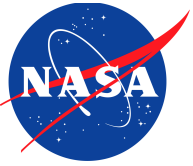


Kepler Science Update for ExoPAG

Thomas N. Gautier
Kepler Project Scientist
24 June 2010



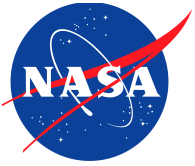
STScI



The State of Kepler



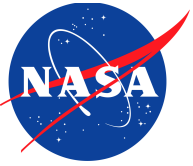
- Launched March 2009
- Started science operations in May 2009
- End of observations planned in November 2012
 - *3 ½ years of operation*
 - *Will miss ~½ of Earth analogs: need to see 4 transits of Earth-size planet around 12th magnitude G2V star*
- End of mission deliveries planned in November 2013
- Recent data release. >150,000 light curves for quarters 0 and 1 (Q0 & Q1)
 - *Held back 400 candidate planets for false positive vetting*
 - *Released ~300 candidate planets with little false positive vetting*
- Next data release, Q2, June of 2011
- Q4 data currently available to proprietary users
- Just finishing Q5, rolling to Q6 within days



State of Kepler 2



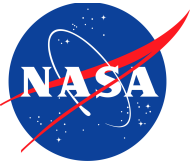
- 5 Planets confirmed with orbits: short period, Neptune-size and larger
- Data reduction pipeline still under development
- Transit detection and validation working for single quarters only, multi-quarter detection and validation expected in Jan 2011
- Ground based follow up program in second season of operation
 - *Working through initial observation protocol for all candidates*
 - *Developing final protocol for planet confirmation without radial velocity orbit determination*
 - RV orbit determination impossible for most small planet candidates
 - Need to measure reliability of confirmation without RV
- Data delivered to archive needs improvement
 - *Currently only deliver full aperture light curves in raw and PDC form*
 - *Need individual pixel light curves*
 - *Need improved PDC processing to clean up instrumental effects in raw curves*
 - *Working to accomplish as best we can*



June 15 Data Release



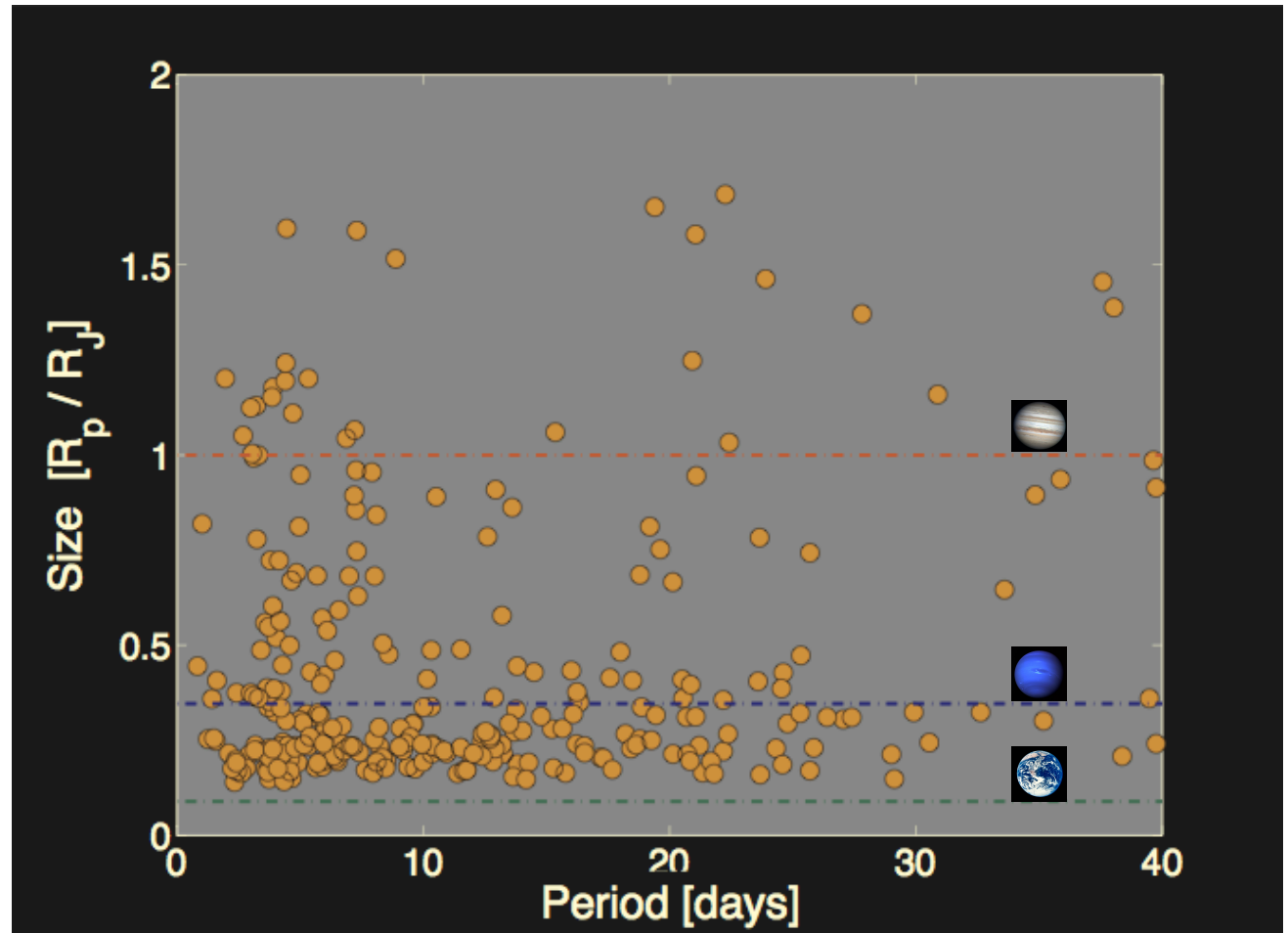
- ~ 156,000 light curves for Kepler targets
- 706 candidates planets identified in the Kepler light curves
 - 400 *held back for planet confirmation*
 - 306 *in the released data*
- 65 targets with transit-like features identified as false positives
- ~1800 eclipsing binaries identified
- 5 targets showing multiple transiting candidate planets released
 - *Many 10's more multiple transiting systems in the 400 withheld targets*
- Statistics on MAST data archive access
 - *Last 6 months: 20-40 downloads/month = ~1 / day*
 - *June 16-19: 200 / day*

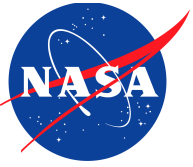


706 candidate planets

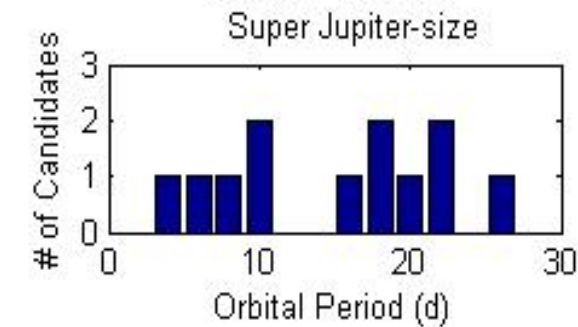
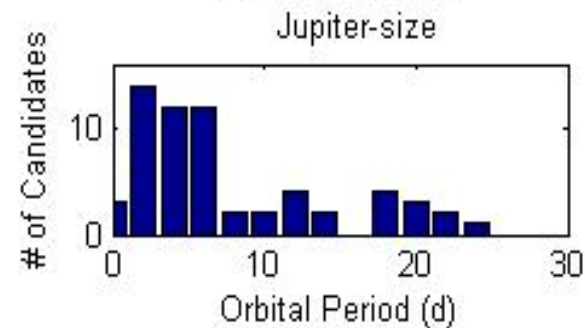
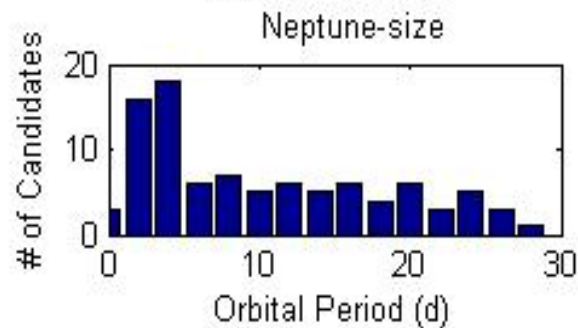
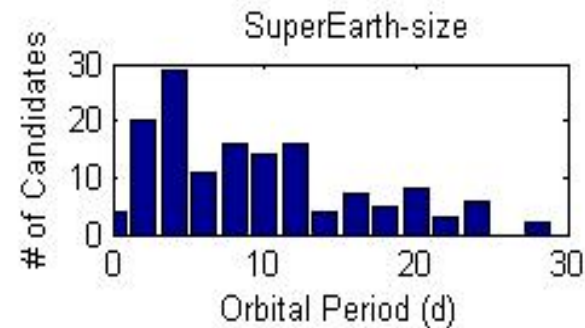
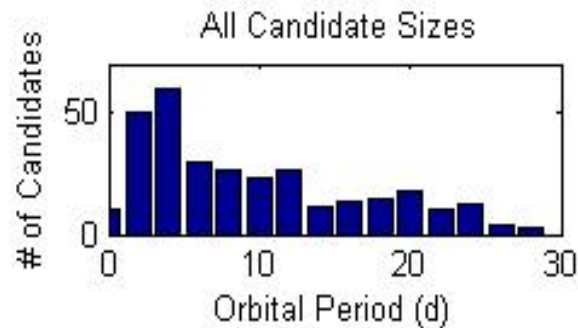


- 306 released candidate planets
- Most are smaller than Neptune
- Exoplanet Encyclopedia histogram has big peak between 0.5 and $1.5 R_{Jup}$
- Expect $<25\%$ of 400 withheld candidates to be false positives
- Expect $>50\%$ of 306 released candidates to be false positives





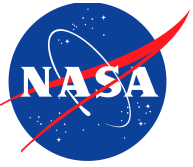
Statistics on released candidate planets



For periods <30d small planets appear to be more common than large planets.

Currently no sign in the Kepler data of the reported bunching of giant planet periods near 3 d

Borucki, et al. 2010, arXiv:1006.2799

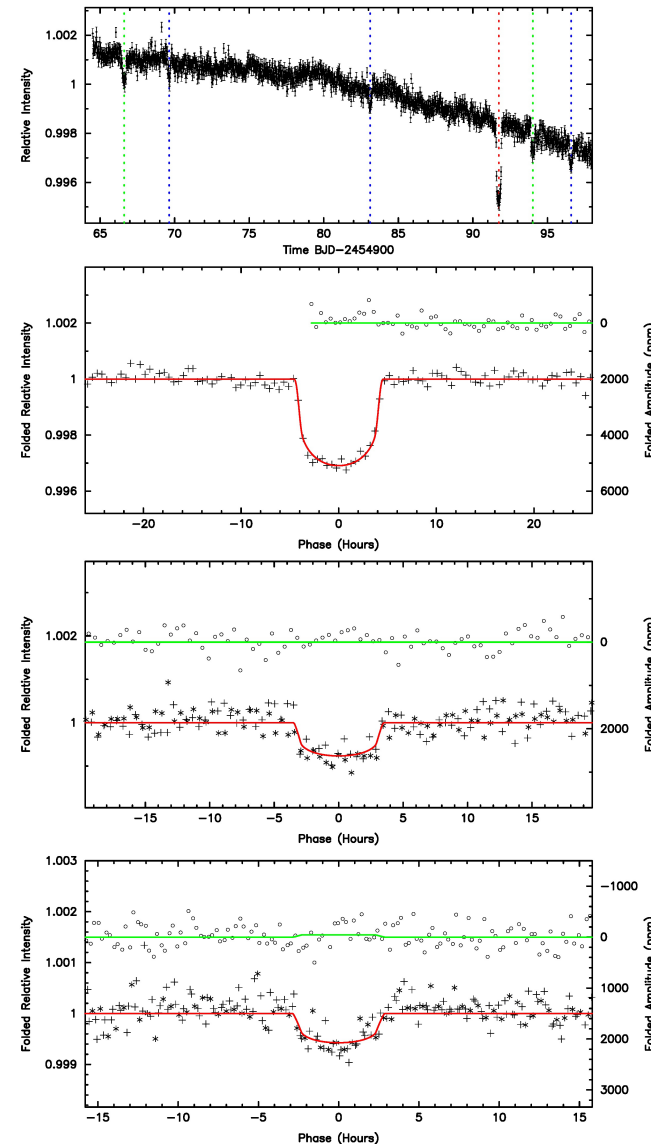


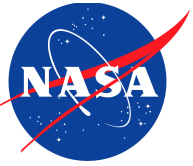
Example Multiple Transiting System



- Multiple transiting candidate KOI 152
- Candidate Period Radius (R_{Jup})
 - 152.01 >21 (51.9) *d* 0.58
 - 152.02 27.406 *d* 0.31
 - 152.03 13.478 *d* 0.30
- Top plot is Q0-Q1 light curve
- Succeeding plots are the transits from outermost to innermost planet

Steffen, et al. 2010, arXiv:1006.2763





Eclipsing Binary Catalog



Classification:

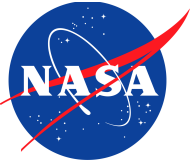
- 5 morphology groups:
detached, semi-detached, overcontact, ellipsoidal, uncertain

Result: ~1800 sources

- 54.1% detached
- 8.4% semi-detached
- 23% overcontact
- 12.2% ellipsoidal
- 2.3% uncertain

1.1 – 1.2% of Kepler targets are EBs
Somewhat greater than reported in other surveys

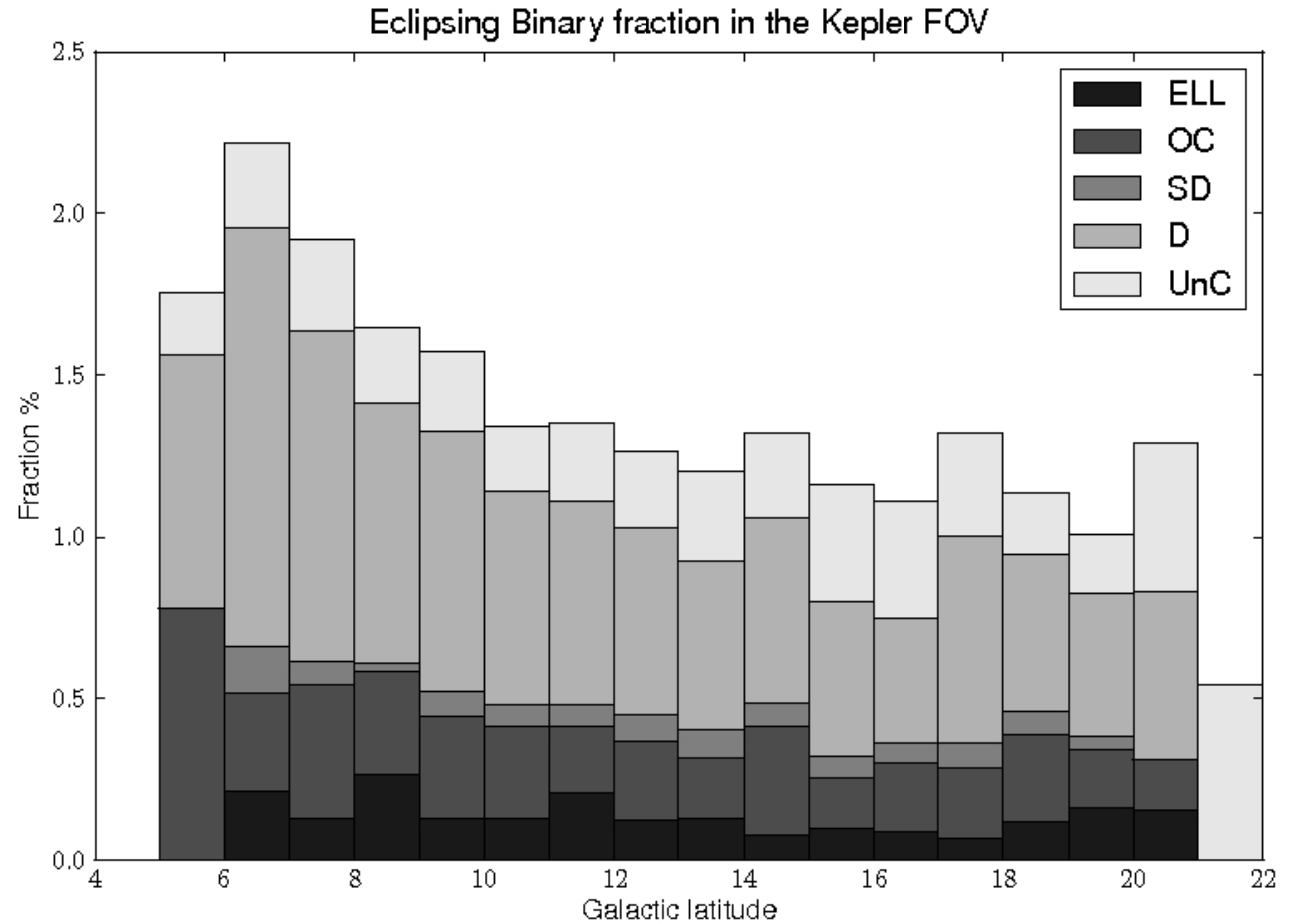
Prsa, et al., 2010, arXiv:1006.2815



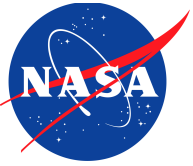
EB Results



Distribution of EBs with latitude and type.



Prsa, et al., 2010, arXiv:1006.2815



EB Results

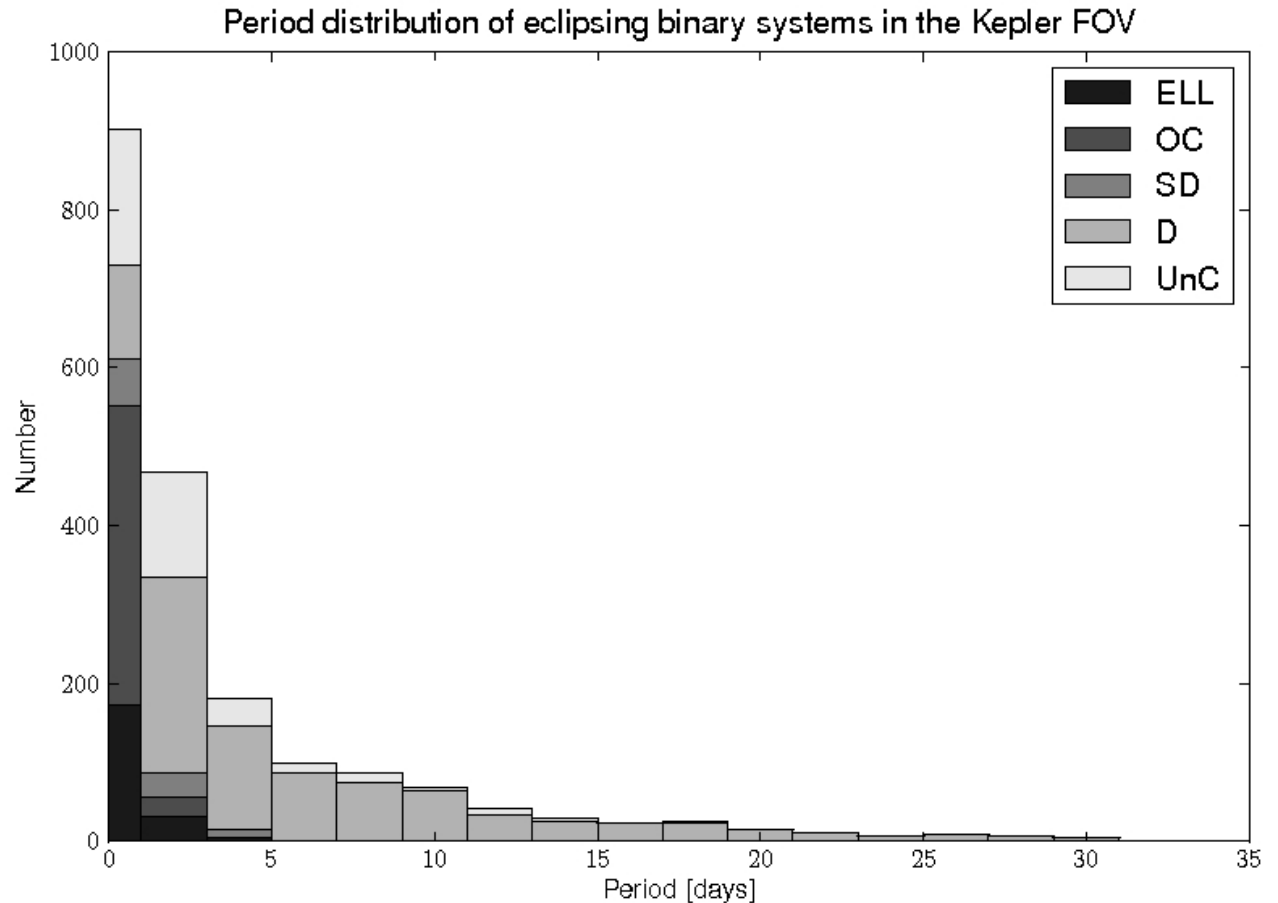


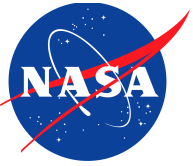
Distribution of EBs with period.

The EB density appears to drop faster with period than the planet density.

This indicates that we may have fewer problems with background EB false positives than we feared.

There is an ongoing search with Kepler data to make a direct measurement of the faint background EB density.

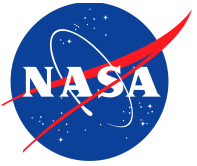




Community Results and Publications



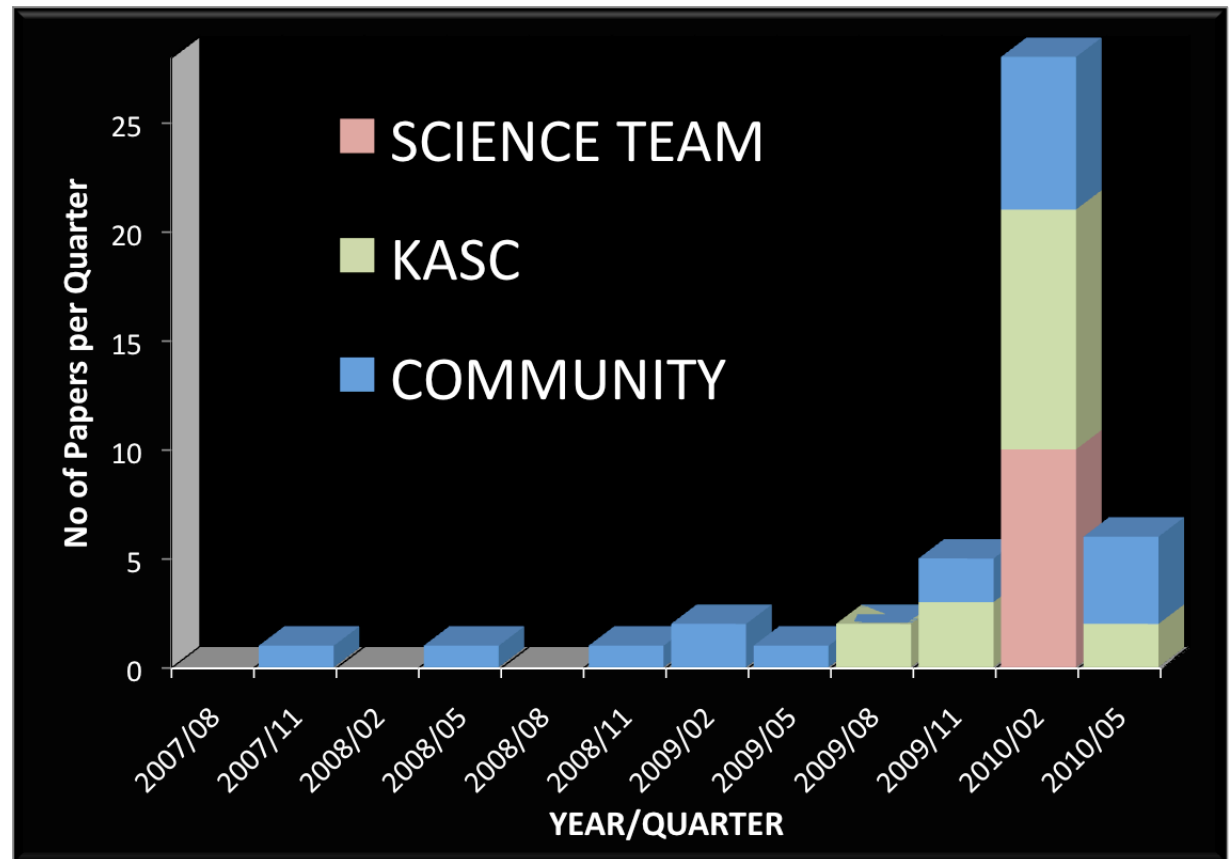
- Two main areas of community research with Kepler data
 - *GO program*
 - 11 programs in cycle 1
 - 36 programs in cycle 2
 - *Observations from 6/2010 to 6/2011*
 - *KASC (Kepler Asteroseismic Science Consortium)*
 - Collaborates with the Kepler team to provide stellar sizes and ages
 - European based with world wide membership
 - >300 participants
 - Well organized, very productive
- Expect sizeable increase in community participation with the major release of Kepler data this month



GO program



- Papers published on non-exoplanet Kepler astrophysics



Kepler photometry of the prototypical Blazhko star RR Lyr

K. Kolenberg^{1*}, S. Bryson², R. Szabó³, D. W. Kurtz⁴, R. Smolec¹, E. Guggenberger¹,
J. Benkő², M. Chadid⁵, Y.-B., Jeon⁶, G. Kopacki⁷ J. M., Nemeč⁸, J. Nuspl³,
R. L. Gilliland⁹, M. Still², J. Christensen-Dalsgaard¹⁰, H. Kjeldsen¹⁰, T. Brown¹¹,
W. J. Borucki², D. Koch², J. M. Jenkins¹², KASC SC members,

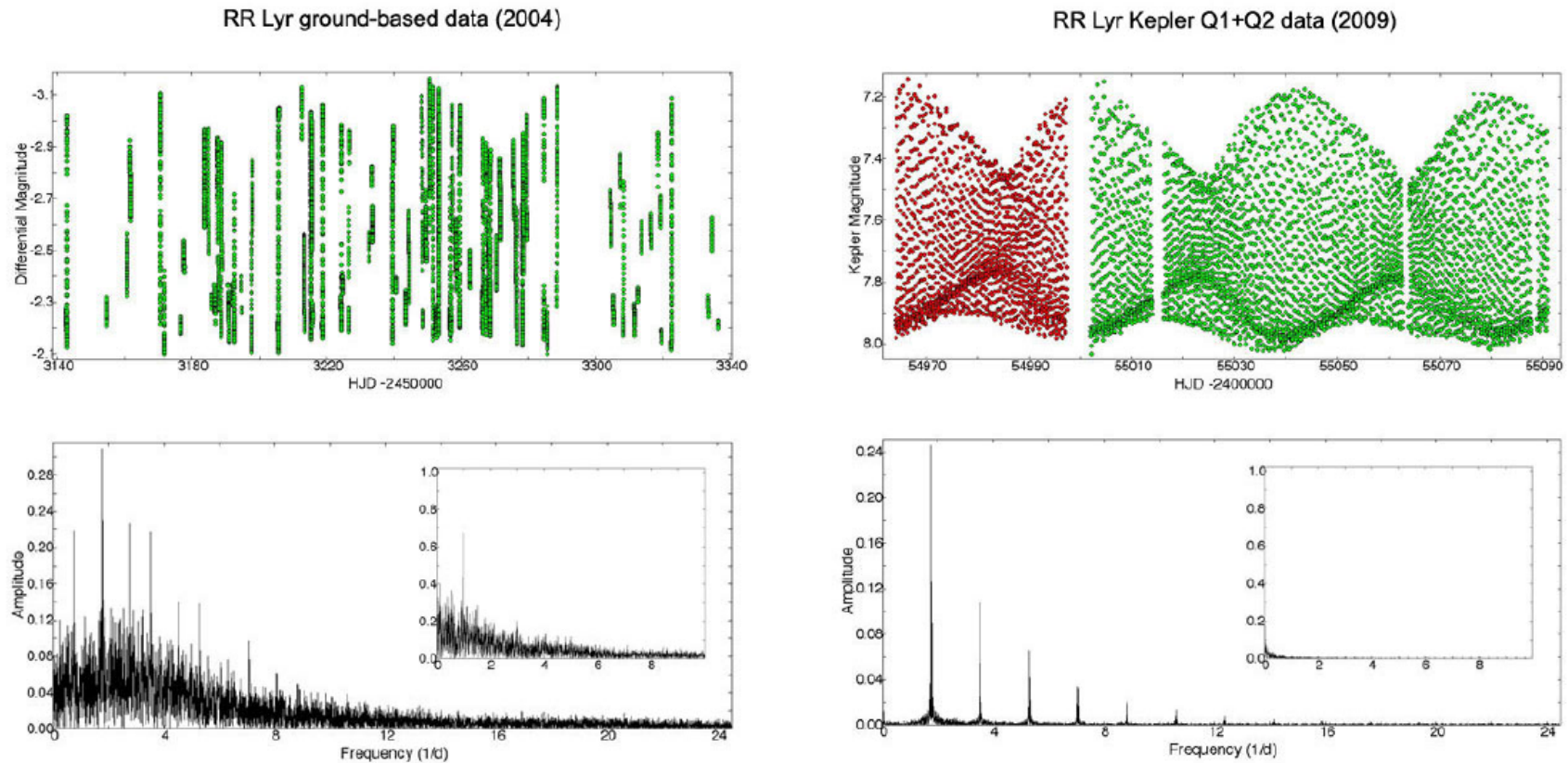
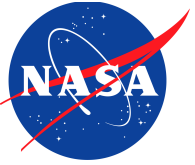


Figure 1. Comparison of the ground-based RR Lyr data, gathered from six different observatories, published by Kolenberg et al. (2006) and the *Kepler* Q1 and Q2 data of the star transformed to the magnitude scale (top panels). Bottom panels: Fourier transform of the data; the insert shows the window function.



KASC Publications



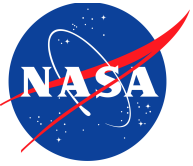
KASC Data publication strategies and policies

1. Papers are made in the KASC W

16 new KASC papers ready for publication

many more (~60) papers in September

...
by KASC and after approval
submitted to a journal



Summary



- Kepler's unprecedented precision combined with continuous observation is revolutionizing the study of photometric variations of all kinds.
- Kepler is producing important and exciting scientific results both from the Kepler team and from the community.
- Lots of planets are being detected with the majority being smaller planets
- Looking forward to detection of longer period planets with multi-quarter transit detection and sensitivity improvements from pipeline development
- Participation in Kepler is increasing.
 - *GO proposals up*
 - *Increasing activity in KASC*
 - *Collaborations outside the Kepler team are increasing*
 - *Data release to the community*
- Operations status is excellent.
 - *The causes of past safe mode entries and loss of fine pointing are largely worked around.*