RELATION OF BRIGHTNESS VARIATIONS OF SHORT-PERIOD COMETS 28P/NEUJMIN 1, 53P/VAN BIESBROECK, 63P/WILD 1 WITH THE ACTIVITY OF THE SUN

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The report examines the relationship between the brightness variation of the daily mean values of comets 28P/Neujmin 1, 53P/Van Biesbroeck, 63P/Wild 1 with the activity of the Sun. The correlation coefficient of the mean daily brightness of comets versus.Wolf number and the area of sunspots for each orbital period of the above comets have been determined. It turned out that the influence of solar activity in comet 28P/Neujmin 1 is insignificant in comparison with comets 53P/Van Biesbroeck, and 63P/Wild 1. Only in the appearance in 1966 the value r (W) = 0.92 r (S) = 0.94, in other occurrences (1931, 1984, 2002 and 2020), the value of the correlation coefficient is insignificant. Although the diameter of the comet's nucleus is larger than that of other short-period comets, and the albedo in the R filter is only 0.03. The values of the correlation coefficient for comet 53P/Van Biesbroeck in the appearances (1978, 1991, 2003, and 2016) are in the range 0.56÷0.77 (for the Wolf number) and 0.54÷0.71 (for the sunspot number).

Keywords: comets – brightness – Solar activity – correlation coefficient

1. INTRODUCTION

Investigation of the evolution of photometric parameters of short-period comets has made it possible to detect a very important regularity, namely, the inverse dependence of the velocity of incidence of the absolute brightness of some short-period comets on the perihelion distance of their orbit. This confirms the gradual overgrowth of the icy cometary nucleus by the refractory mineral crust

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and the evolution of such comets into asteroids-like bodies. Subsequent studies of Comet 1P/Halley, 9P/Tempel 19P/Borrelly, 81P/Wild 2 and 67P/Churyumov-Gerasimenko using spacecraft (VEGA-1, 2, Giotto, Deep Impact, Deep Space 1, Rosetta) confirmed the presence of a dark refractory crust on the surface of the nucleus of these comets [1].

There are families of short-period comets of other major planets. The number of such comets in the second place are short-period comets of the family of the planet Saturn. Because the period of rotation around the Sun of comets of this family is much larger than the period of rotation of short-period comets of the Jupiter family, the number of observations of these comets is less than the number of observations of comets of the Jupiter family [2], [3], [4], [5].

The purpose of this work is to reveal the relationship between the photometric parameters of short-period comets 28P/Neujmin 1, 53P/Van Biesbroeck, 63P/Wild 1 with the activity of the sun for each orbital period.

2. OBSERVATION

Comet 28P/Neujmin 1 was discovered on September 3,98 1913 by G.N. Neuimin (Simeis Observatory, Cremia, Russia). The object was stellar and of magnitude 10,0. [6]. The comet's orbital period P is about 18 years. The diameter of the comet's nucleus is 21.4 km and its albedo is very low (0.025) [7]. Comet 53P/Van Biesbroeck was discovered on September 1, 1954 [6]. The comet's orbital period around the Sun is 12.53 years. The diameter of the comet's nucleus is 6.66 km and its albedo is 0.03 [7]. Comet 63P/Wild 1 was discovered on March 26, 1960, since the comet was not found in 1986, it was discovery on February 4, 1973 [8]. The comet's orbital period around the Sun is 14.90 years. The diameter of the comet's nucleus is 2.9 km and its albedo is 0.03 [7]. The comet was observed in investigation in 1999 and 2012. Its next orbital perihelion transition will take place on July 6, 2026.

In this work, the investigation of comet 28P/Neujmin 1 in 1931, 1966, 1984, 2002 and 2020 is studied, for comet 53P/Van Biesbroeck, the investigation of 1978, 1991, 2003 and 2016 is considered, and for comet 63P/Wild 1, the investigation of 1960, 1999 and 2013.

3. METHOD

For the analysis of the light curve of comets, more than a dozen estimates of the integrated visual brightness for individual comets were used. Integral visual brightness of comets borrowed from the archives of the International Comet

Quarterly, Comet Section of BAA and IAUC. For the most accurate information, the comet's brightness estimates were reduced to the standard telescope aperture using the Morris method [9], and the daily mean apparent brightness of the comet was derived. The obtained values were reduced to a unit geocentric distance according to the technique given in [10].

The method of qualitative comparison of features is convenient for studying cometary phenomena, which was first used by O.V. Dobrovolsky [11]. The essence of the method is to divide the entire observation period T of the comet into n equal time intervals , so that at each of them there is no more than one maximum of the Sun's activity or the brightness of the comet m. We have chosen the daily average apparent brightness and have chosen daily Wolf numbers and sunspot area as solar activity.

For an accurate determination of the correlation coefficient between the daily average apparent brightness with the activity of the Sun, there is such a pattern [11]:

$$r = \frac{N_{mW}N - N_W N_m}{\sqrt{\bar{N}_W \bar{N}_{\bar{W}} \bar{N}_m \bar{N}_{\bar{m}}}}, \tag{1}$$

and its standard is:

$$\sigma = \frac{1 - r^2}{\sqrt{n}}, \tag{2}$$

where N_{mW} is the number of intervals with maxima W and m, N_W is the number of intervals with maxima W but no maximum m, N is the number of intervals without maxima m, N_m is the number of intervals without a maximum W, but with a maximum m, $\bar{N}_W$ is the total number intervals with maxima W, $\bar{N}_{\bar{W}}$ is the number of intervals without maxima W, $\bar{N}_{\bar{m}}$ is the number of intervals without maxima m and n is the total number of intervals.

4. RESULTS AND DISCUSSION

The results of the study of the relationship between the brightness variation of the daily mean values of comets 28P/Neujmin 1, 53P/Van Biesbroeck, 63P/Wild 1 with the activity of the Sun showed that for comet 28P/Neujmin 1 the influence of solar activity, with the exception of 1966, is insignificant. In 1966, the value of the correlation coefficient for 40 daily average brightness after the moment of passing the perihelion of the orbit for the area of sunspots is 0.94 and for the Wolf number 0.92. Hence it follows that the variation in the daily brightness of the comet 28P/Neujmin 1 correlates with the activity of the Sun. Comet 28P / Neujmin 1 is not activity nucleus, the nuclei rotation period is 12.75 hours [7]. During

the past centuries, the comet made only two close approaches to the Earth, but as many as five approaches to Saturn. As a result, the approach to the Earth at a distance of 0.55 AU. September 2, 1913 contributed to the discovery of the comet. The second time at a distance of 0.87 AU. from Earth on August 10, 1984. Most comets of the Saturn family depend on the disturbing force of Jupiter.

Table 1. The value of the correlation coefficient for short-period comets 28P/Neujmin 1, 53P/Van Biesbroeck and 63P/Wild 1

	Sunspot area (S)			Wolf numbers (W)		
Years of observation	γ	R	σ	γ	r	σ
Comet 28P/Neujmin 1						
1931	50	0.75	±0.06	50	0.77	±0.06
1966	40	0.94	±0.02	40	0.92	±0.02
1984	60	0.80	±0.02	60	0.81	±0.04
2002	100	0.63	±0.06	100	0.60	±0.06
2020	70	0.40	±0.10	70	0.43	±0.09
Comet 53P/Van Biesbroeck						
1978	43	0.70	±0.06	43	0.77	±0.06
1991	60	0.54	±0.09	60	0.56	±0.09
2003	130	0.68	±0.04	130	0.69	±0.04
2016	140	0.71	±0.04	140	0.70	±0.04
Comet 63P/Wild 1						
1960	43	0.97	±0.01	43	0.83	±0.05
1999	80	0.69	±0.05	80	0.67	±0.06
2013	130	0.54	±0.09	130	0.60	±0.09

The table 1 shows the moments of comet observation, the number of the total average daily visual brightness of the comet γ, the values of the correlation coefficient r and the standard σ.

The results of the correlation of the average daily total brightness of comet 53P/Van Biesbroeck show that the values for the sunspot area vary from 0.54 to 0.71, and the values of the Wolf number from 0.56 to 0.77. Results of the study by Kresak et al. [12], comet 53P/Van Biesbroeck is a secondary fragment of a hypothetical comet that fragmentation in March 1845.

The results showed that for comet 63P/Wild 1, the values of the total daily brightness varied with the area of sunspots only in 1960. For other cases, the values of the correlation coefficients for comet 63P/Wild 1 vary from 0.54 to 0.83.

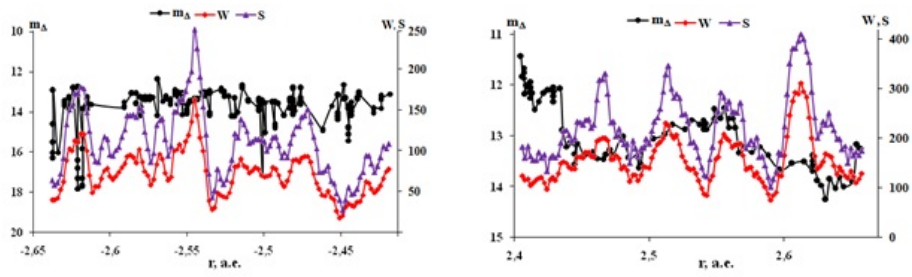

Fig. 1. Brightness variation of short-period comets 53P/Van Biesbroeck in 2003 before and 1991 after the orbital perihelion distance and solar activity

The results of the study by Bettio et al. [13] showed that the absolute stellar magnitude of the comet during the observation period of January and April 2013 is 16 magnitudes. Lowry and Fitzsimmons [8] research shows the comet's nuclei radius to be 0.6 km and Betty et al. [13] results show the comet's nucleus radius to be 1.5 km.

5. CONCLUSIONS

The correlation coefficient of the mean daily brightness of comets 28P/Neujmin 1, 53P/Van Biesbroeck, 63P/Wild 1 versus Wolf number and the area of sunspots for each orbital period of the comets. It turned out that the influence of solar activity in comet 28P/Neujmin 1 is insignificant in comparison with comets 53P/Van Biesbroeck, and 63P/Wild 1. Only in the appearance in 1966 the value r (W) = 0.92 r (S) = 0.94, in other occurrences (1931, 1984, 2002 and 2020), the value of the correlation coefficient is insignificant. The values of the correlation coefficient for comet 53P/Van Biesbroeck in the appearances (1978, 1991, 2003, and 2016) are in the range 0.560.77 (for the Wolf number) and 0.540.71 (for the sunspot number).

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