Planetary and Space Science ■ (■■■■) ■■■–■■■

Contents lists available at ScienceDirect

Planetary and Space Science

journal homepage: www.elsevier.com/locate/pss

Short Communication

Three predictions: Comet 67P/Churyumov–Gerasimenko, comet C/2012 K1 PANSTARRS, and comet C/2013 V5 Oukaimeden

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ARTICLE INFO

Article history:
Received 10 March 2014
Received in revised form
24 April 2014
Accepted 2 May 2014

Keywords:
Comets
Solar system

ABSTRACT

We make the following predictions: (1) The secular light curve (SLC) of comet 67P/Churyumov–Gerasimenko exhibits a photometric anomaly in magnitude that is present in 1982, 1996, 2002 and 2009. Thus it must be real. We interpret this anomaly as a topographic feature on the surface of the nucleus that may be a field of debris, a region made only of dust or an area of solid stones but in any case it is depleted in volatiles. We predict that images taken by spacecraft Rosetta will show a region morphologically different to the rest of the nucleus, at the pole pointing to the Sun near perihelion. (2) Comet C/2012 K1 PANSTARRS exhibits the same Slope Discontinuity Event (SDE)+magnitude dip after the event than other comets listed in Table 1 most of which disintegrated. This group includes comet C/2012 S1 ISON. Thus, it is reasonable to expect that this comet may disintegrate too. The probability of disintegration of this comet is 27%. (3) Comet C/2013 V5 Oukaimeden exhibits the same SDE+standstill signature exhibited by other comets in Table 1. We predict that there is a 93% probability that this comet will disintegrate. (4) Another purpose of this work is to present evidence to conclude that the SLCs have predictive power.

1. Introduction

An important part of the Scientific Method establishes that predictive power is a required component of any scientific theory. Predictions test our capability to understand the Universe. Recently the research line on secular light curves of comets (SLCs) has been advanced significantly (Ferrín, 2005–2010, 2013a, 2013b, 2014). The SLCs are the scientific way to study the brightness behavior of a comet, and more than 20 physical parameters, most of them new, can be extracted from the light curves. SLCs allow making predictions on comets as we will see. Thus they are a valuable tool to understand these objects.

In the *Atlas of Secular Light Curves of Comets*, V.1, (Ferrín, 2010), several light curves of comets showed photometric anomalies that do not have a physical explanation. One of those comets was 67P/Churyumov–Gerasimenko. In this work we interpreted the photometric anomaly of this comet as a topographic feature on the surface of the nucleus.

Advances in our SLCs comprehension have allowed predicting the disintegration of comet C/2012 S1 ISON (Ferrín, 2013a, 2013b, 2014). The prediction was based on the fact that the comet exhibited a slope discontinuity event (SDE)+standstill after the event signature, that appears also in other comets listed in Table 1, many of which disintegrated. This comet disintegrated before reaching perihelion (Battams and Knight, 2013; Ferrín, 2014).

We will make two predictions on the disintegration of comets C/2012 K1 PANSTARRS, and comet C/2013 V5 Oukaimeden, and will give a probability for their occurrence.

After the SDE some comets exhibit a "standstill" in magnitud, while others exhibit a "dip". For example the dip of comet Bressi is large and reaches $\Delta m = +1.5$ mag, while the dip of comet ISON is practically zero (a standstill) (Fig. 5). This behavior is related to some physical characteristic of the comet but explaining the reason why is beyond the scope of this paper, whose only purpose is to prove that the SLCs have predictive power.

2. Comet 67P/Churyumov–Gerasimenko

There has been a recent determination of the diameter of this comet by Kelley et al. (2009) and it is adopted in the SLC presented in Fig. 1 and 2. The SLC of this comet exhibits a dip in magnitude that is reproduced in 1982, 1996, 2002 and 2009. Thus it must be real. There has not been a physical interpretation of this feature and we are now proposing that a possible explanation is a topographic feature on the surface of the nucleus. The feature may be a field of debris, a region made only of dust or an area of solid stones but in any case it has to be an area depleted in

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http://dx.doi.org/10.1016/j.pss.2014.05.005

Table 1
ISON's Group. (7), (8), (9).

Nos.o.	Comet				R (Dis) [AU]	Q [AU]	CODE (1)	1/a Original or e (10)	Identifier (1)
01	**C/2002**	O4	(Hönig)	(6)	−0.88	0.78	S+d+DN+D	−0.00077249	I. Ferrín
02	**C/2012**	T5	(Bressi)		−0.66	0.32	S+d+DN+D	−0.00022724	J. Cerny
03	**C/1999**	S4	(LINEAR)		−0.92	0.77	S+d+DN+D	−0.00005451	G. Kronk
04	**C/2009**	R1	(McNaught)	(5)	−0.79	0.41	S+d+DN+D	−0.00003180	C. Hergenrother
05	**C/2012**	V1	(PANSTARRS)	(14)	−3.49	2.09	DN+D	−0.00001928	I. Ferrín
06	**C/2012**	S1	(ISON)	(12)	−0.67	0.01	S+d+DN+D	0.00000852	I. Ferrín
07	C/2012	K1	(PANSTARRS)	(7)	——	1.05	S+d	0.00003136	I. Ferrín
08	C/2013	V5	(Oukaimeden)	(7)	——	0.63	S+d	0.00003300	I. Ferrín
09	C/2010	X1	(Elenin)		−0.64	0.48	S+d+D	0.00011071	A. Cook
10	C/1996	Q1	(Tabur)		−0.93	0.84	S+d+D	0.00182608	I. Ferrín
11	C/1897	U1	(Perrine)=1897 III		−1.61	1.36	D	1.0000000	Z. Sekanina
12	C/1957	U1	(Latyshev-Wild-Burnham)		−1.11	0.54	D	1.0000000	Z. Sekanina
13	C/1974	V2	(Bennet) 1974XV		−0.98	0.86	D	1.0000000	Z. Sekanina
14	C/1953	X1	(Pajdusakova) 1954 II		−0.74	0.07	D	1.0000000	Z. Sekanina
15	C/2004	S1	(Van Ness)	(13)	−1.36	0.68	D	1.0000000	I. Ferrín
16	C/2008	J4	(McNaught)Headless comet	−0.64	0.45	D	1.0000000		I. Ferrín
17	C/1925	X1	(Ensor)=1926	III	−0.63	0.32	D	1.0000000	Z. Sekanina
18	C/1887	B1	headless comet	(3)	——	0.005	D	1.0000000	Z. Sekanina
19	20D/1913	S1	(Westphal)	−1.43	1.25	D	0.9198301		Z. Sekanina
20	P/2006	HR30	(Siding Spring)	(4)	——	1.23	S+d	0.8437940	I. Ferrín
21	C/1997	N1	(Tabur)(unconfirmed)	——	0.40	D	1.0001344		G. Kronk

1. CODE: S=slope discontinuity event (SDE); *d*=dip (or standstill) after SDE; DN=dynamically new; D=disintegrated. Additionally the group has $-1.61 < R$(Dis) < -0.63 AU.
2. After publishing the first manuscript in the Arxiv.org depository, Gary Kronk, Toni Cook and Jacub Cerny (personal communication), discovered four additional members of the group.
3. See Sekanina (1984).
4. All comets in this list are Oort Cloud members, while this comet is periodic, which raises some interesting questions about its origin. Additionally this comet has not disintegrated and it is due to return in 2027. However it exhibits the signature.
5. Hergenrother (2010) has a light curve showing the SDE+standstill, while Seiichi's web site http://www.aerith.net shows that the comet was not detected post-perihelion, all consistent with disintegration, although this was not observed.
6. Dynamically new comets have been highlighted in black.
7. These two comets exhibit the SDE+stanstill signature, but are still far from perihelion and have not yet disintegrated.
8. From column 3, *R*(Dis), we deduce that there is a *R*(limit)$=-0.63$ AU (pre-perihelion). All comets have disintegrated before reaching this limit.
9. From the next to the last column, it is clear that dynamically new comets have a clear tendency to disintegrate.
10. The SLCs of many of these comets have been presented by Ferrín (2013a, 2013b, 2014) and are not repeated here due to space limitations.
11. In this work we define dynamically new as $1/a$ (original) < 0.00001000. Negative $1/a$ apply to hyperbolic comets. The $1/a$ (original) value is given when available.
12. The disintegration distance for comet ISON was determined using data by Ferrín (2013a) and by Combi et al. (2013) (CBET 9266).
13. Sekanina et al. (2005). C/2004 S1 Van Ness: A Split Suddently Vanishing Comet. Cometary Science Team Preprint Series No. 203, July 2005.
14. Although this comet is dynamically new and disintegrated, the large pre-perihelion distance at which it took place, is suspect. This could happen only if this comet were a very fast rotator.

volatiles. Spacecraft mission Rosetta is due to reach the comet in middle 2014 and will take high resolution images of the nucleus. *Thus our prediction is that these images will show a region of different morphological characteristics to the rest of the nucleus at the pole pointing to the Sun near perihelion*.

If the north or south pole of the comet pointed to the Sun at ~ -68 days before perihelion (obliquity of 90°), then there would be a polar cap of $\sim 54°$ in radius, depleted in volatiles by a factor of $5.3\times$. On the other hand if the pole has an obliquity of 45°, then the depleted area may extend to half of the nucleus, producing two unequal hemispheres with different terrains. If the equator of the comet pointed all the time to the Sun (zero obliquity), there would be no way to explain the observations. Thus the photometric observations suggest that the comet has a large obliquity.

This prediction will be tested when spacecraft Rosetta reaches to the comet and takes high resolution images of its surface (http://sci.esa.int/rosetta/2279-summary/). The spacecraft will arrive at the comet on August 2014 when it will start a global mapping, and a lander will be deployed in November of the same year.

3. Comet C/2012 K1 PANSTARRS

This comet exhibits the same Slope Discontinuity Event (SDE)+ magnitude dip after the event (Fig. 3) than other comets listed in Table 1 (Fig. 5). Thus it is reasonable to expect that this object may disintegrate too. However, the perihelion distance is $q=1.05$ AU, and thus it does not reach to the critical distance $R(\text{critical})=-0.63$ AU deduced from Table 1 (negative Rs mean pre-perihelion observations). *From Table 1, three comets of 14 have disintegrated at distances larger than 1.05 AU, thus it is possible to predict that the probability of disintegration of this comet is only 27%.*

This prediction will be tested around August 27th, 2014, when the comet will reach perihelion. However, the comet will be immersed in the solar glare. From August 6th to August 14th, the elongation angle from the Sun will be $E < 4°$ which implies that it should appear in images taken by spacecrafts observing the Sun, like SOHO and STEREO. On August 27th, the perihelion date, the elongation angle will be $E=18°$, so it may be observed for a brief period of time from ground based observatories.

4. Comet C/2013 V5 Oukaimeden

This comet exhibits the same SDE+standstill signature (Fig. 4) exhibited by other comets in Table 1 that disintegrated (Fig. 5), including the famous comet C/2012 S1 ISON. This is a dynamically new comet (DN) and from Table 1 it is clear that DN comets have a large probability of disintegrating. This result plus a perihelion distance $q=0.628$ AU $< R(\text{critical})=0.63$ AU deduced from Table 1, makes it virtually certain that this comet is going to disintegrate.

Please cite this article as: Ferrín, I., Three predictions: Comet 67P/Churyumov–Gerasimenko, comet C/2012 K1 PANSTARRS, and comet C/2013 V5 Oukaimeden. Planetary and Space Science (2014), http://dx.doi.org/10.1016/j.pss.2014.05.005