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Probing activity and rotation of M dwarfs with X-rays and photometric timeseries

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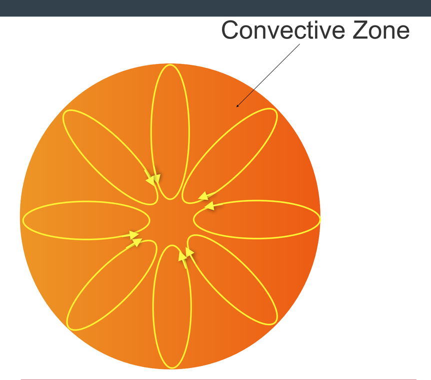


Fully Convective structure for SpT > M3.5

Which dynamo model for M Stars?

The stellar magnetic activity is not well understood for fully convective stars, because the well known solar dynamo model does not work for this stellar structure. M dwarfs with spectral type lather than M3.5 are fully convective. We investigate the activity-rotation relation for the Lepine & Gaidos (2011) SUPERBLINK proper motion catalog, that includes 8889 M dwarfs with J < 10 mag, V - J $\geq$ 2.7 mag, and spectral types from K7 to M7. One of our aims is to constrain the switch point from solar-like to fully convective stars, where activity is expected to change.

The Activity-Rotation Relation

We perform comprehensive studies of the rotation-activity relation of M dwarfs analyzing the X-ray emission from XMM-Newton, Chandra and eROSITA and rotation periods from K2 and TESS. These new observations are complemented by a compilation from the literature, forming the largest and uniform data base for M dwarfs existing so far about the study of the activity-rotation relation. The regime with $P_{rot} \leq 10$ d is saturated, i.e. all stars are expected to exhibit the same follow the same mean activity level. However, we found a slight decrease of X-ray activity towards higher P_{rot} in the saturated regime (Magaudda et al. 2020; see al Reiners et al. 2014).

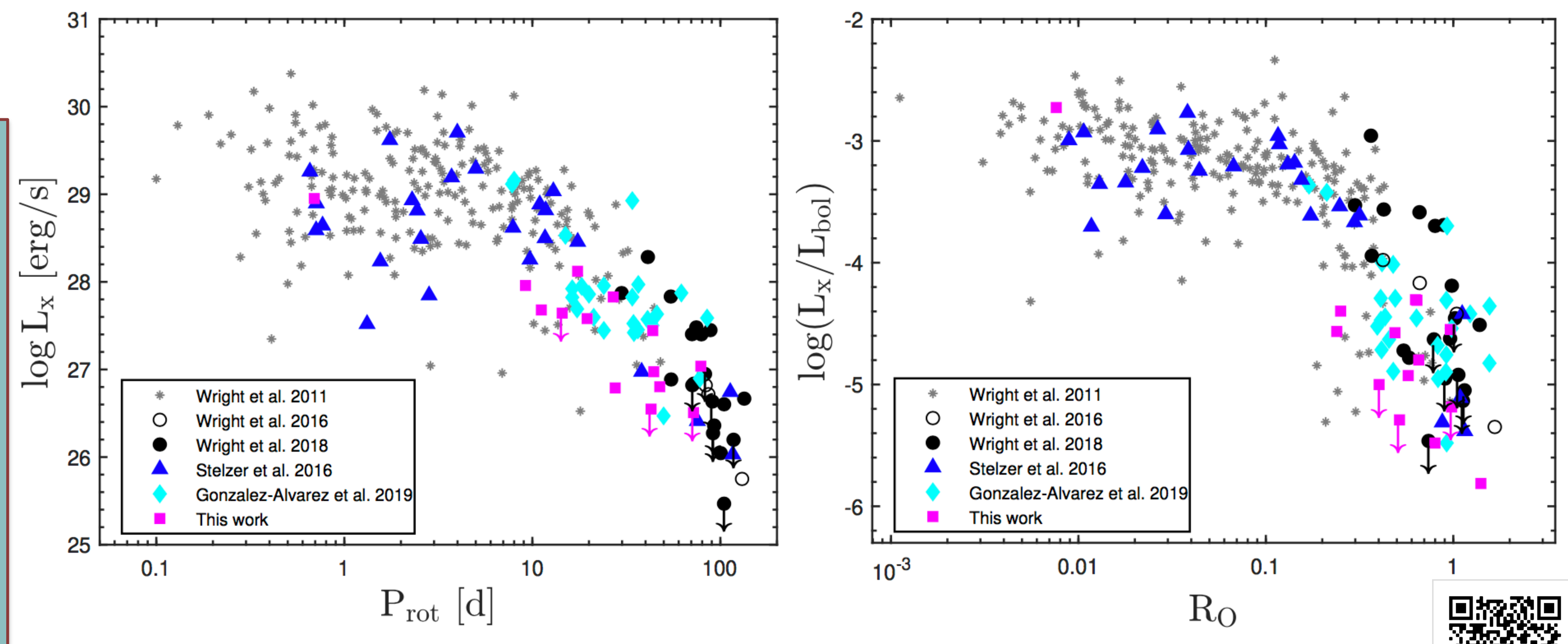


Fig. 1: The activity-rotation relation of M dwarfs combining the re-analyzed literature data with new XMM-Newton and Chandra X-ray data and K2 light curves. Left: X-ray luminosity vs rotation period. Right: Fractional X-ray luminosity vs Rossby number.

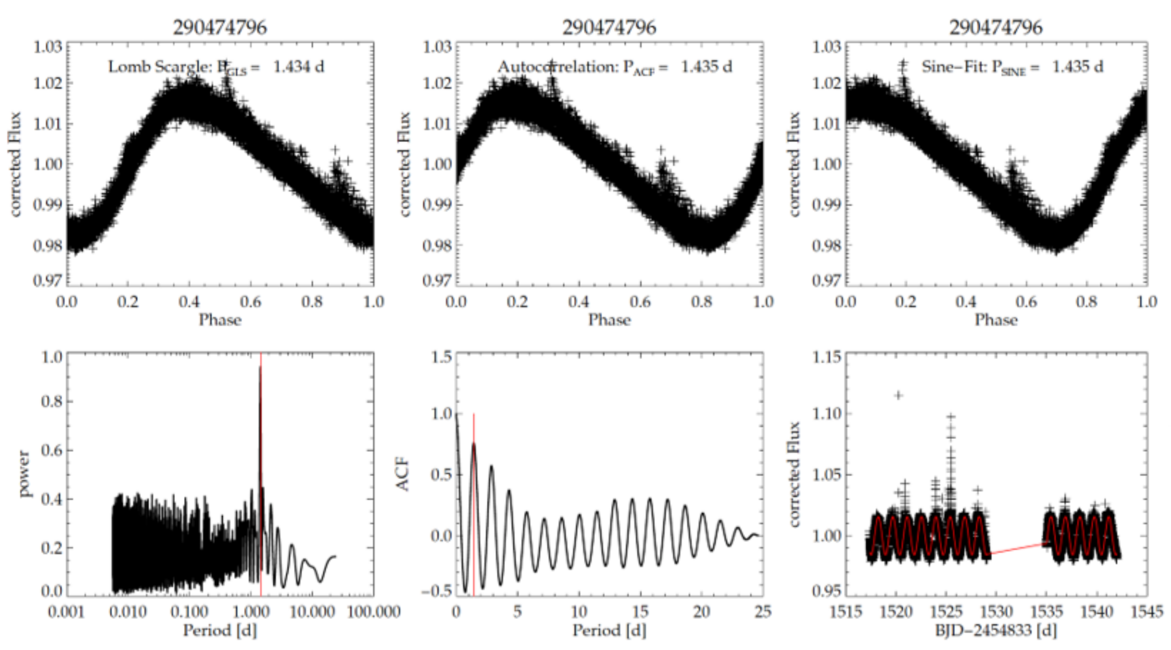
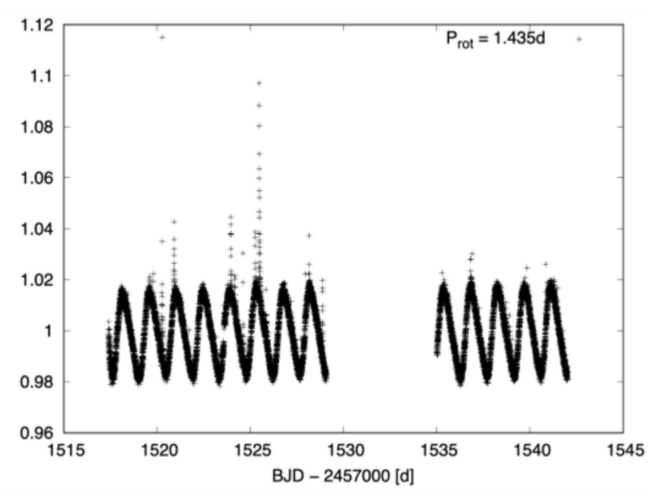


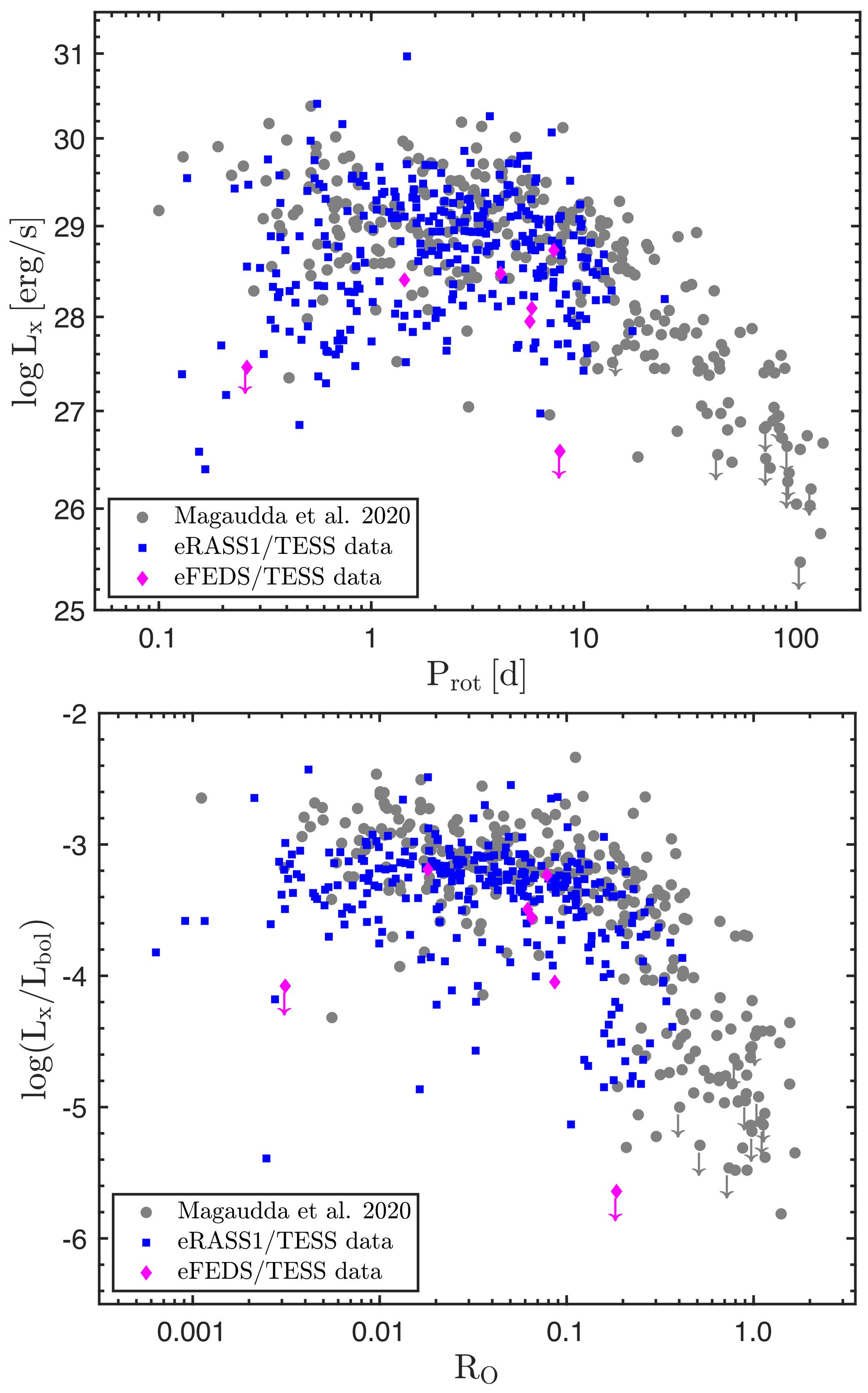
Fig.2: Determination of rotation periods by applying three different methods to the TESS light curves. More info in Raetz et al. 2020, A&A, 637, A22

Fig.3: An example of TESS light curve, showing the rotation modulation together with optical flares.



TESS Light Curve Analysis

We determine reliable rotation periods by applying three different methods to TESS light curves: the Lomb-Scargle periodogram, the aucorrelation function and the sine fit procedure (Raetz et al. 2020). The final P_{rot} is the mean result of the three methods (Raetz et al. 2020). An example is shown in Fig. 2.
In Fig. 3 an example of TESS light curve is shown. For the analysis of the rotational signal the flares were removed.



New Data from eROSITA & TESS

Including eROSITA and TESS data doubled the amount of stars in the "saturated regime" (see Fig. 4 left), allowing a more detailed study for fast rotating M dwarfs.
In particular, analyzing the saturated level for spectral sub-classes allows to study how the X-ray activity changes in saturation (Fig. 4 right). It is clear that for less massive stars the L_x–level is lower and the turnover P_{rot}–point to the uncorrelated regime is higher for fully convective stars.

- Detailed comparison between Rosat-eROSITA results
- Comparison between eROSITA X-ray and TESS optical activity

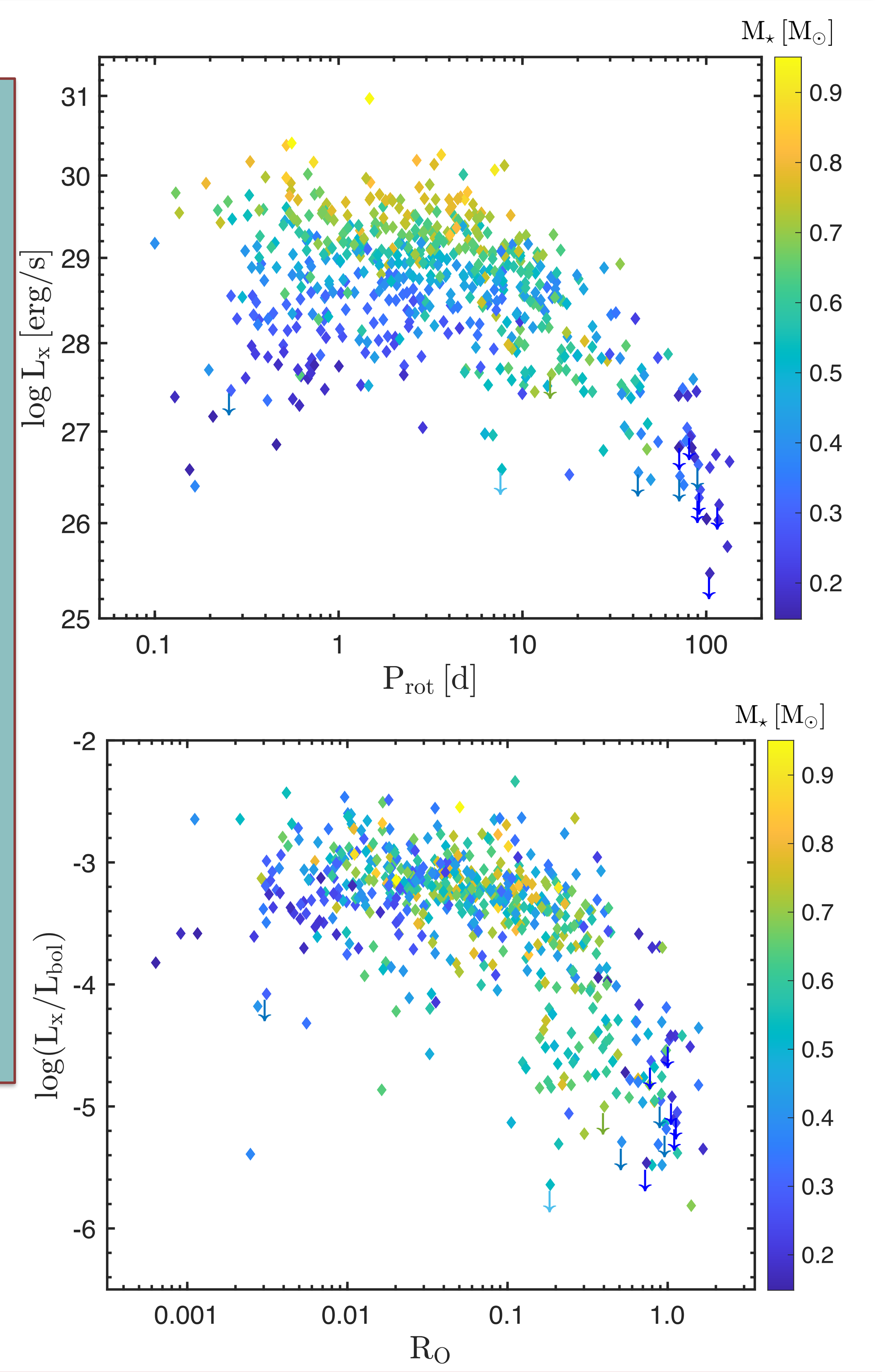


Fig.4: New data from eROSITA and TESS included in the activity-rotation study. Left: distinction of the three samples investigated in this work. Right: mass-dependence of the activity-rotation relation.

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