Understanding Stellar Periodicity with Kepler Quarter One Data

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Abstract

The NASA/IPAC 2011 Teacher Archive Research Program (NITARP) research team, utilizing publicly available Kepler Mission data sets, characterized the variability of 250 main sequence stars from the early-release quarter one Kepler data release. Our goal was to investigate sources of stellar variability as a function of stellar temperature (4000 – 10000 K). By utilizing a Lomb-Scargle periodogram analysis and a visual inspection of phased light curves, we investigated the presence of periodicity in each of these stars. We explored the percentage of variable stars that are periodic and the associated distribution of periods as a function of stellar temperature.

Summary of Results

* Periodicity increases in period moving from high stellar temperatures (A-stars) to low stellar temperatures (M-stars). This is likely a result of shifting from pulsations to rotation/binarity as the primary cause of the periodic variations.

* Nearly all of A and F variable stars have identifiable periods, while only 50% of G, K, and M stars had identifiable periods

* Not a significant difference in the period distributions for the highly and moderately variable populations for the A, F, and G stars; the K and M stars appear to show stronger variability at longer periods.
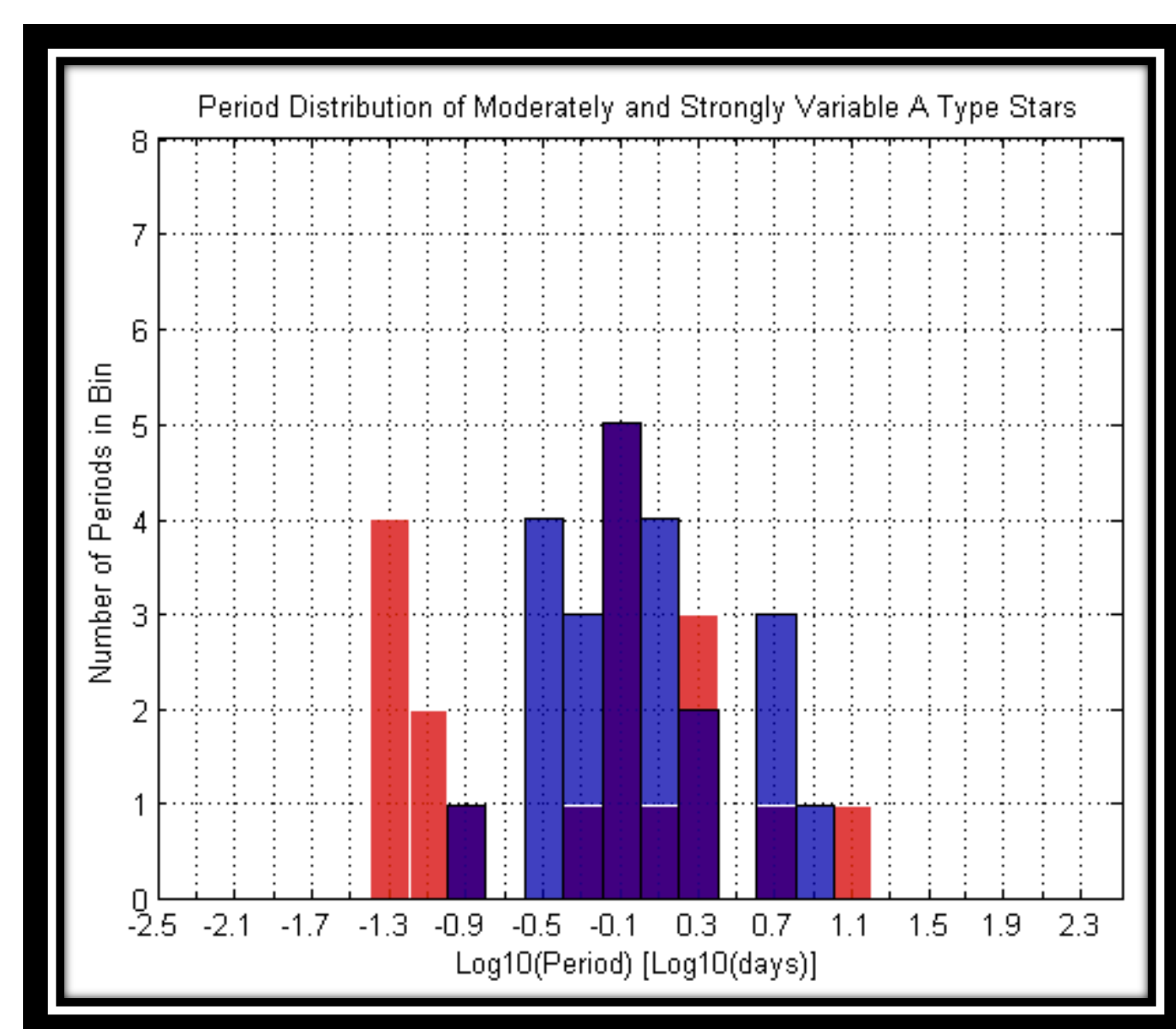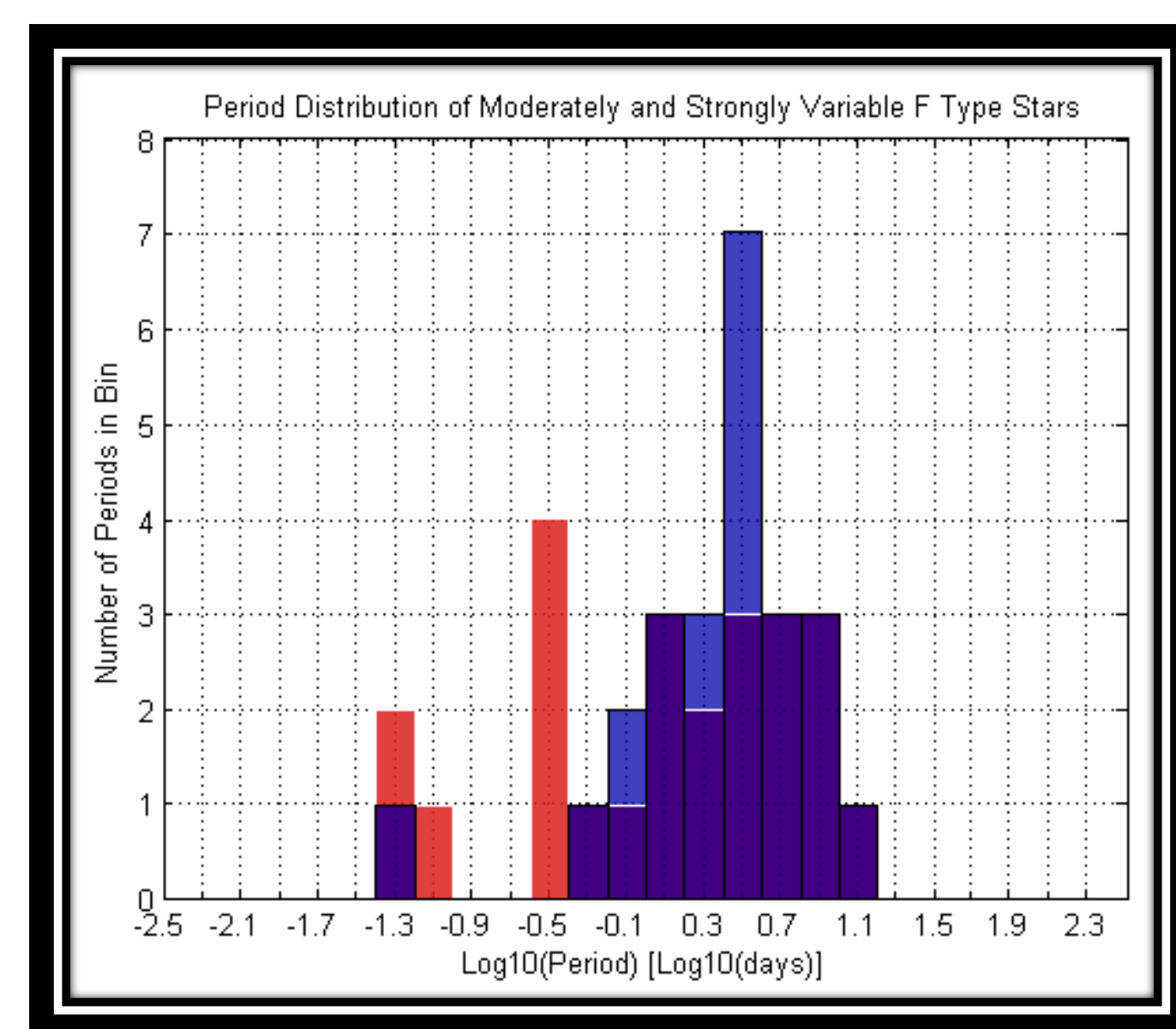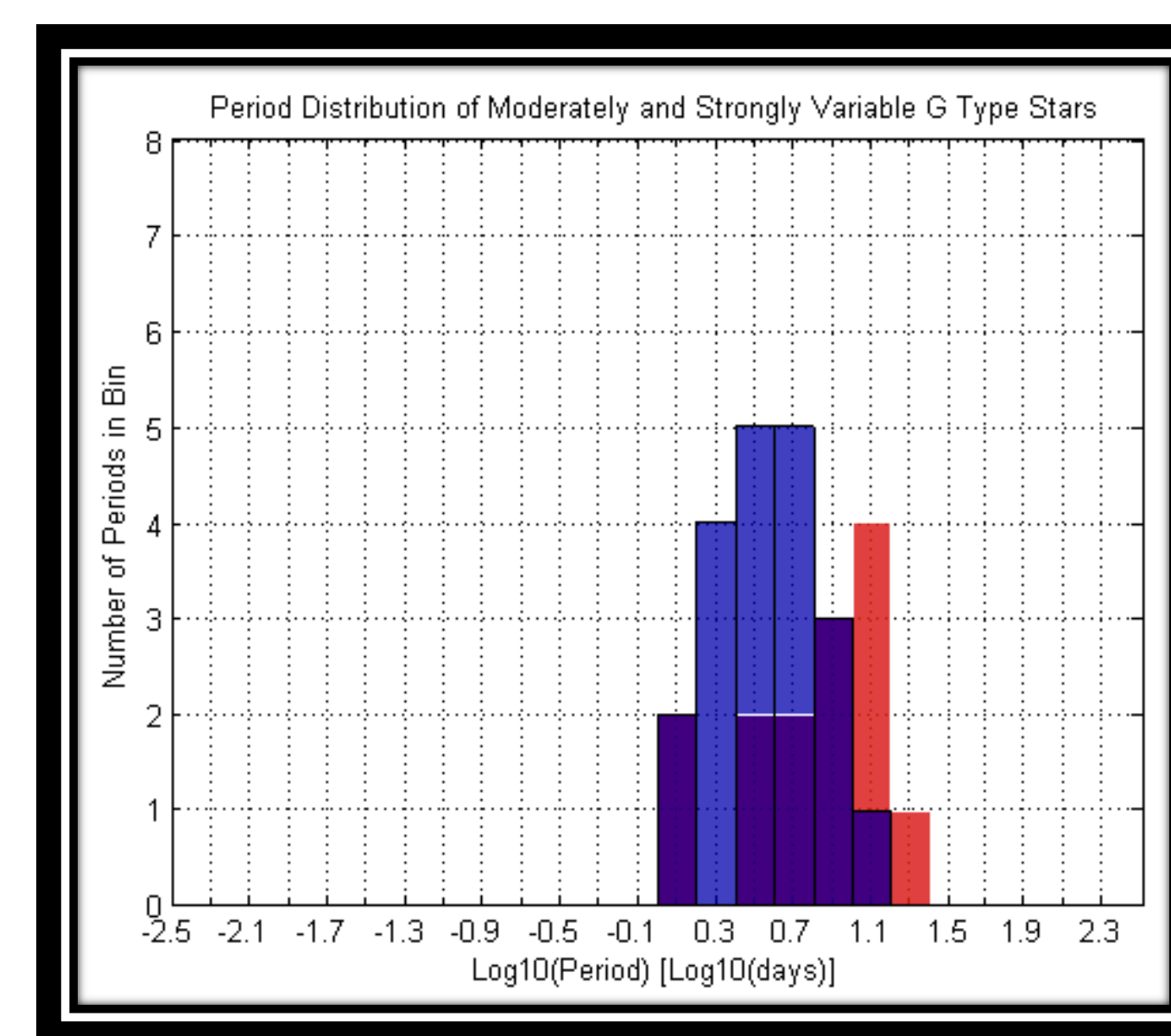

Figure 1: Type A Dwarfs
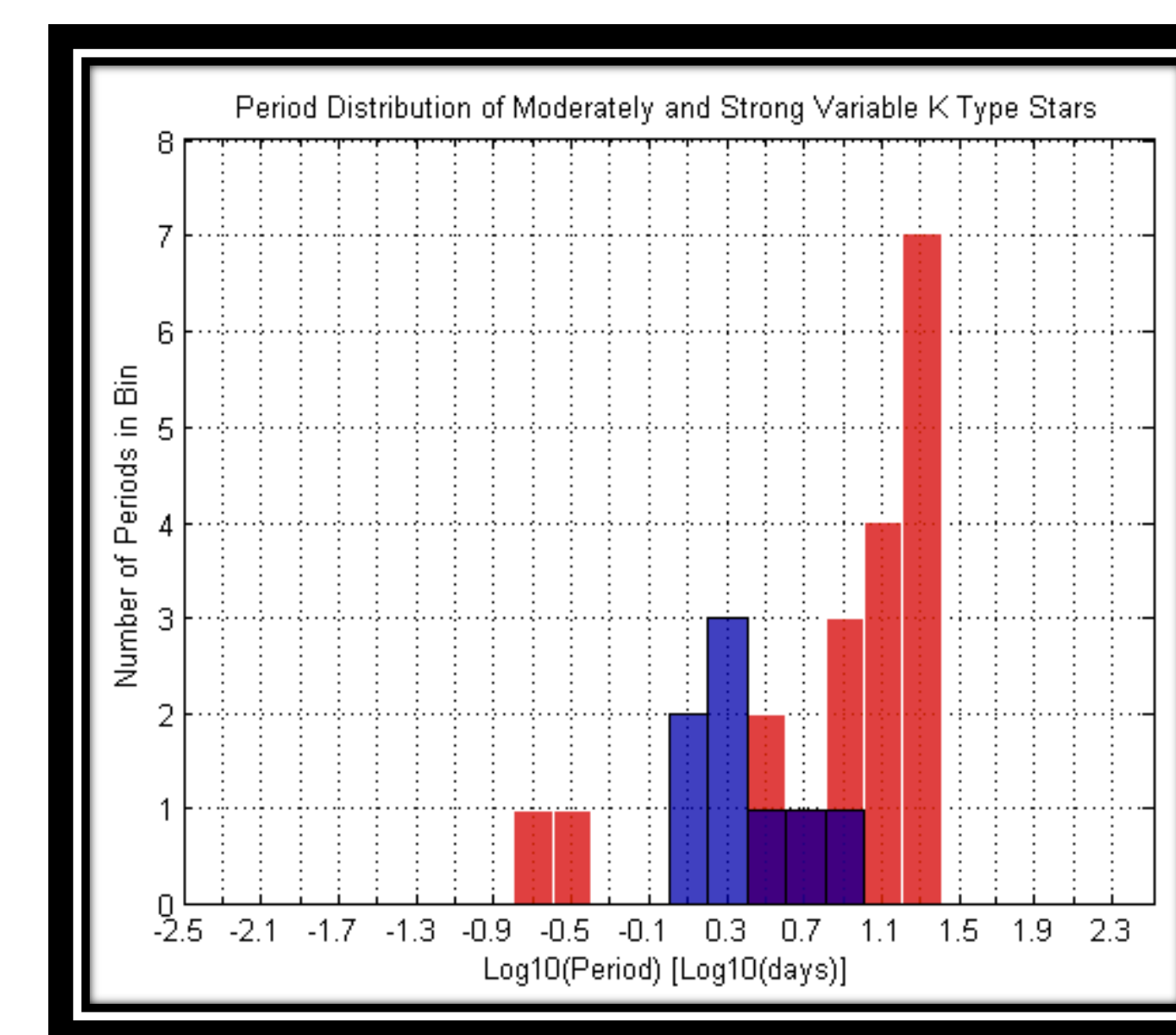

Figure 2: Type F Dwarfs
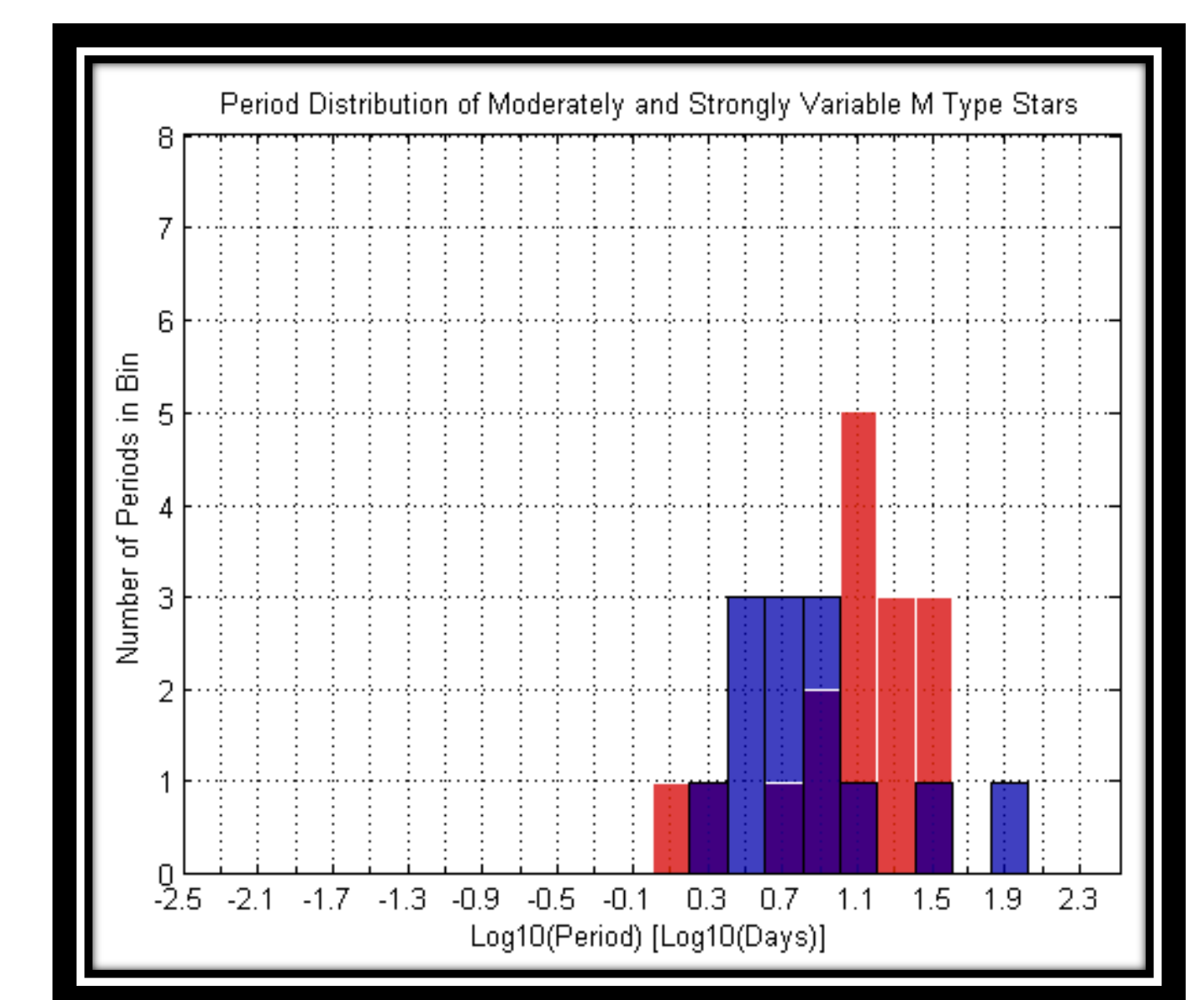

Figure 3: Type G Dwarfs

Figure 4: Type K Dwarfs

Figure 5: Type M Dwarfs

Data Statistics

	A (~1 mmag)	A (~ 0.1 mmag)	F (~1 mmag)	F (~ 0.1 mmag)	G (~1 mmag)	G (~ 0.1 mmag)	K (~1 mmag)	K (~ 0.1 mmag)	M (~1 mmag)	M (~ 0.1 mmag)
Number of Stars in Bin	19	23	24	24	14	20	19	8	16	13
Number of Stars with More than One Period	1	0	0	0	0	0	0	0	0	0
Number of Stars with No Obvious Period	7	1	1	1	11	5	6	13	7	3
Number of Repeat Stars in Data Set	0	1	0	0	0	0	0	0	3	9
Min Period (days)	0.0423	0.1014	0.0456	0.0549	1.2922	1.3461	0.2403	1.075	1.5299	1.8538
Max Period (days)	12.4719	7.9923	10.4154	11.4455	19.6772	10.9212	24.6099	8.543	30.4112	94.9037
Median Period (days)	0.6735	0.8698	1.5493	2.8508	7.6703	3.8923	10.4154	2.1939	14.994	5.5964

Goals:

1. Investigate if the strength of stellar variability is related to the periodicity (if any) of the stars
2. Determine the period distributions as a function of stellar temperature (spectral class)

Data:

* Kepler Quarter 1 light curves
* 33 days
* 30 minute cadence
* Light curve statistics from the NASA Exoplanet Archive

Technique

1. Stellar selection
   * Selected from 50 random dwarf stars for each stellar type (A,F,K,G,M; see Ciardi et al. 2011)
   * 25 stars marked as moderately variable (blue) and 25 stars marked as highly variable (red) - see figure 7
2. Light curve
   * Kepler Quarter 1 light curves assessed through the NASA Exoplanet Archive
   * Assessed by eye for obvious periodicity (i.e., should we expect to see a periodic signal)
   * All light curves run through NASA Exoplanet Archive online periodogram service to determine if the light curve is indeed periodic
   * Periodogram results assessed by P-value probability and quality of resulting phase curve
   * All light curves assessed by eye
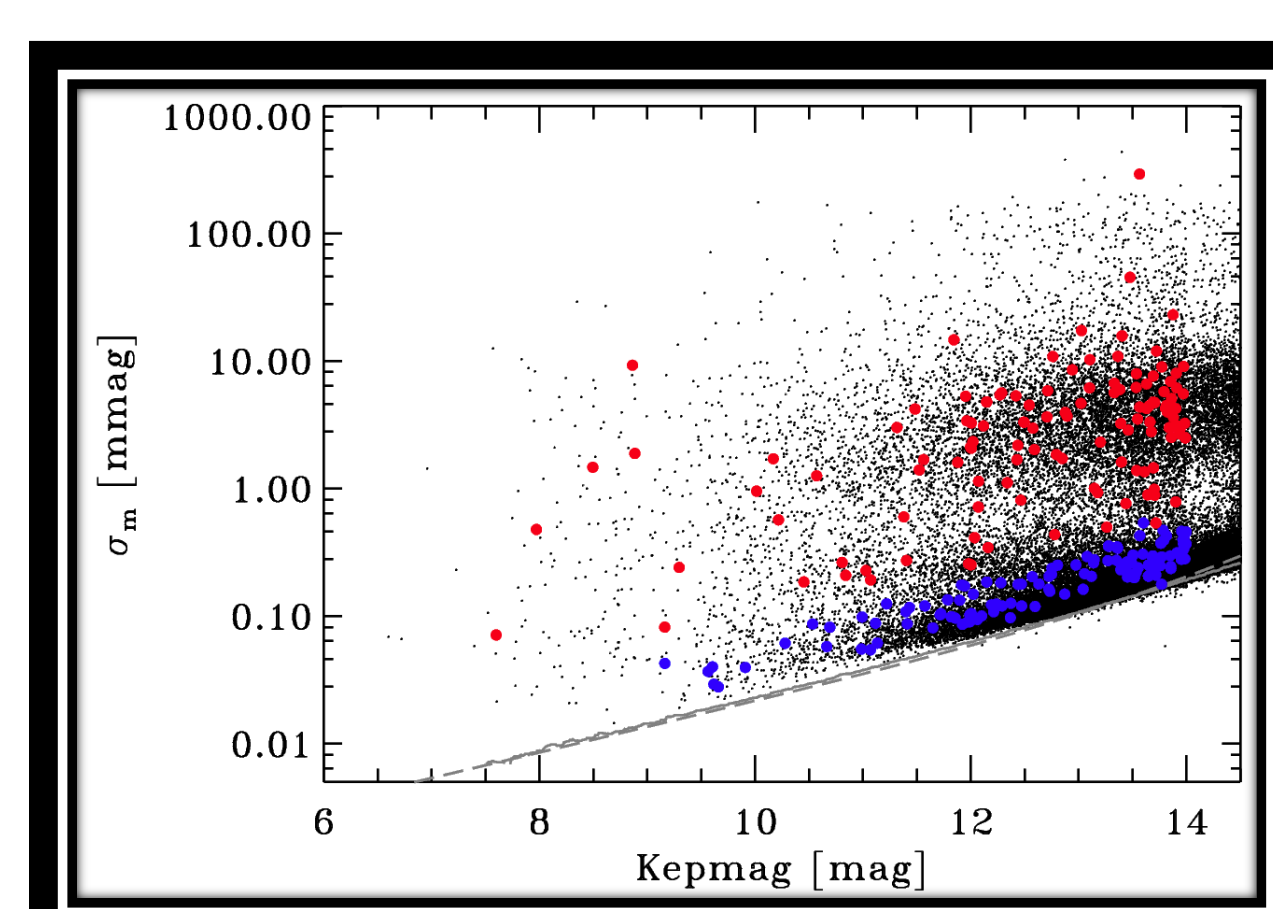
Plot for Data Selection

Figure 7: Ciardi et al. 2011 AJ, 141, 108
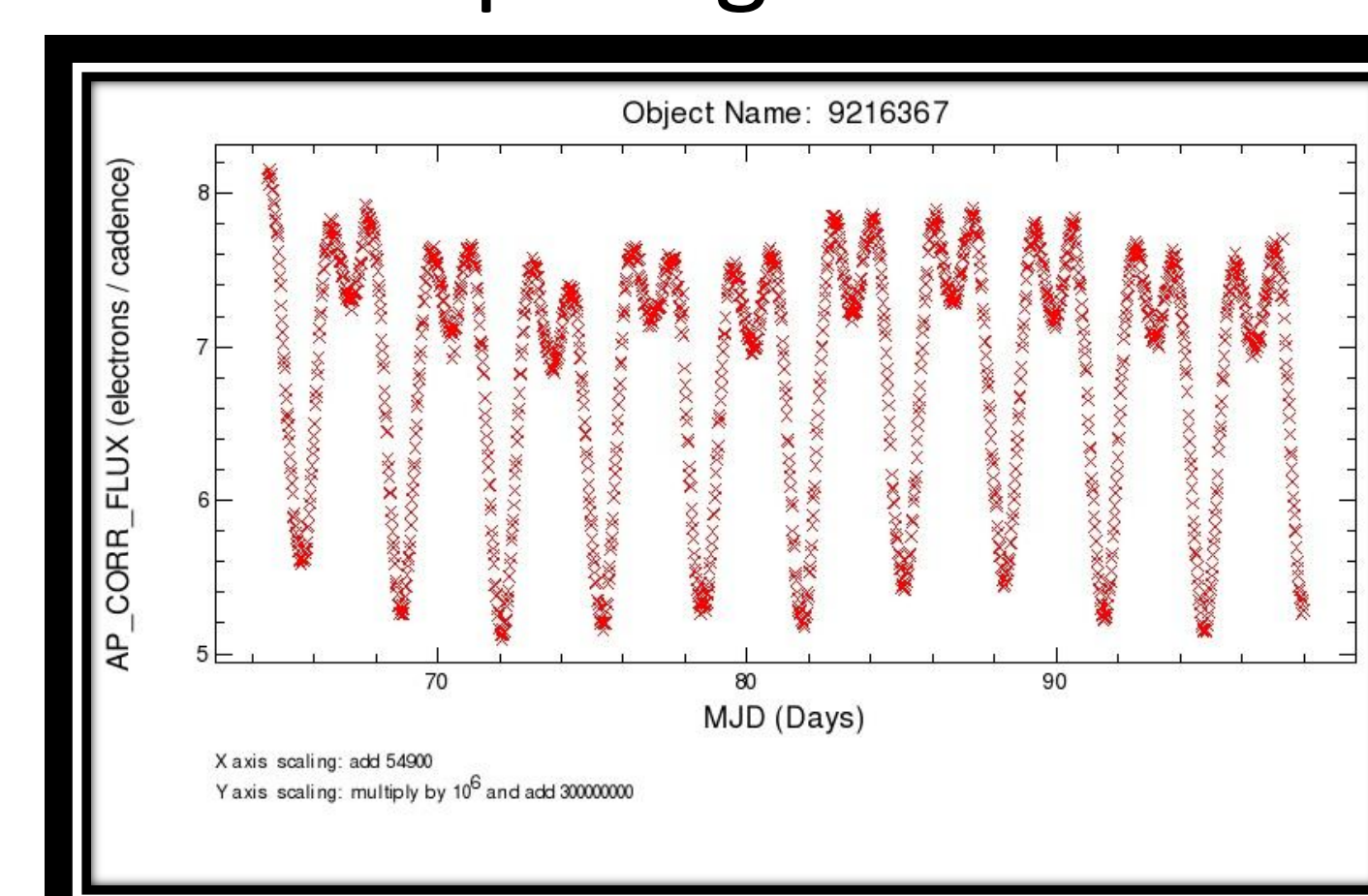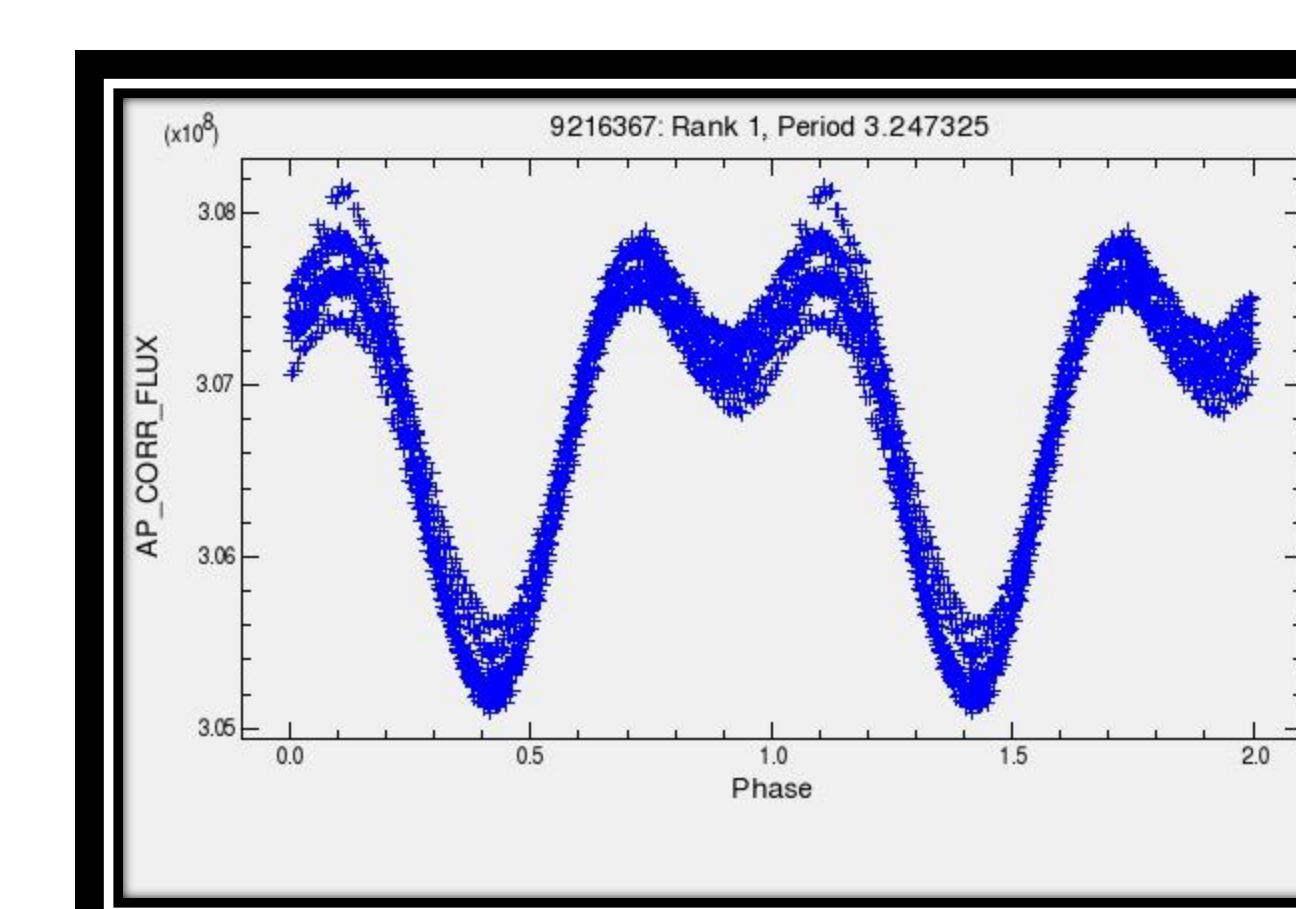
Sample Light curve

Figure 8: http://exoplanetarchive.ipac.caltech.edu

Sample Phased light curve

Figure 9: http://exoplanetarchive.ipac.caltech.edu