Recent high-cadence photometry and outburst characteristics of Comet 29P/Schwassmann-Wachmann 1

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Abstract

Results of high-cadence observations of Comet 29P during 2014–2018 inclusive are presented and the types of outburst characterised. Between 2014 March 03 and 2018 April 24, a total of 59 outbursts were detected and quantified in terms of outburst date and amplitude. The observed frequency corresponds to an average of >12 outbursts p.a. which is much higher than seen in previous years because of the fact that some 46% of the observed events were of less than 1.0 mag amplitude (i.e. mini-outbursts) and so would have essentially been missed by previous observers. Owing to the very high cadence, outburst timing accuracy was extremely good at 0.05d (mode), 0.27d (mean), and 0.34d (st.dev.). The brightest outburst attained ***r*** = 12.1 and the greatest observed amplitude was 5.1 mag. For the first time, 29P was imaged whilst outbursting (on 2017 July 02) and the derived photometry showed the rise from quiescence to half maximum light occurred within only 0.018d. Coma morphologies indicate prograde nuclear rotation.

1. Introduction

29P is arguably the most enigmatic and little understood comet known, especially given the fact that it has exhibited several outbursts each and every year since its discovery in 1927, and despite it occupying a relatively distant near-circular orbit about 6 au from the Sun, where incident solar radiation is weak and somewhat uniform over time. Two papers based on observations of 29P made between 2002–2014 resulted in a more detailed understanding of the comet showing that the spin period of the nucleus is extremely long, exhibiting a mean solar time of 57.7d [1, 2]. In 2014, as a follow-up to this previous work, intensive photometry of Comet 29P was begun, initially by the first two named authors but later supported by many other amateur astronomers, more especially those named here. This paper describes the results of these latest observations.

2. Observational Coverage

Each apparition of 29P lasts about 13 months, of which 2-3 months are out of view from Earth, being close to solar conjunction. The breakdown of the 59 outbursts detected since 2014 is as follows: 11(6) in 2014; 10(9) in 2015; 17(6) in 2016; and 20(8) in 2017. The number of outbursts of >1.0 magnitude amplitude are given in brackets, from which it can be seen that proportionately more mini-outbursts were detected in 2016 and 2017.

The chronology of outbursts has been evaluated by plotting the outburst times folded on a periodicity of 57.71d as illustrated in Figure 1. The seasonal distribution is very clearly non-random. Furthermore, 77% of **all** outbursts fall into two very distinct categories: either they are separated in time by almost exactly a **single** revolution of the nucleus (shown in green), or they occurred less than 0.2 of a revolution after a previous outburst (shown in red). These follow-up studies confirm earlier findings that several discrete cryovolcanoes are active and that one eruption can trigger one or more further events from nearby locations on the nucleus. Recent data show seasonal effects to be more pronounced than before.

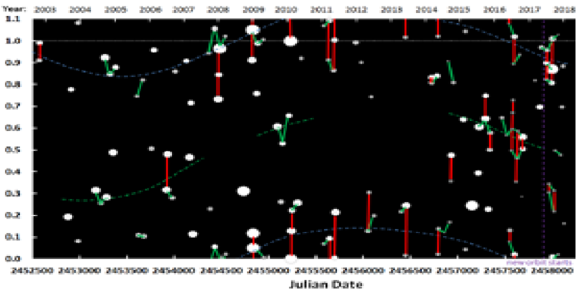

Figure 1: Seasonal plot of times of 120 outbursts (2002-2018) folded on a period of 57.71days.

3. Outburst: Rise to Maximum

Prior to 2017, no observer had ever measured the rising light-curve of any outburst of 29P. Miles et al. previously inferred from outburst statistics that the mean rise-time was about 1.7h [2]. Astonishingly, **two** European observers took a time-series of observations on 2017 July 02.05-02.11 that by chance happened to coincide with an outburst some 2.0 mag in amplitude. Figure 2 illustrates the first 75% of the observed rise to maximum, which was completed in about 0.05d or 1.2h confirming the earlier work. Half-light (50% maximum amplitude) was reached after just 0.018d indicative of the explosive nature of these events on the nucleus. Expansion of the dust and debris cloud appears to go through two regimes: a fast early stage when gas pressure accelerates material, followed by steady-state expansion during which time the debris cloud turns optically thin and some further disintegration of material may also occur.

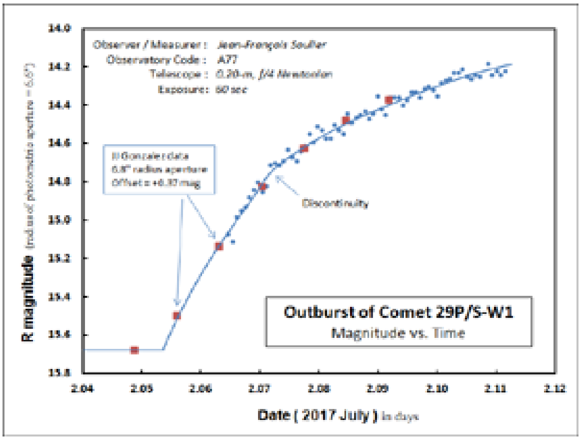

Figure 2: Plotted data from J.-F. Soulier (blue circles) and J.J. Gonzalez (red squares) of outburst light-curve of 2017 July 02.

4. Coma Morphology

Much more work will be needed to link the changes in the coma in the days following an outburst with active sites on the nucleus. Imaging of 29P using 1.0-m and 2.0-m telescopes has been crucial for studying the nature of the coma within about 2 days of an outburst. Given that cryo-eruptions are triggered by solar heating during local afternoon at the location of any eruption, preliminary findings indicate that rotation of the nucleus is in the prograde direction.

5. Conclusions

Much progress has been made in characterising the behaviour of 29P and this intensive monitoring by amateurs will continue, given that coverage of a 2nd orbital year of data began in 2017. As well as confirming seasonal dependence of outburst activity, it is hoped that new findings will support the proposed underlying mechanism in which hypervolatile CO (and potentially N_2), on dissolving in a hydrocarbon phase, liberates heat of solution thereby facilitating radial heat transfer in a very slowly rotating nucleus [3]. Waxy hydrocarbons would also facilitate the formation of an extensive crust able to withstand a significant internal pressure, but which could be easily weakened by long-lasting insolation. This work has yielded further evidence that repeat eruptions can arise from the same cryovolcano, the signature of which is evident from the resultant coma morphology, and which vent must therefore be easily plugged following each eruption.

Acknowledgements

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References

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