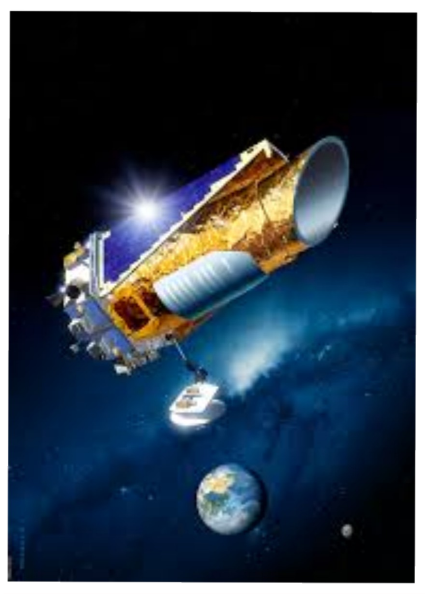

Activity and rotation of the X-ray emitting *Kepler* stars

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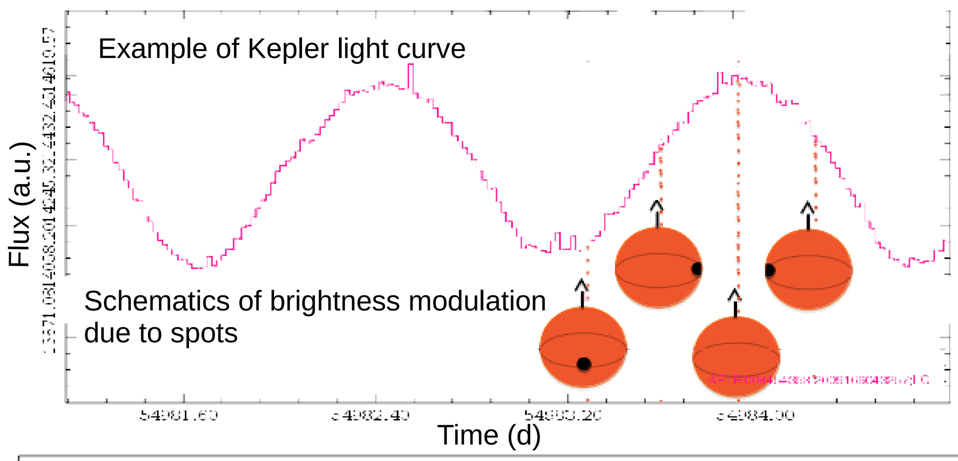
ABSTRACT

The relation between magnetic activity and rotation in late-type stars provides fundamental information on stellar dynamos and spin evolution. Previous studies suffer from bias (spectroscopic rotation periods) and inhomogeneity (different instruments/techniques). **We characterize the activity/rotation relation of the X-ray emitting main-sequence late-type stars observed by XMM-Newton and Kepler**. We measure photometric rotation periods from the high-precision Kepler light curves. As activity indicators, we adopt the X-ray luminosity from XMM-Newton, the number/frequency of white-light and X-ray flares (from the light curves produced in the EXTraS Project [1]).

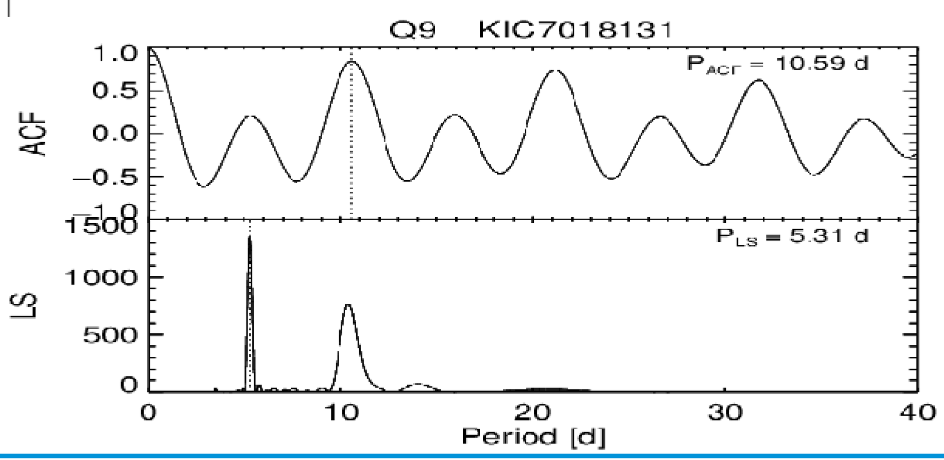
This is the first analysis of the activity/relation link across the whole late-type spectral range performed using homogeneous photometric rotation periods from high precision Kepler light curves and homogeneous X -ray data. Our results reinforce the current picture of the rotation/activity relation and give important insights into the relation between X-ray activity and rotation and between X-ray and white-light flaring activity.

KEPLER

High photometric precision optical light curves
High sampling rate (29.4 min)
Large sample of stars (~170,000)
Kepler Input Catalogue: collection of photometry



Auto-correlation function and Lomb-Scargle periodogram for the Kepler light curve plotted above



SCIENTIFIC RATIONALE

ANALYSIS OF THE **ACTIVITY/ROTATION** RELATION IN
LATE-TYPE MAIN-SEQUENCE STARS
PHOTOMETRIC ROTATION PERIODS FROM KEPLER
MAIN ACTIVITY INDICATORS:
- X-RAYS FROM **3XMM-DR5** CATALOGUE;
- WHITE-LIGHT AND X-RAY **FLARING**

-> HOMOGENEITY IN ROTATION PERIOD & ACTIVITY MEASURE

DATA ANALYSIS

Sample: 107 late-type main-sequence stars detected in 3XMM-DR5 and with light curve in Kepler database

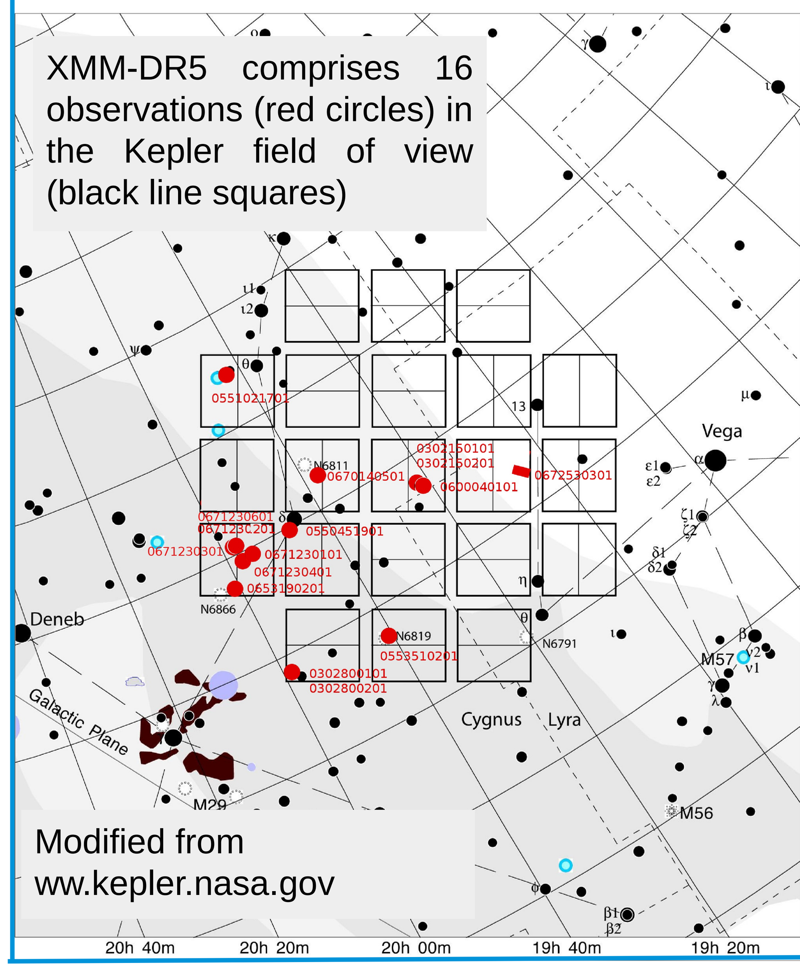
Kepler light curves: brightness modulation due to spots on the rotating stellar surface. Automated algorithm based on Autocorrelation function (ACF) & Lomb-Scargle Periodogram;

Rotation period, Rossby number, white-light flares

X-ray activity: X-ray luminosity from 3XMM-DR5 count rate 0.2-2.0 keV; thermal model kT=0.82 keV (from spectral fit of brightest sources).Search for flares in EXTraS[1] light curves

XMM-NEWTON

3XMM-DR5 catalogue [2]: largest X-ray source catalogue (~390,000)
16 XMM-Newton observations in the Kepler field of view.

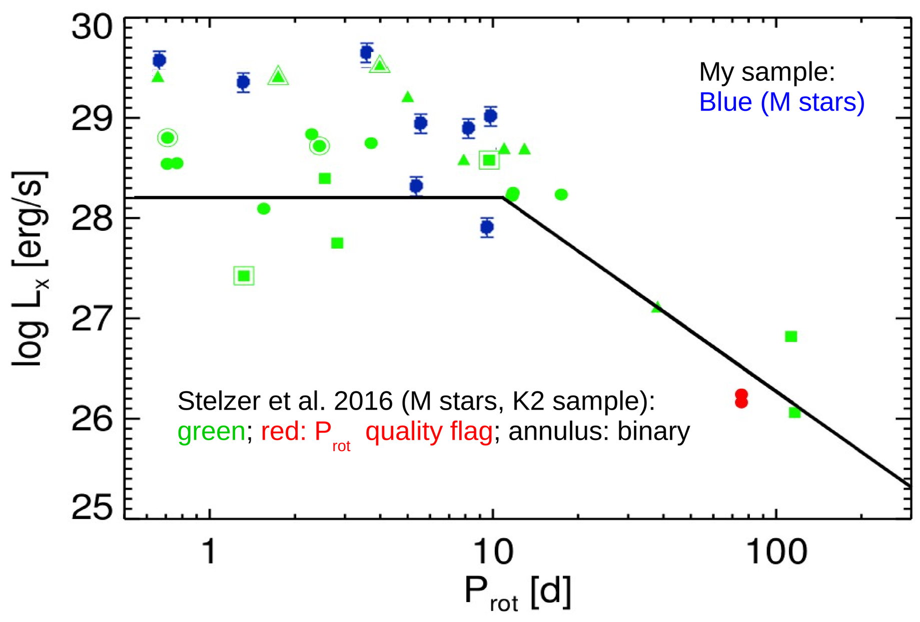


RESULTS

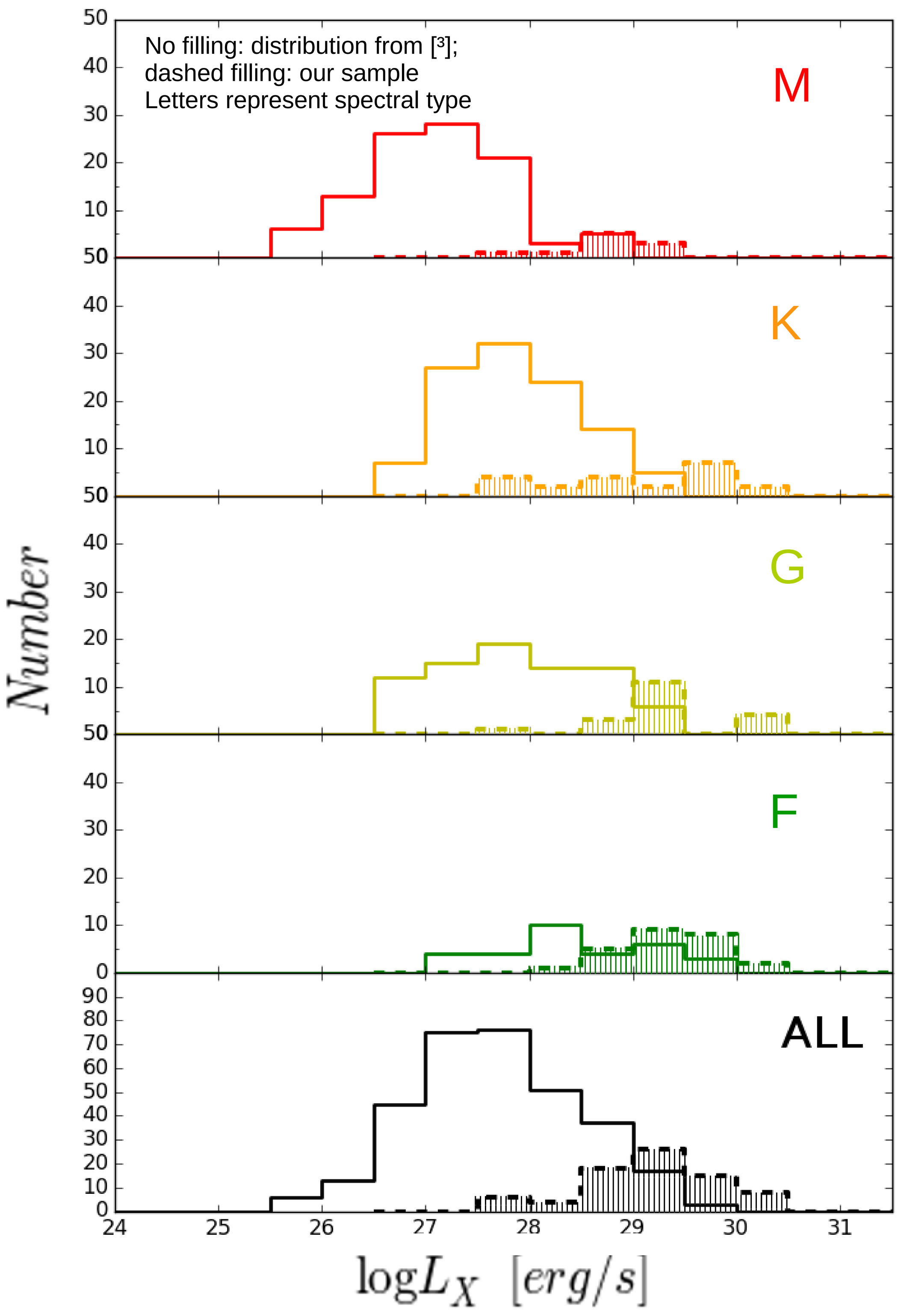
First characterization of the activity/rotation link on the whole late-type main-sequence spectral range with rotation periods measured from high-precision Kepler light curves and homogeneous measure of activity from XMM-Newton data and Kepler light curves.

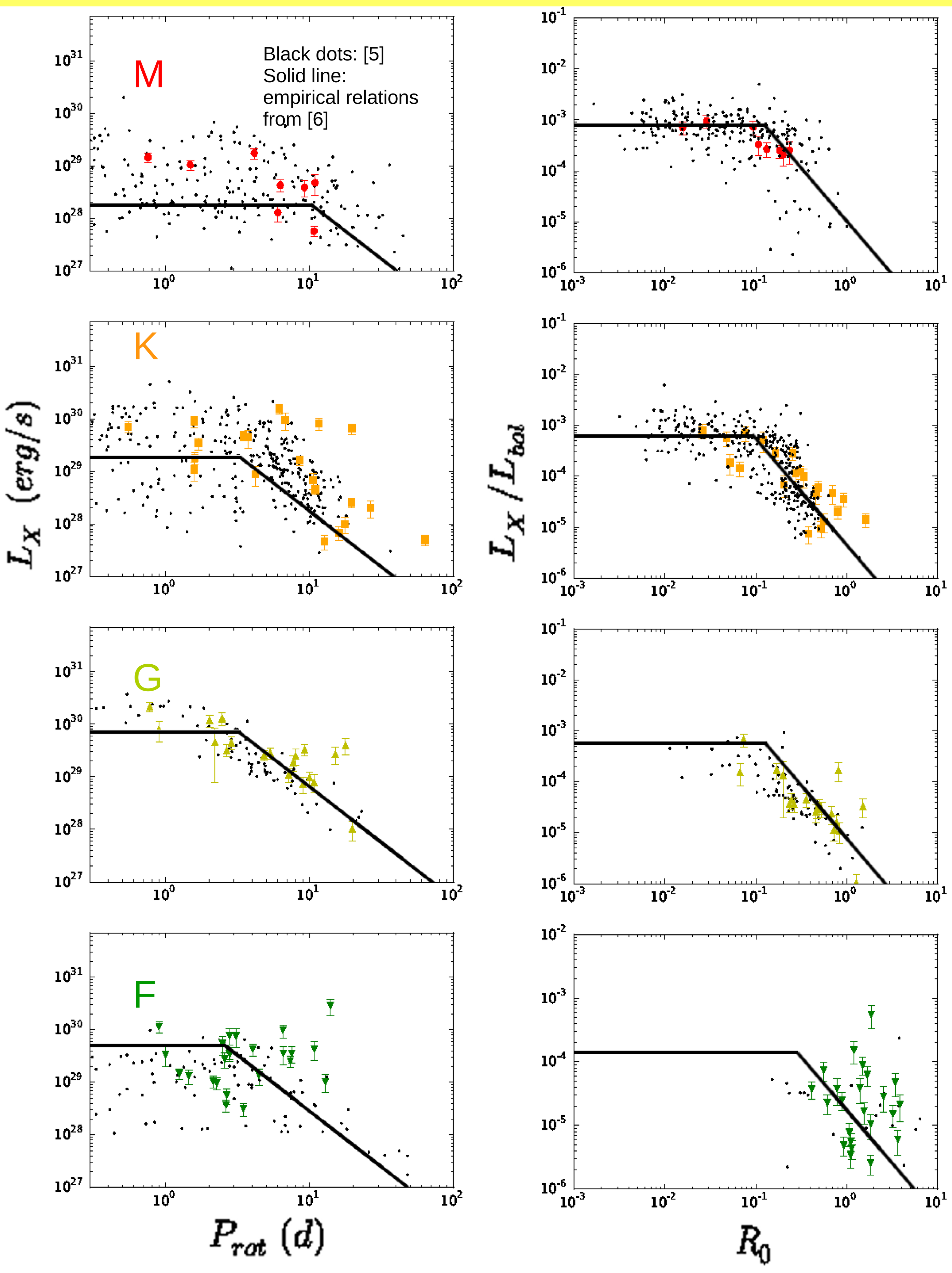
Rotation periods: 76 stars (72%) present rotational variability -> rotation period in the range ~0.3-70 d. Very high fraction of rotators, due to selection bias towards very active stars. Twenty-nine new rotators.

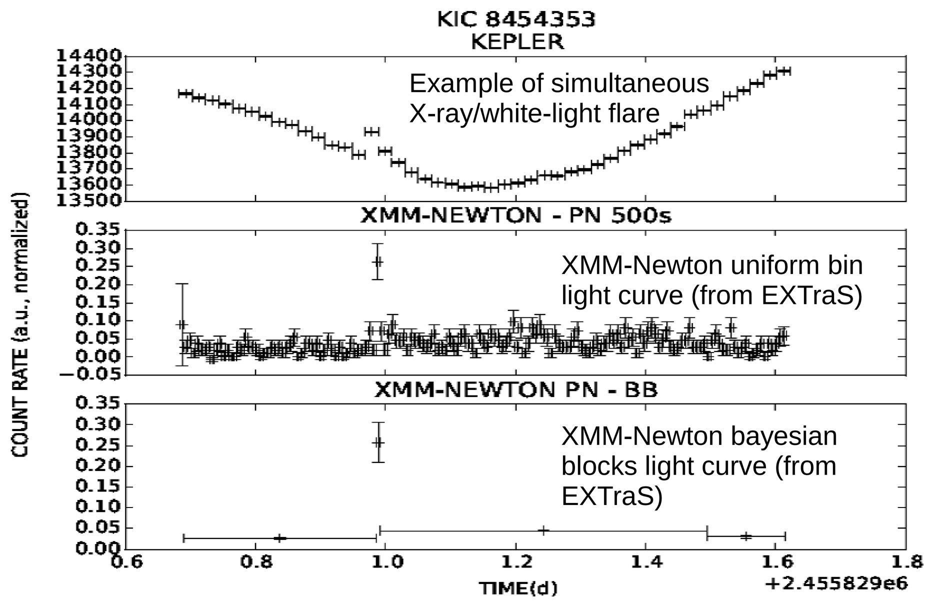
X-ray activity/rotation: X-rays flux-limited sample + large average distance of Kepler stars (~270 pc) -> bias towards very active stars (see comparison with the distribution by [3], 90% completeness).
X-ray activity decreases with period; hints of two regimes: correlation for slow rotators, saturation for fast rotators.
Good agreement with previous results [4] (K2 sample of M stars within 10 pc), [5], [6].

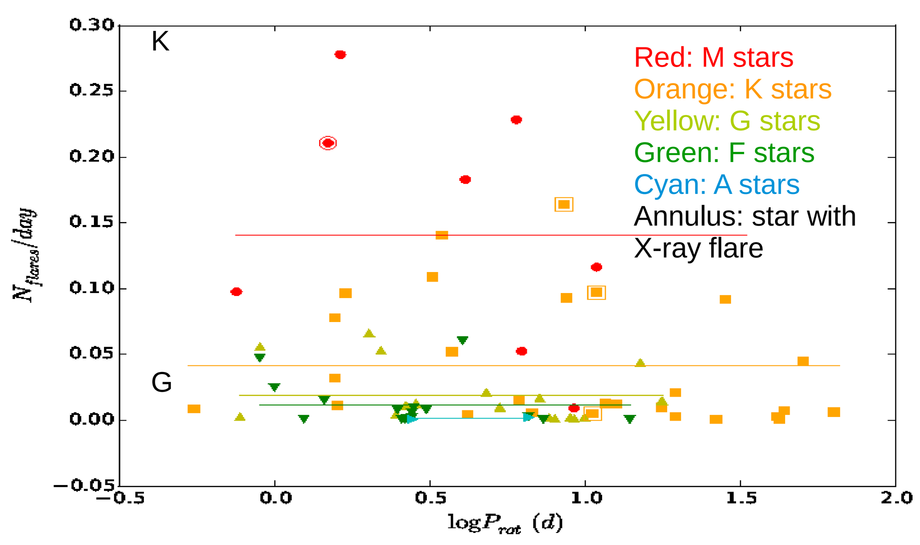


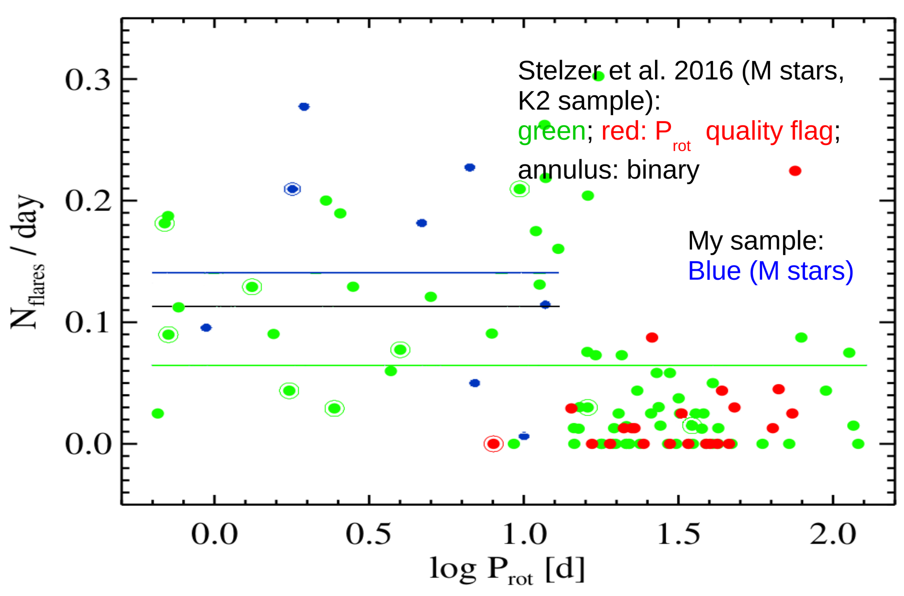
Flaring activity: white-light flaring rate increases towards later spectral types; possible decrease towards long rotation periods. Six X-ray flares: all with chromospheric long-duration counterpart. Consistent X-ray/white-light flaring rate. Good agreement with [4]











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