VARIABILITY ACCORDING TO KEPLER

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The Kepler mission consists of a 1-m telescope and CCD camera, designed to measure Earth-like transiting planets orbiting solar-like stars.

Kepler stares at one 115 sq. degree field of view in Cygnus/Lyra for 4-6 years, collecting light curves for >100,000 stars.

Kepler light curves consist of 1 or 30 min samples with ~10 ppm precision (best).

Launch – 6 March 2009
Open cluster NGC 6791

Note defocus & square-ish stars.

Int time = 6 sec

Pixel = 4"

FWHM = 6.5"

Star Aperture = ~30+ pixels
Note curvature and CCD pairs
Kepler “V+R” bandpass

CCDs covered with coated field flattener lens (FFL)
Exo-Planet Hat-P-7b

HAT-P-7b data from the ground
A. Pal et al., 2008

Kepler Commissioning data (10 days)
W. Borucki et al., 2009
New, fun objects too!
Light Curves not without Instrumental/other effects

Figure 4: An SC Example with (possibly) Interesting Astrophysics. Cadences identified as gaps by the Pipeline are omitted from this plot, but some out of Fine Point Cadences remain after momentum dumps (Section 5.1), as labeled above. If the stellar flare had fallen on one of the noisy regions, it might have been missed. The target is an eclipsing binary, with the transits indicated by ‘EB transit’).
~50% of solar-like stars are more active than the active sun -- 1/3 for G type, >>50% for mid-K and cooler.

From Koch et al. 2010
Basri et al. 2010
Some example variables
Best Photometric Precision

History of Photometric Precision

-2
-3
-4
-5

Log σ

Year

1990 2000 2010

Kepler
Kepler Photometric Precision

$r \sim 8.5 \text{ to } 19$

![Graph showing the relationship between Log $\sigma$ and Approx. $r$ magnitude. The line segment labeled 'Best GB' indicates a region of interest.](image)
V344 Lyr – Cataclysmic Variable
r~18 at minimum, 14 at max
Superoutburst humps
Detailed analysis of Periods and Amplitudes

Period Stability

Orbital Period

Superhump Period

Amplitude Stability

Frequency (Hz)

Half-Amplitude (electrons)

0.40

0.30

0.20

0.10

0.00

60

65

70

Time (Days)
Can Nothing Escape? 
A r=18.8 White Dwarf showing
0.08 mag humps, rotation?

From Kepler Calibration and Science program (Holberg, Howell, Mighell)
SUMMARY

- 4 year time span providing >100,000 light curves of stars from r~10-16
- Additional thousands of light curves from GO programs (r~10-20)
- Instrumental and blending effects involved, getting worked out
- Precision – 0.00002 – 0.00060 mag !! (r~ 8-13)
- Variability - >50% of all stars are variable (will likely increase as we refine light curve analysis)
- Hundreds of new / odd variables – Need follow-up (phot + spec) observations. Relatively easy, but need (lots of) telescope time.
- New detailed phenomena observed – The more you