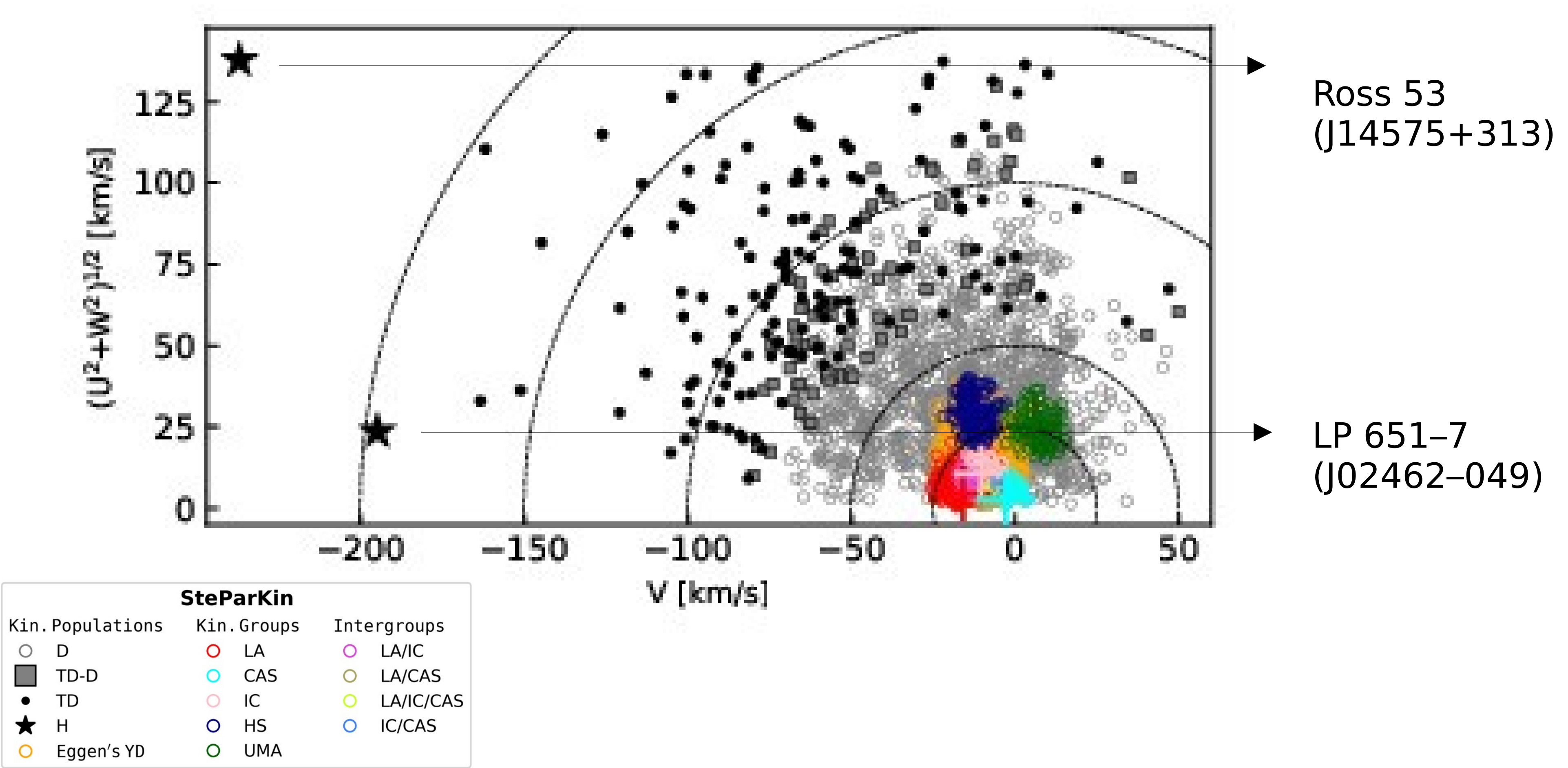

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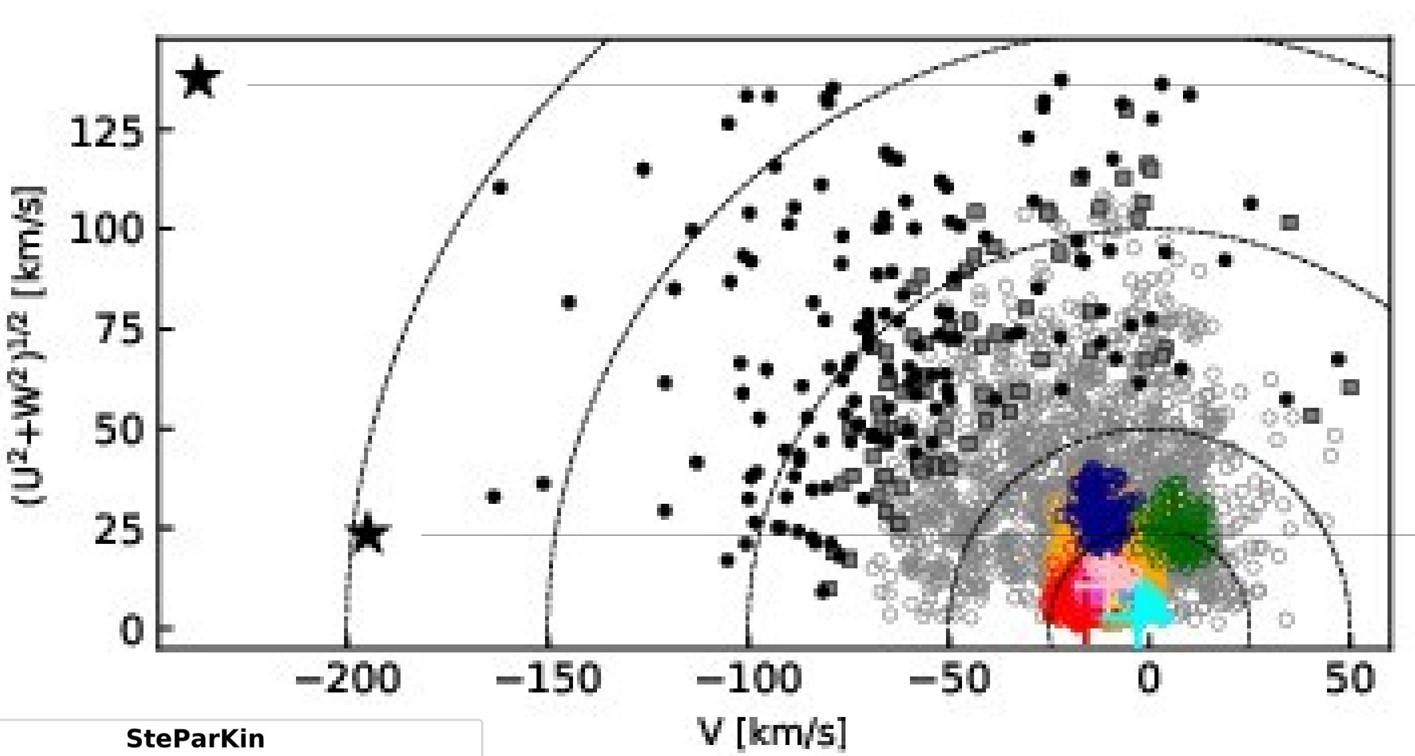
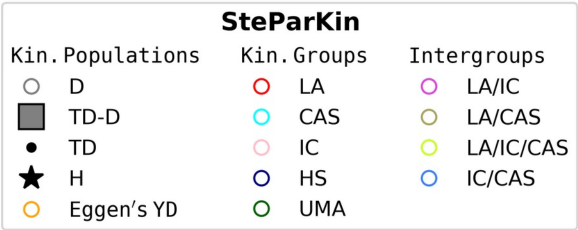


Ross 53
(J14575+313)
Metallicity: ~-0,4
Close binary

LP 651–7
(J02462–049)
Solar metallicity --
NOT/ALFOSC



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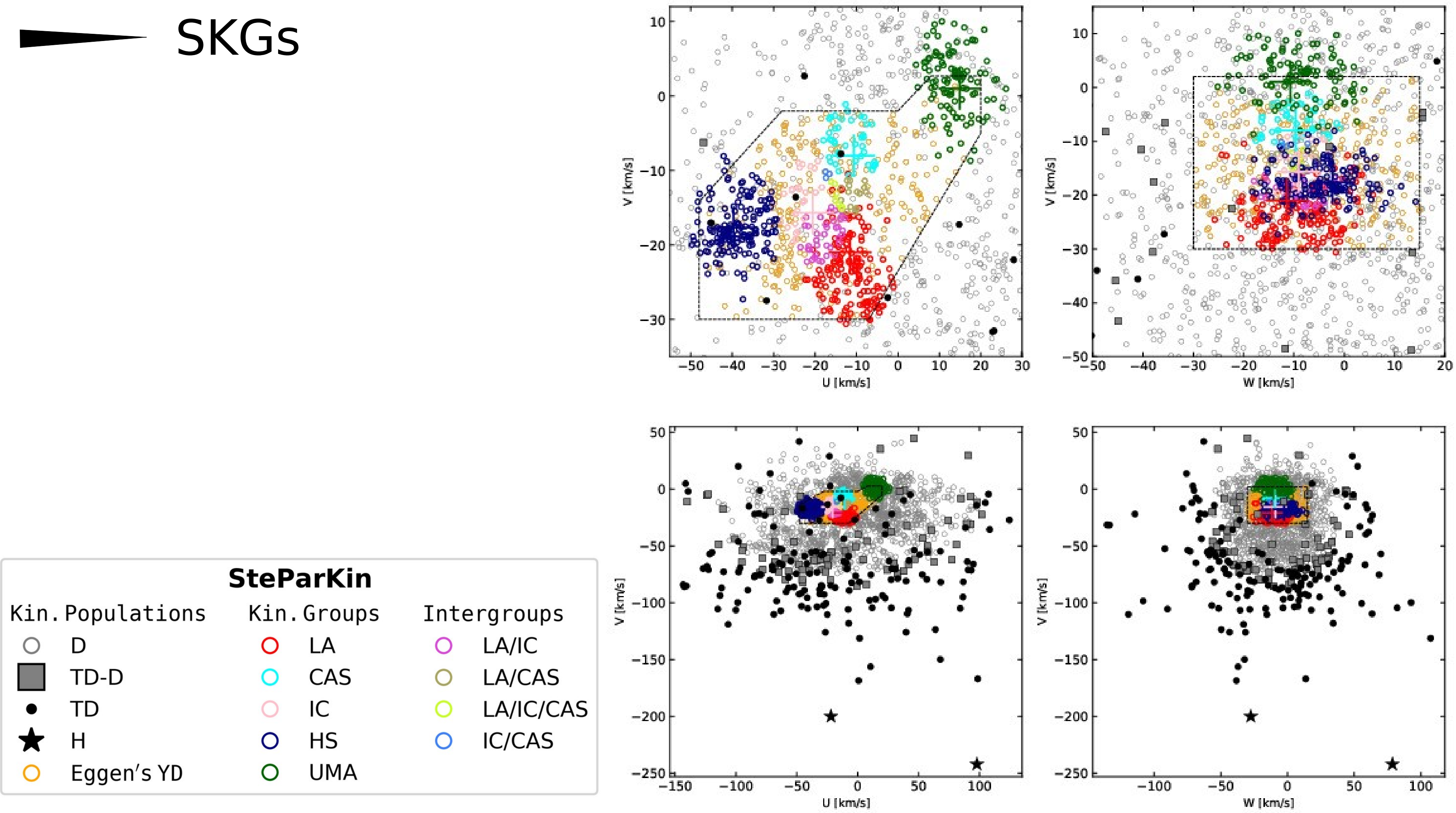


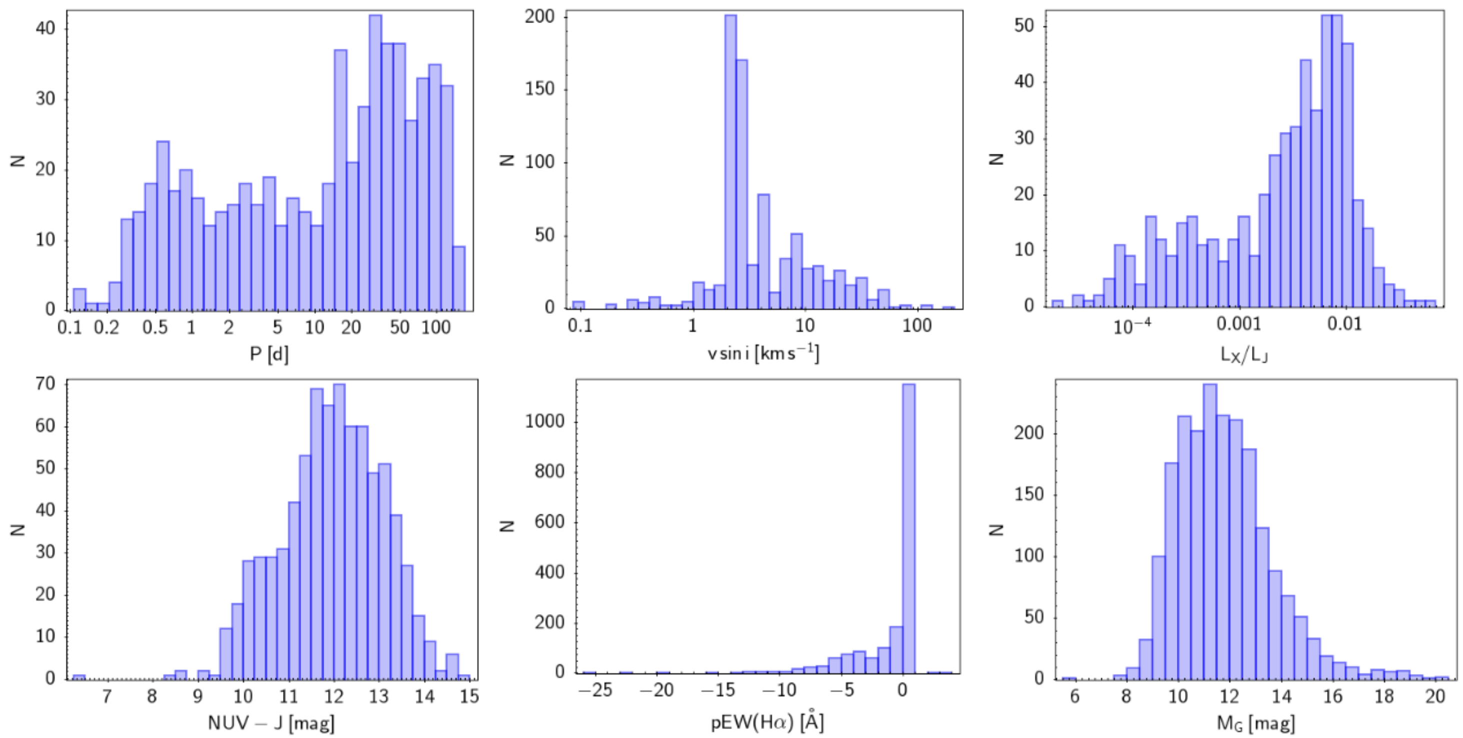
- SteParKin: UVW
  - Stellar populations: H, TD, TD-D, D
  - SKGs
- LACEwING (Riedel+, 2017) && BANYAN Σ (Gagne+, 2018)
  - SKGs

“Only” for 2037 stars with Gaia’s RVs*

SKG	SteParKin	LACEwING	BANYAN Σ
Tau	...	...	2
USco	...	...	1
Argus	...	14	16
IC 2391	25	...	...
Local Association	148	...	...
β Pic	...	13	21
Col	...	...	11
CarN	...	...	12
Tuc-Hor	...	1	...
AB Dor	...	26	27
UMa	101	5	1
Castor	39	...	...
Hyades	154	22	16
Total	467[b]	81	107

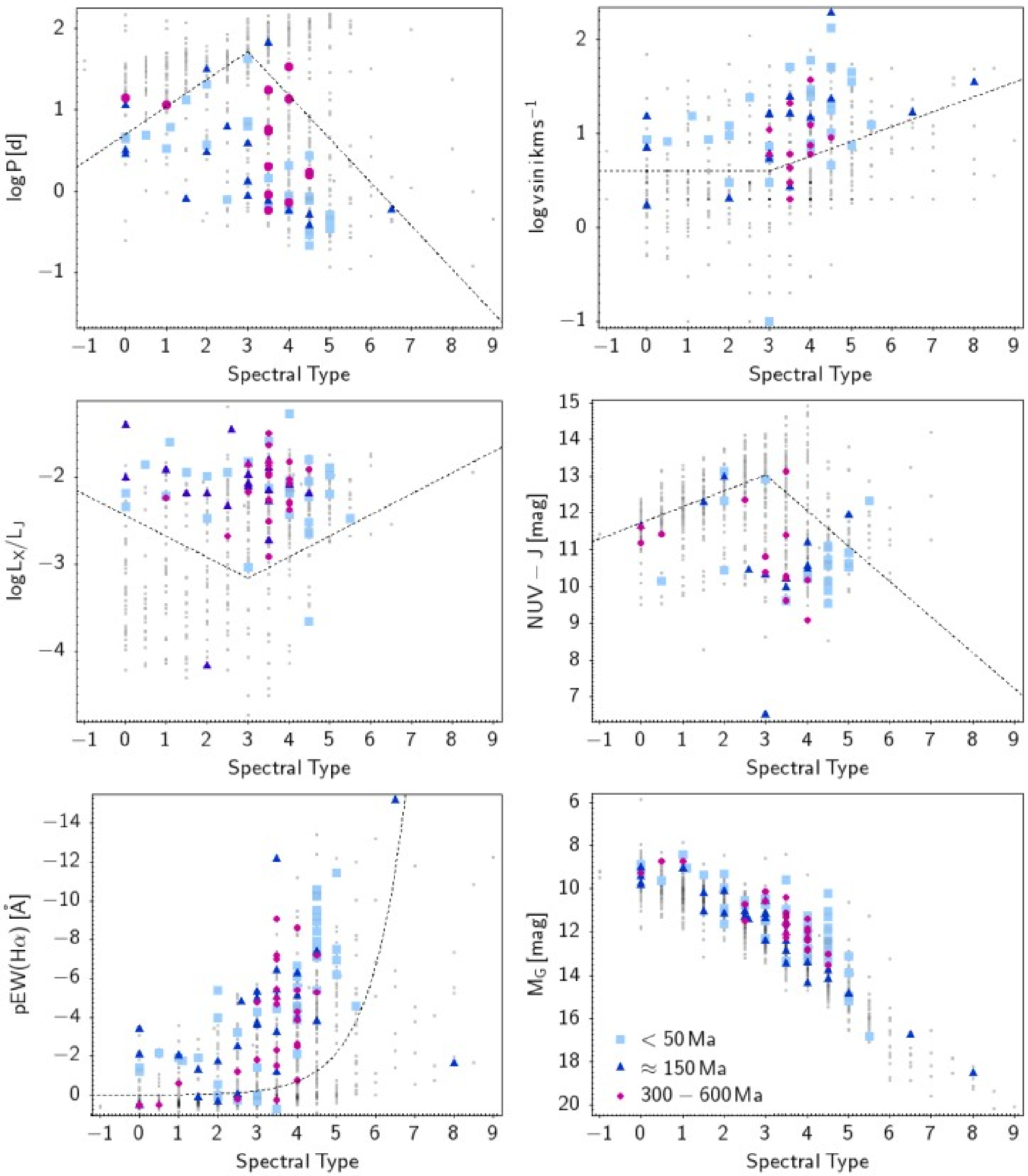
carmenes

- Activity & Rotation (1581 single):
  - P_{rot}, vsini, X rays (L_X/L_J), [NUV-J], pEW(Hα)



	Karmn+v_r	P	$v \sin i$	X-rays	$NUV - J$	pEW(Hα)
N_{total}	2037	637	820	563	772	1811

► Activity & Rotation & Kinematics (1581 single):



$$\log P \le 0.70 + 0.34\,\mathrm{SpT}, \quad \mathrm{SpT} \le \mathrm{M3}$$
$$\log P \le 3.331 - 0.537\,\mathrm{SpT}, \quad \mathrm{SpT} > \mathrm{M3}$$

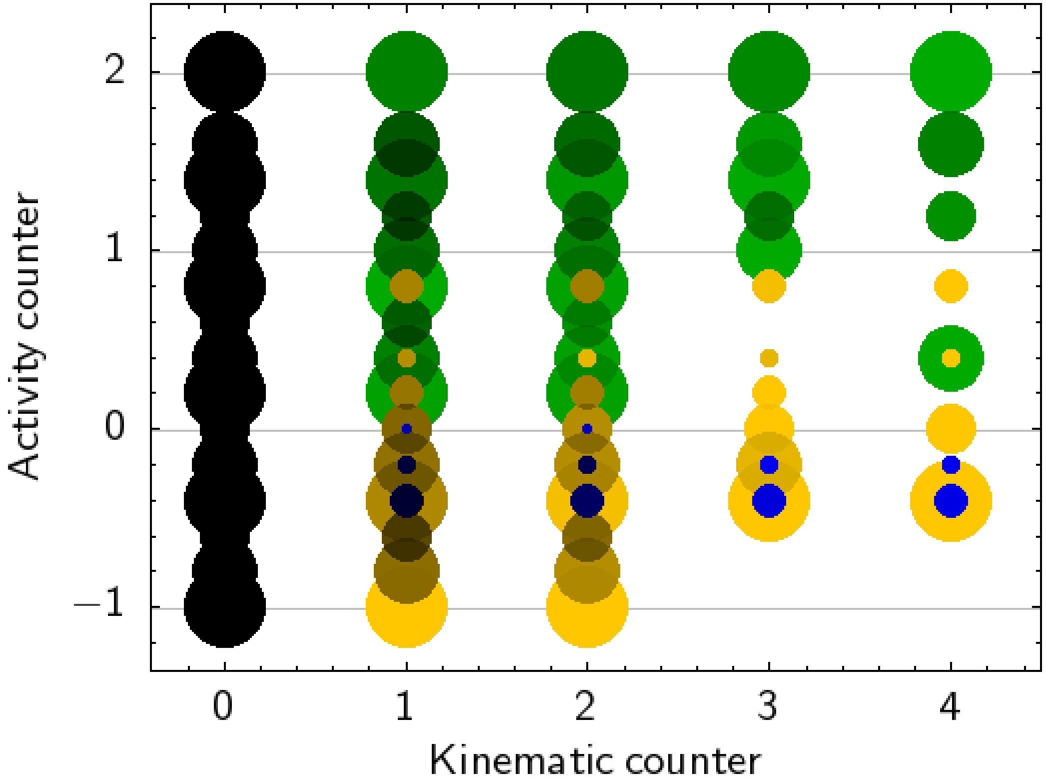
$$\log v \sin i > 0.602, \quad \mathrm{SpT} \le \mathrm{M3}$$
$$\log v \sin i \ge 0.131 + 0.157\,\mathrm{SpT}, \quad \mathrm{SpT} > \mathrm{M3}$$

$$\log L_X/L_J \ge -2.44 - 0.24\,\mathrm{SpT}, \quad \mathrm{SpT} \le \mathrm{M3}$$
$$\log L_X/L_J \ge 0.242\,\mathrm{SpT} - 3.886, \quad \mathrm{SpT} > \mathrm{M3}$$

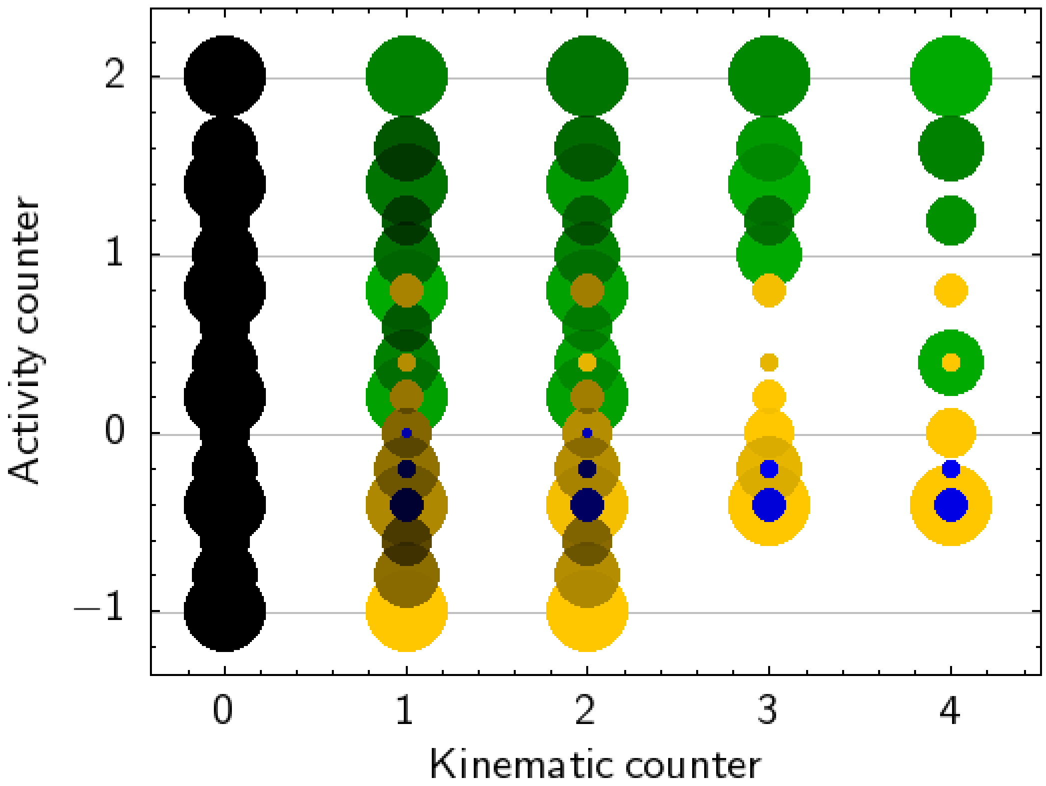
$$NUV - J \le 11.735 + 0.435\,\mathrm{SpT}, \quad \mathrm{SpT} \le \mathrm{M3}$$
$$NUV - J \le 15.95 - 0.97\,\mathrm{SpT}, \quad \mathrm{SpT} > \mathrm{M3}$$

$$\mathrm{pEW(H\alpha)} \le -0.008\exp(1.12\,\mathrm{SpT}), \quad \forall\, \mathrm{M}$$

► Activity & Rotation & Kinematics (1581 single):



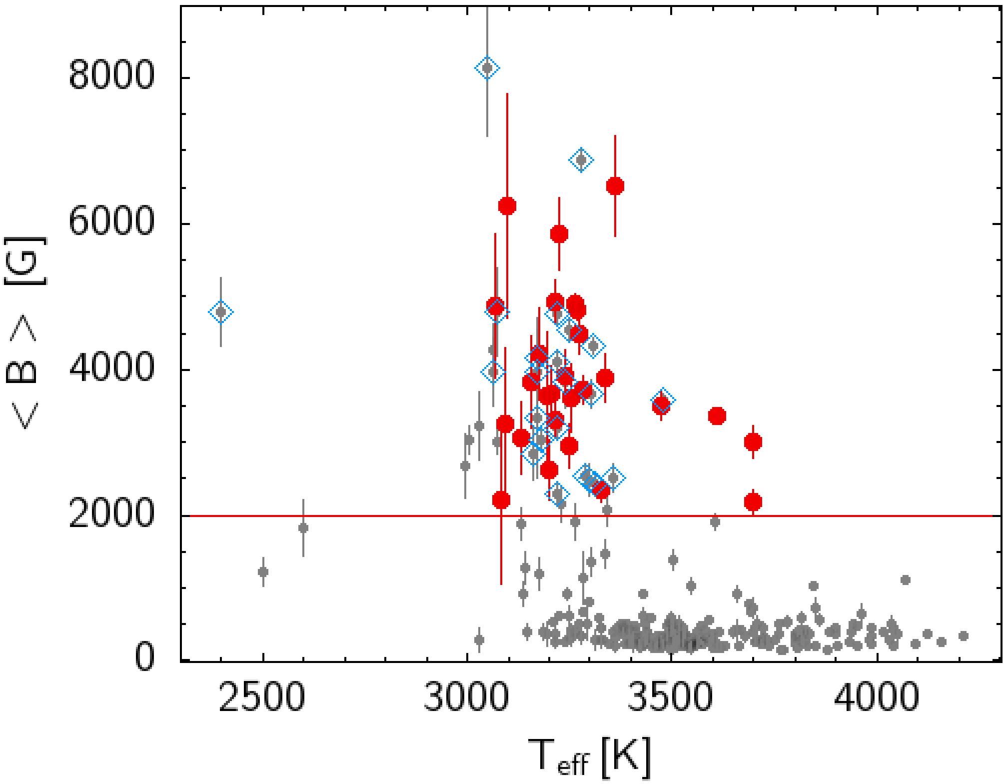
- Activity & Rotation & Kinematics (1581 single):



- 165 young
  179 dubious
  193 inconclusive
  995 field

- Very active stars:

27 + 23 with <B> > 2000 G



- The combination of kinematics **and** activity/rotation information provides a more reliable assessment for identiying young (<800 Ma) M dwarfs.

Thank you