Researches of Exoplanets Influence on Host Star Chromospheric Activity

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Observing techniques, instrumentation and science for meter-class telescopes II
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Target Setting

Search of close massive exoplanets influence on their host stars.

Optimal conditions: **Distance ≤ 0.5 AU, Mass ≥ $M_{Jupiter}$**

11-year-old cycle of solar activity is connected with resonant gravitational influence of giant planets Jupiter and Saturn?

=> Is this connection in other planetary systems exist?

=> Result of such influence can be evidence of chromospheric activity variations of host stars.

Nature of star-planet interaction:

- Tidal (gravitational) interaction
- Magnetic interaction

Event of **chromospheric activity variations** of host stars

Most probably causes of appearance of chromospheric activity variations is **resonant gravitational and magnetic influence** of close massive exoplanets on host star chromospheres.

How can chromospheric activity variations appear?

Feature of **chromospheric activity for sun-like stars** is **periodical variability** in the most strong chromospheric lines **H&K CaII and Hα** =>

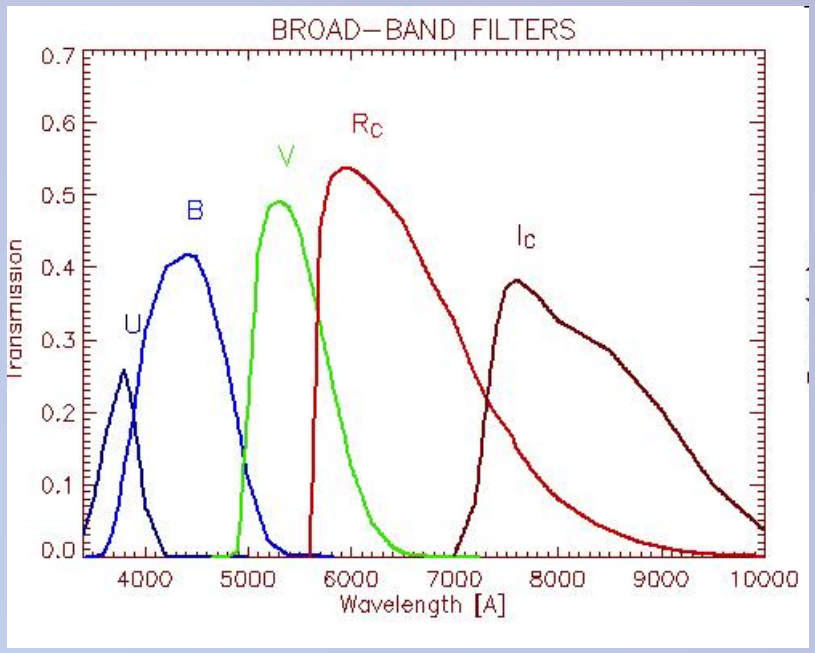
Observational data analysis on base of behavior of chromospheric lines H&K CaII and Hα will permit to detect the periodical variations of them =>

It can directly indicate to existence of chromospherical activity of host stars induced by close massive exoplanets.

WHY MULTICOLOR PHOTOMETRY?

Because B and R Johnson filters contain H&K CaII and Hα chromospheric lines!

Filter	l_0, μm	Chromospheric line
B	0,44	Ca II H (3968,492 Å) Ca II K (3933,682 Å)
V	0,55	
R	0,70	Hα (6562,808 Å)



Effective wavelengths of broadband BVR Johnson filters and corresponding wavelengths of absorption Fraunhofer lines.

NEXT STEP => searching for a correlation between light flux variation period of parent stars and orbital periods of their exoplanets

Research Aims

- Realization of multicolour CCD photometry of some exoplanet systems with close massive Jovian planets using some small meter-class telescopes

- Periodogram Fourier analysis and searching of light flux variation periods corresponding to orbital periods of exoplanets or their harmonics

- Interpretation of results as existence of chromospherical activity of host stars induced by close massive exoplanets

OBJECTS SELECTION

Simplest variant for our investigations:

to search planets of **Jovian radii**

on the **short period orbits**.

Criteria of Object Selection:

- star magnitudes ≤ 15 m
- orbital periods ≤ 7 days
- presence of 1 exoplanet near host star
- observational altitude ≥ 30°

Exoplanet Systems
selected for observations

Name	HD 168746	HD 68988	HD 219828	QATAR-1
Spectral type	G5	G0	G0IV	K
Appar.mag, V	7.95	8.21	8.04	12.84
Mass	0.88 ± 0.01 M_{Sun}	1.2 M_{Sun}	1.24 M_{Sun}	0.85 M_{sun}
Period rot	34.77 d	26.90 d	26.00 d	19.82 d
Effective temperature	5610 ± 30 K	5767 K	5891 ± 18 K	4861 ± 125 K
Metallicity [Fe/H]	-0.06 ± 0.05	0.24	0.19 ± 0.03	0.2 ± 0.1
M × sin *i* of planet	0.23 M_J	1.9 M_J	0.066 M_J	1.09 M_J
Semi-major axis of planet	0.065 AU	0.071 AU	0.052 AU	0.02343 AU
Planet orbital period, d	6.403	6.276	3.834	1.420

Instruments

Celestron-14’’, Kyiv, Ukraine

60-cm Zeiss telescope
Peak Terskol Observatory
Northern Caucasus

Celestron-14’’, Lisnyky, Ukraine

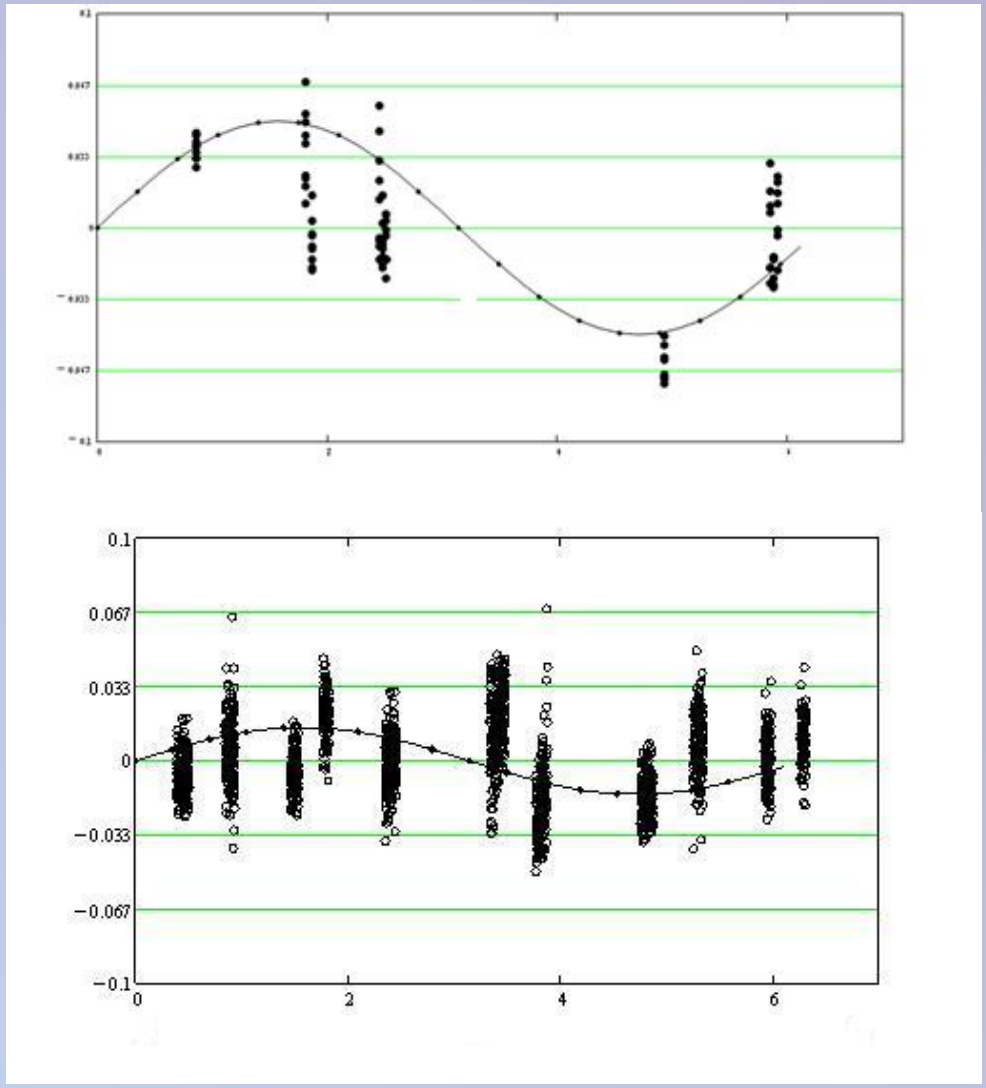
Cassegrain 380-mm telescope
CrAO, Ukraine

HD168746

Most significant detected periodicities of flux variations for exoplanet system **HD168746** (**P = 6.403±0.001 d**)

Period Search Method	Fil-ter	2005-2006			2012			
		P_{atm}, min	P_1, days	Ampli-tude, m	P_1, days	Ampli-tude, m	P_2,days	P_3,days
Stelling-werf	B V R I						3.138±0.23 3.551±0.83 3.320±0.13 3.330±0.20	--- --- 2.73±0.11 2.73±0.18
Moving Average Method	B V R I	39-47	6.403 ± 0.012	0.055				
Maxi-mum Entropy Method	B V R I	42-48	6.403 ± 0.008	0.055	6.403 ± 0.008	0.03 0.015 0.02 0.015		

Phase curves of **HD168746** folded with orbital planet period T=6.403 d



- **2005-2006**

R-filter

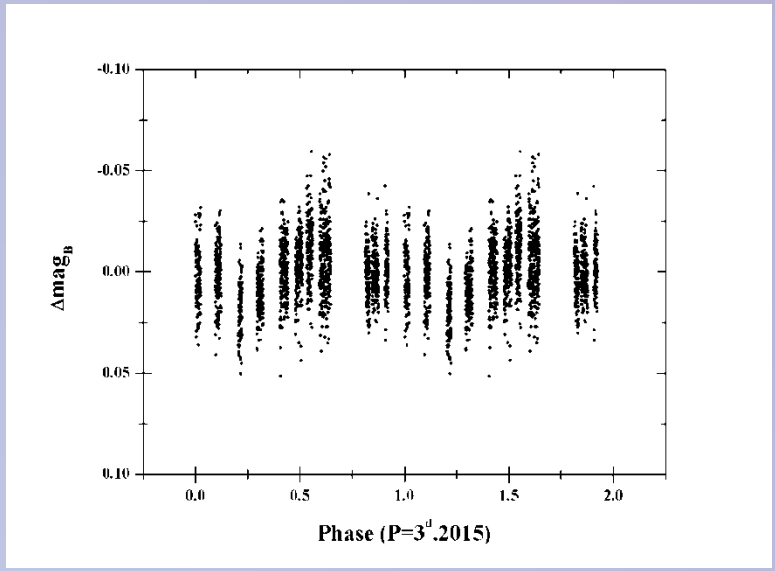
A = 0.055 m

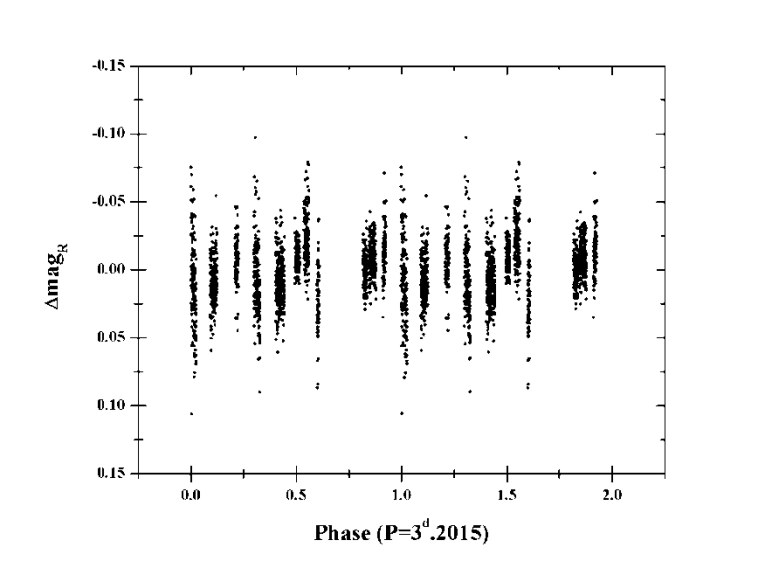
2012

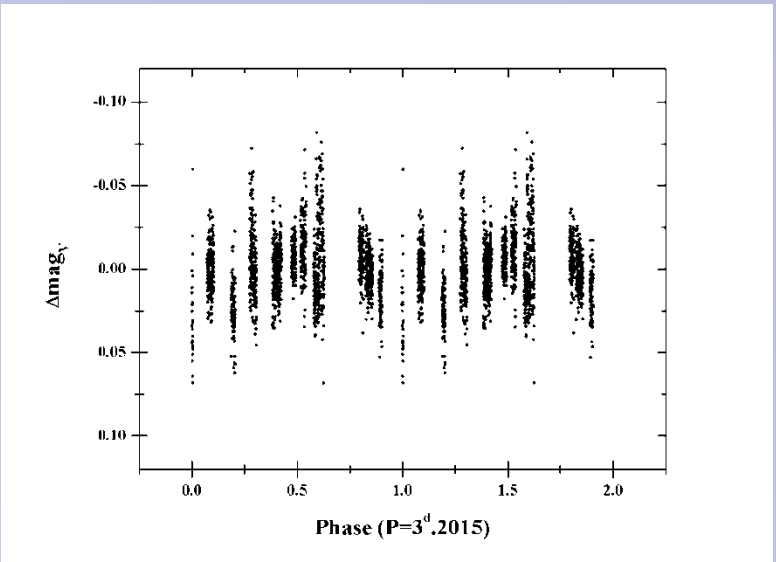
I-filter

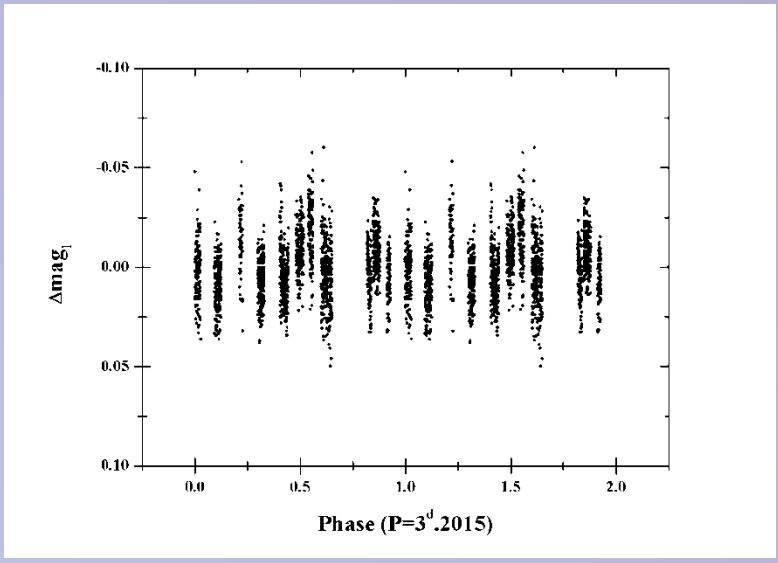
A = 0,015 m

Phase curves of **HD168746** in Johnson filters BVRI
2012, July
folded with semi-period P = 3.2015 d





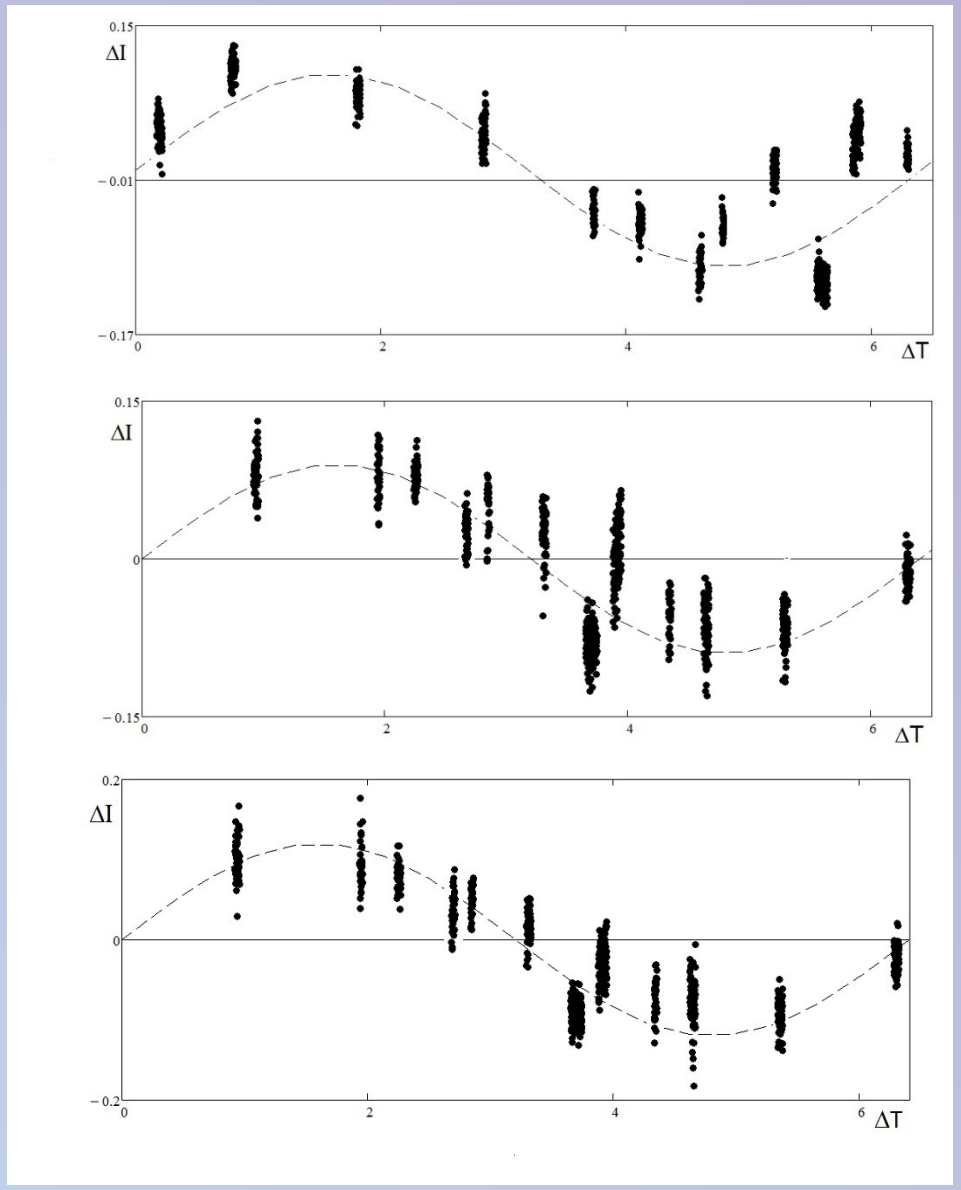




Detected periodicities of flux variations for exoplanet system **HD168746** (P = 6.403±0.001d)

Period Search Method	**Filter**	**2013**		
		P_{atm}, min	**P_1, days**	**Amplitude, m**
Maximum Entropy Method	**B** **V** **R**	42-48	**6.403 ± 0.008**	**0,010±0,008** **0,009±0,006** **0,012±0,006**

Phase curves of **HD168746** (2013, July) folded with orbital planet period T=6.403 d



B filter

V filter

R filter

Most significant detected periodicities of flux variations for exoplanet system **HD68988**

P = 6.276 ± 0.002 days

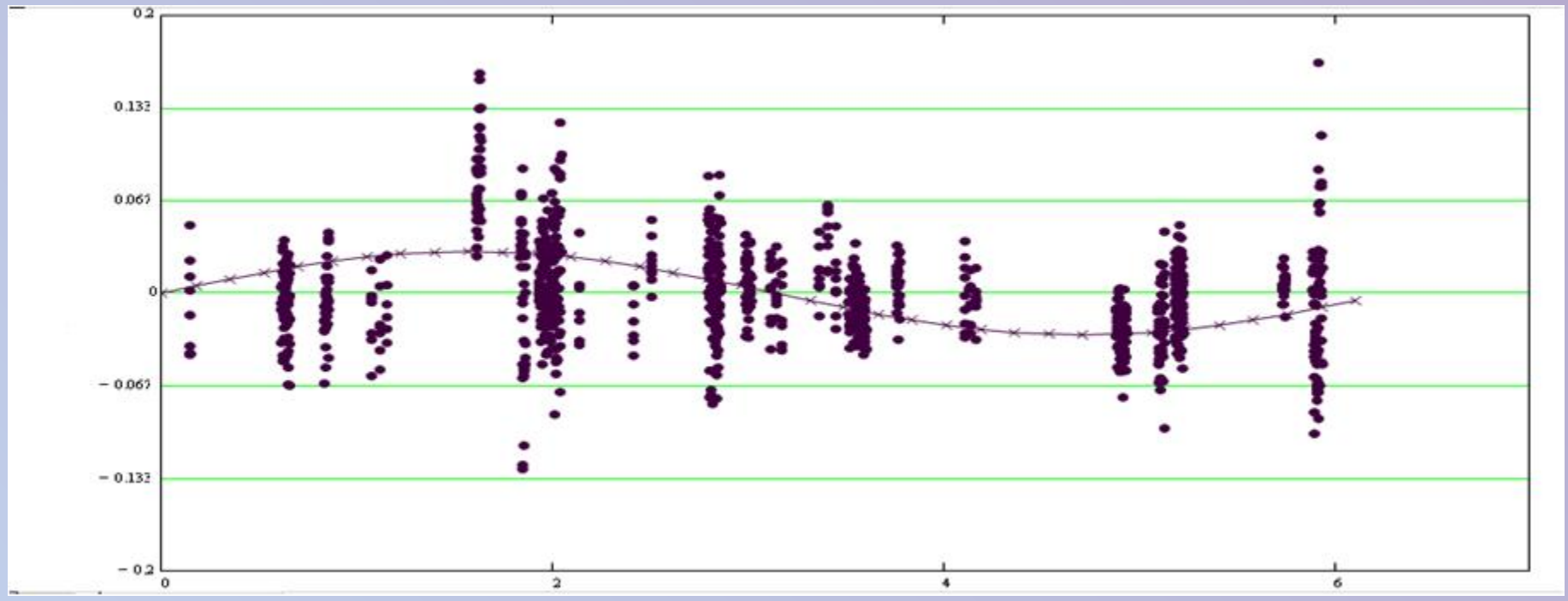
Period Search Method	Filter	2005-2006				
		P_{atm}, min	P_1,days	P_3,days	P_4,days	P_5,days
Stellingwerf	**R**			**3.74±0.04**	**2.39±0.31**	**1.68 ± 0.09**
Moving Average Method	**B V R I**	**37-47, 82-112**	**6.277 ± 0.009**			
Maximum Entropy Method	**B V R I**	**39-48, 92-109**	**6.403 ± 0.0006**			

Phase curve of **HD68988** **(2005-2006)**

folded with orbital period P = 6.276 d

R - filter

Amplitude: A = 0.035 m



Detected periodicities of flux variations exoplanet system **HD219828** 2012, July P = 3.8335 ± 0.0013 days

Period Search Method	Fil-ter	2012				
		P_{atm}, min	P_1, days	Ampli-tude, m	P_2,days	P_3,days
Stelling Werf	B V R I				--- 3.58±0.64 3.63±0.79 3.58±0.75	3.32±0.44 --- 3.30±0.55 ---
Maxi-mum Entropy Method	B V R I	18-23, 42-48 103- 109	3.83 3.83 3.83 3.83	< 0.015 < 0.015 < 0.015 0.015		

Detected periodisities of flux variations

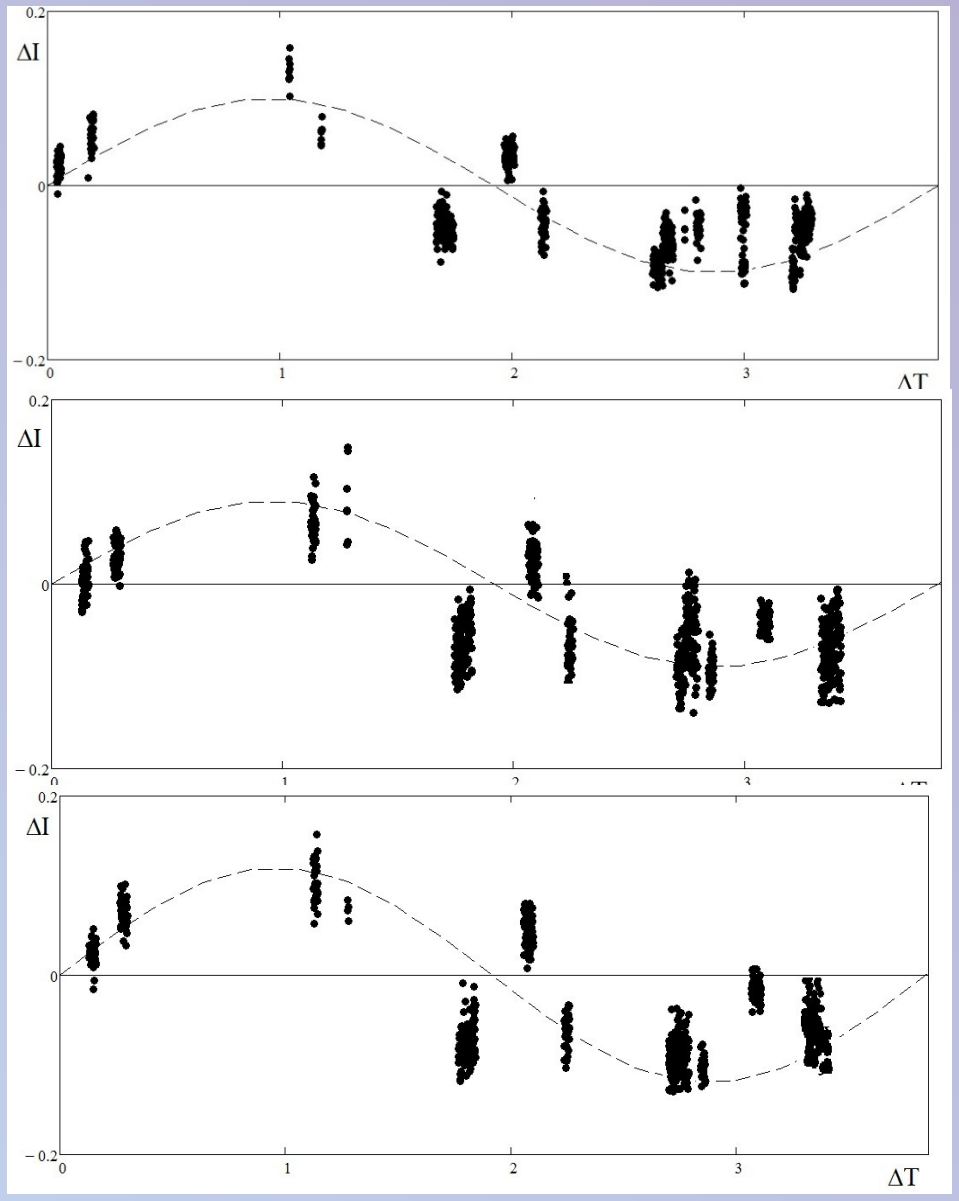
exoplanet system **HD219828**

2013, July

P = 3.8335 ± 0.0013 days

Period Search Method	**Filter**	**2013**		
		P_{atm}, min	**P_1,days**	**Amplitude, mag**
Maxi-mum Entropy Method	B V R I	18-22, 42-47	3.83 3.83 3.83 3.83	< 0,012±0.007 < 0,012±0.007 0,012±0.007 < 0,012±0.007

Phase curve of **HD219828** **(2013)** in Filters BVR folded with **orbital period P = 3.8335 d**



Amplitudes:

A_R = 0,012±0.007 m

A_B, A_V < 0,012±0.007 m

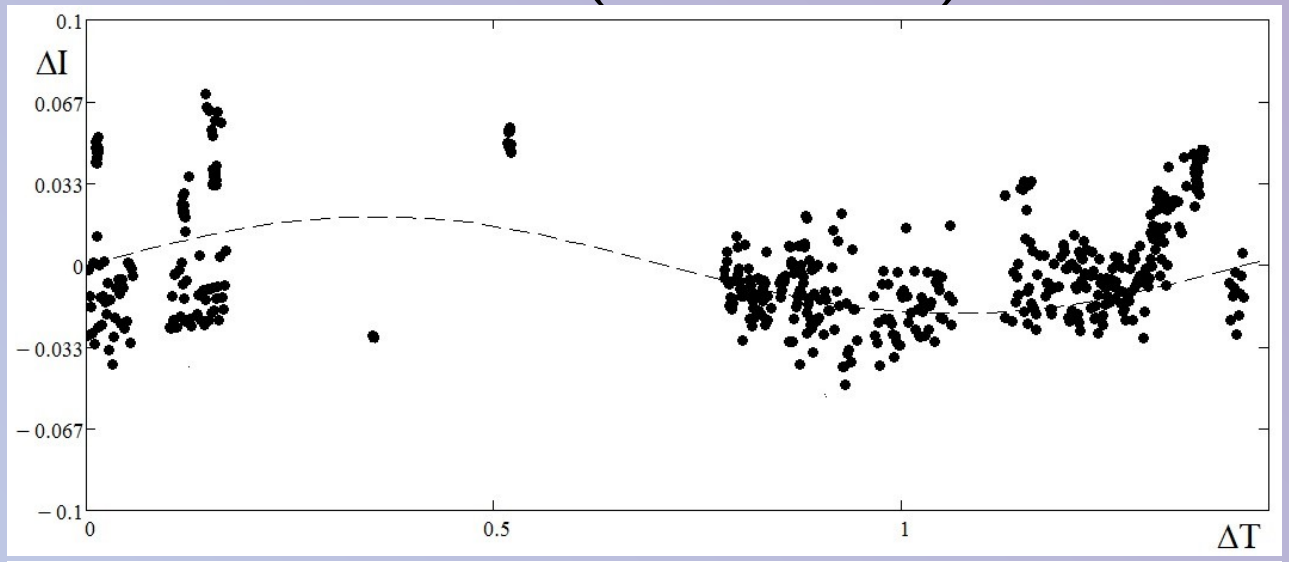
Detected periodicities of flux variations

exoplanet system **Qatar-1**

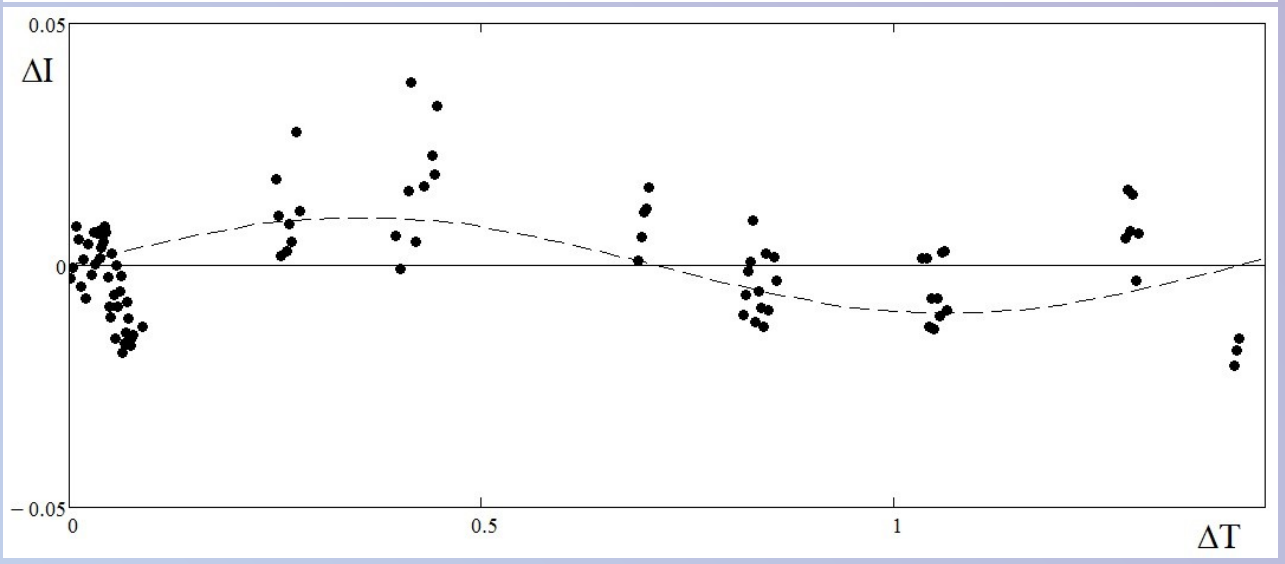
P = 1.42 ± 0.001d

Period Search Method	Filter	2012-2015			
		P_{atm}, min	P_1, days	Amplitude, mag (CrAO)	Amplitude, mag (Terskol)
Maximum Entropy Method	B V R	18-21, 41-48	1.42 ± 0.008	0,013±0,015 0,010±0,009 0,010±0,009	0,02±0.007 0,02±0.007 0,02±0.007

Phase curve of **Qatar-1** folded with orbital period **P = 1.42 d** Filter R (2012-2015)



peak Terskol observatory



Crimean Astrophysical observatory

SUMMARY

Name		**HD68988b**	**QATAR-1 b**	**HD168746b**	**HD219828 b**
M × sin *i*		**1.9 M_J**	**1.09 M_J**	**0.23 M_J**	**0.066 M_J**
a, AU		**0.071 AU**	**0.02343 AU**	**0.065 AU**	**0.052 AU**
Orbital period, d		**6.276** ± 0.002	**1.42002** ± 7e-07	**6.403** ± 0.001	**3.8335** ± 0.0013
Amplitude B, mag	2013Crao Terskol: 2012-2015		0,013±0,015 0,02 ±0.007	0,010±0,008 0.03	< 0,012±0.007 < 0.015
Amplitude V, mag	2013Crao Terskol: 2012-2015		0,01±0,009 0,02±0.007	0,009±0,006 0.015	< 0,012±0.007 < 0.015
Amplitude R, mag	2013Crao Terskol: 2012-2015 2005-06	 0.035	0,01±0,009 0,02±0.007	0,012±0,006 0.02 0.055	0,012±0.007 < 0.015
Amplitude I, mag	2013Crao 2012			 0.015	< 0,012±0.007 0.015

CONCLUSIONS

- The phase curves analysis for 4 exoplanet systems and variation periods obtained from periodogram analysis indicate the correspondence to orbital period of exoplanets or their harmonics. Values of variation periods detected in different filters are in close agreement.

- Amplitudes of variations are within 0.055-0.012 magnitudes range for different filters.

- Detected periods of variations indicate to connection of chromospheric activity variations with exoplanet orbital periods. So, it is quite possible that variations of host star chromospheric activity caused by close massive exoplanets.

- Observation precisions with using small telescopes are completely enough for solution of task. Further it is necessary to carry out spectral monitoring observations to confirm obtained results using 2-meter class telescopes.

Thank you for attention!