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STATISTICAL ANALYSIS OF OBSERVATION DATA OF EXOPLANETS (for the period from 1992 to March 2016)

Abstract: *The modern and advanced methods of the detection and investigation of exoplanets are analyzed. The statistical analysis of exoplanets was carried out on the basis of existing data on their specific features and properties.*
Key words: *Exoplanets, transit methods, statistical analysis, radial velocity, Kepler telescope, wasp, timing, observation.*
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Introduction

Difficulties in detecting exoplanets are associated with their rotation around stars outside the solar system and their relatively small size. They differ significantly from stars in brightness and are ranked as dim planets. According to recent estimates, the number of "confirmed planets" reached about 2125 without taking into account another 6 exoplanets discovered in March 2016. There are more than 4175 “candidates for exoplanets,” thanks to ongoing projects [1-2].

According to forecasts, there are up to 100 billion of them in the Milky Way Galaxy [3,5]. With the joint use of the spectrometric method for measuring the radial velocity of a star (Doppler method) and the transit method, when the planet passes through the background of a star. Not only density is calculated, but also the size of the planet. The Doppler method (for example, using a high-precision HARPS spectrograph) allows to record the shift of the star’s spectrum, planet mass, orbital period, eccentricity and lower limit of the mass of the exoplanet $M_jSIN\alpha$.

The transit method was used by SuperWASP, consisting of 2 observatories. The method of gravitational microlensing is based on the principle of observing an object with two derivatives. Between the studied star or galaxy and the observation point, another star acts as a lens, concentrating with its gravitational field the light of the star under observation. If planets are present in the lens star, an asymmetric light curve arises. The astrometric method is based on taking into account changes in the star’s own motion under the gravitational influence of the planet. So the mass of the exoplanet Epsilon Eridanus b was studied. In the case when the planets revolve around the pulsar, strong concentrated clusters of radiation will form conical surfaces in space, that is, the emitted signal is stabilized and has a stable character. This method is known as pulsar radio surveillance. The direct observation method allows to obtain images of exoplanets by isolating them from star light. It is used when observing young stars that have retained heat since their inception. So four planets of the HR 8799 system were discovered [6,7,8]. In the study of exoplanets, based on world databases [4], a statistical analysis of these objects from the point of view of detected exoplanets per year was carried out. As can be seen in Fig. 1, studies conducted in 1992, when the first exoplanets were recorded, are considered effective.

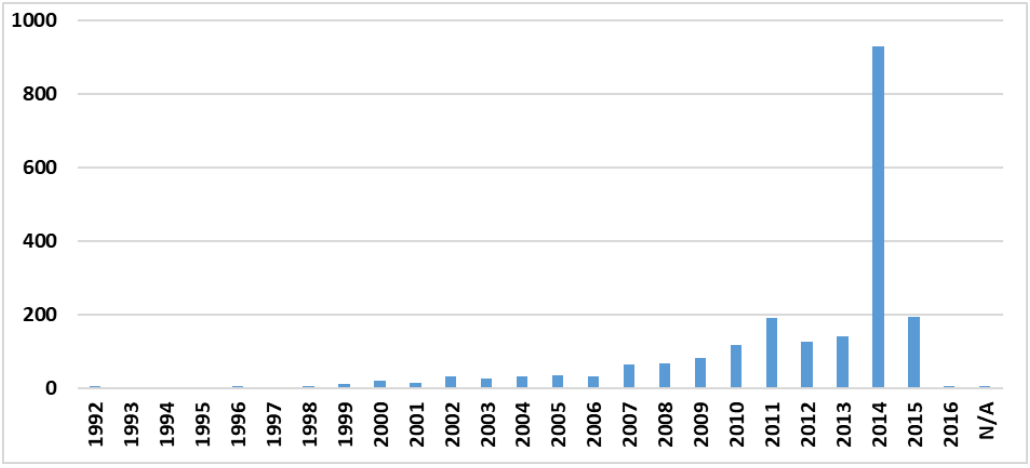
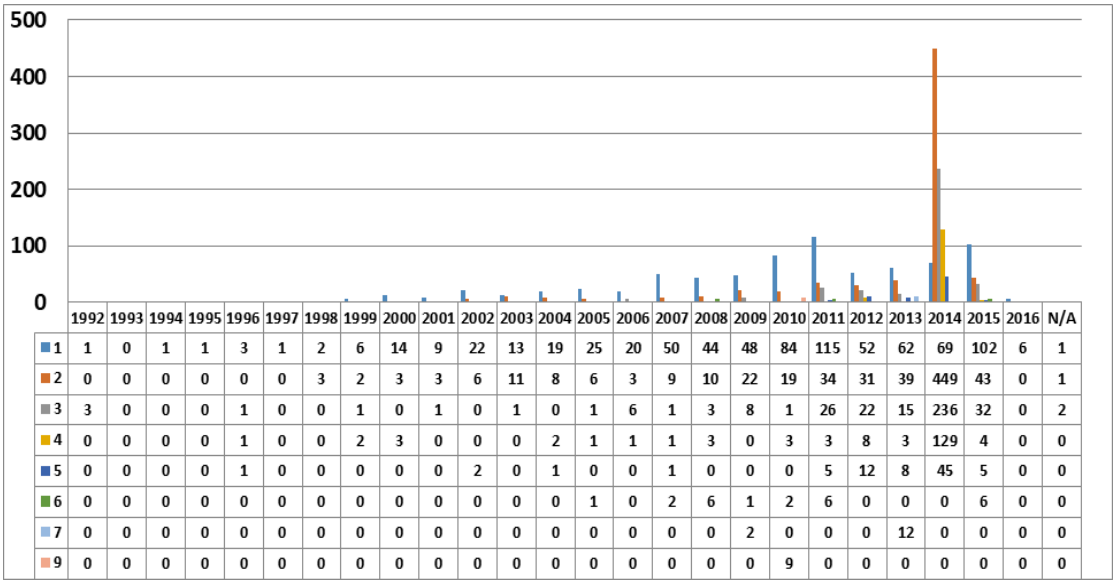


Fig. 1. Number of exoplanets detected per year

From 2007 to 2009, there was a slight increase in cases of successful calculation of the circumstellar planets. An analysis of the discovered circumstellar celestial bodies indicates a steady increase in discoveries and from 2010 to 2013 from 118 to 139 annually with a slight increase. In 2011, 189 exoplanets were discovered. In 2014, their number increased to 928 in one year. The number of confirmed planets has reached about 2125. The distribution of planetary systems from 1 to 9 exoplanets is shown in Fig. 2. Such stars are grouped and determined by the number of exoplanets containing them. That is, the first planetary system includes one exoplanet, the second - two, the third - three, etc. Eight planetary systems have been identified, since each of them has from one to 9 exoplanets. An exception is a star with 8 exoplanets, since it has not yet been possible to fix one (see Fig. 2).



	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	N/A
1	1	0	1	1	3	1	2	6	14	9	22	13	19	25	20	50	44	48	84	115	52	62	69	102	6	1
2	0	0	0	0	0	0	3	2	3	3	6	11	8	6	3	9	10	22	19	34	31	39	449	43	0	1
3	3	0	0	0	1	0	0	1	0	1	0	1	0	1	6	1	3	8	1	26	22	15	236	32	0	2
4	0	0	0	0	1	0	0	2	3	0	0	0	2	1	1	1	3	0	3	3	8	3	129	4	0	0
5	0	0	0	0	1	0	0	0	0	0	2	0	1	0	0	1	0	0	0	5	12	8	45	5	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	6	1	2	6	0	0	0	6	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	12	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0

Fig. 2. Distribution of exoplanets by planetary systems

As can be seen from Fig. 2, in 2014, out of 928 planetary systems, 69 stars with single circumstellar planets, 449 planetary systems of 2 exoplanets, 236 of three, 129 of four circumstellar planets were recorded. In the same year, the largest number was discovered - 45 planetary systems with 5 planets. Only two exoplanet systems were discovered twice - 9 were discovered in 2009, and 12 in 2013. A planetary system with nine exoplanets was discovered in 2010 [9,10,11]. The classification of exoplanets according to their detection methods is shown in Fig. 3.

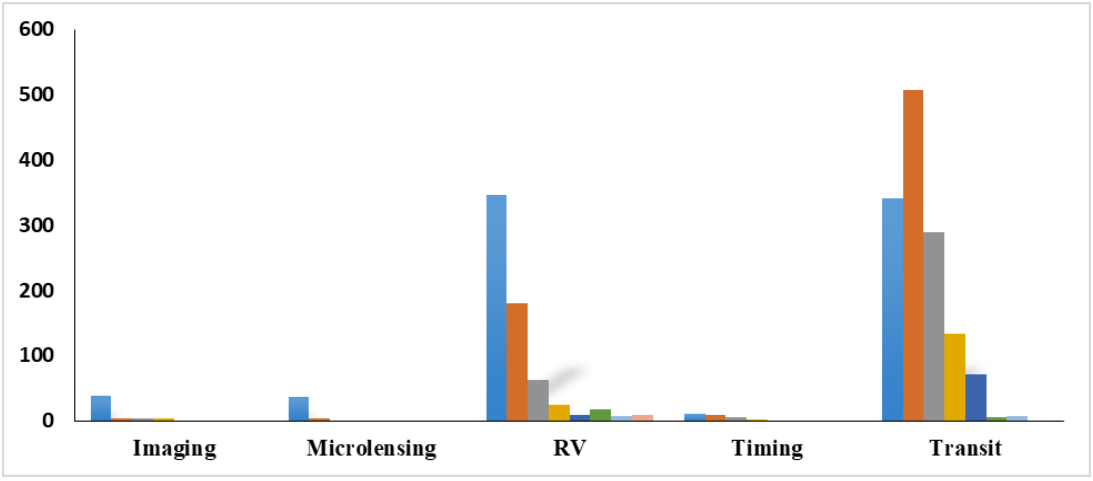


Fig. 3. Classification of exoplanets by their detection methods

By the method of spectrometric measurement of the radial velocity of the star and the transit method, the largest number of exoplanets is discovered. Priority is assigned to stars with one, two, three, four and five exoplanets. The method of gravitational microlensing and direct observation proved to be in the discovery of stellar systems with one and to a lesser extent with two and four exoplanets. Systematization by spectral characteristics made it possible to determine the number of exoplanet parent stars corresponding to the characteristics (in Fig. 4). A temperature with an interval of 500 Kelvin (K) is selected for the analysis of the parent stars. The sun has a temperature of about 5750 K. As shown in Fig. 5, the temperature distribution of stars has an asymmetric shape with a maximum of about 6000 K. This means that many stars have temperatures close to the sun.

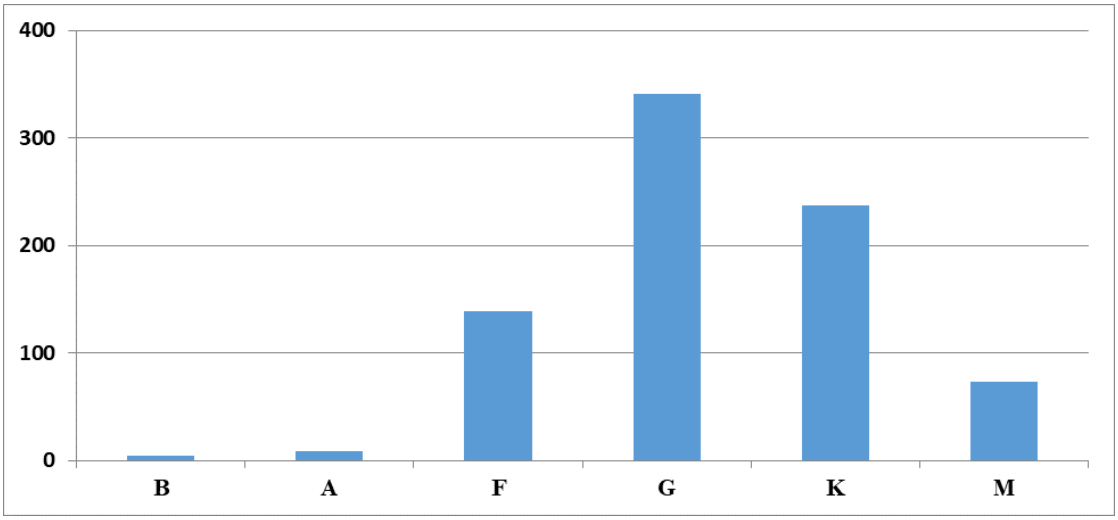


Fig. 4. Spectral classification of exoplanet parent stars

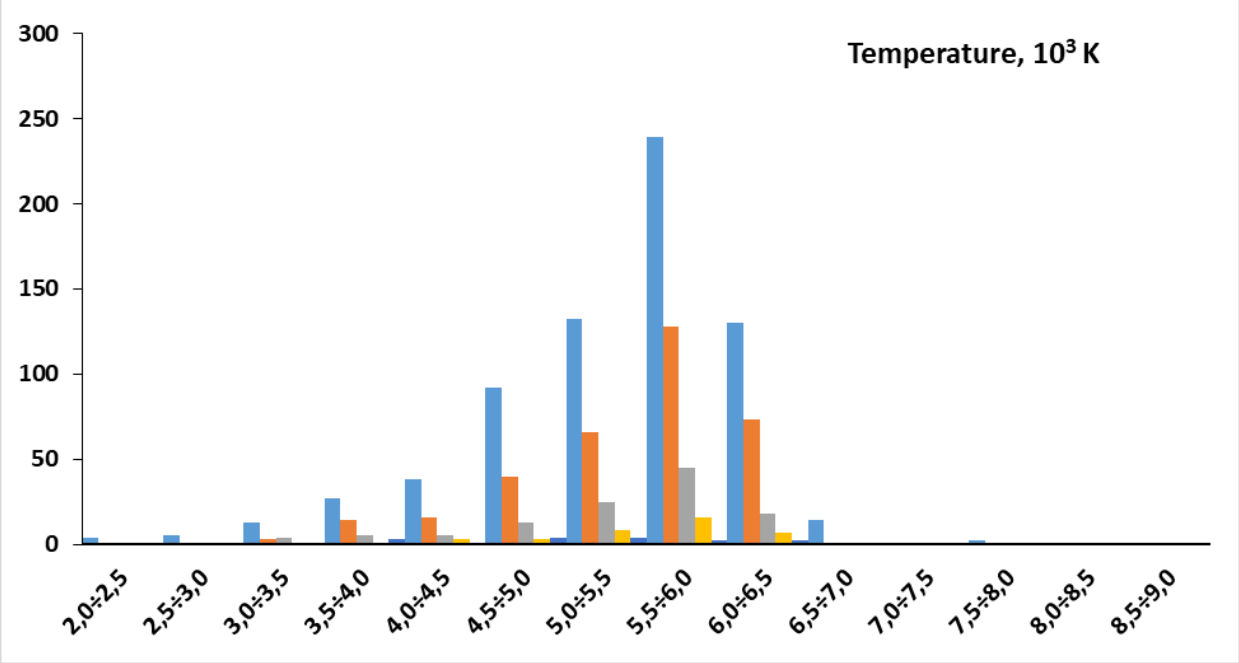


Fig. 5. Temperature distribution of exoplanet parent stars

Conclusions

Consequently, the study of exoplanets is entering a fairly active phase and will improve the tools for predicting natural disasters and develop measures to prevent space threats, as well as provide the future generation with energy resources and minerals.

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