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# Giant Comet C/2014 UN271 (Bernardinelli-Bernstein) Provides New Evidence for Cometary Panspermia

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## Abstract

The discovery of a giant comet (C/2014 UN271) at a distance of 29 AU in October 2014 and the later discovery in September 2021 of a dramatic brightening episode offers an ideal opportunity for verifying the predictions of a "biological" comet. The eruptions of the comet at a heliocentric distance of 20 AU are plausibly explained as due to high pressure venting of the products of microbial metabolism in radioactively heated subsurface lakes. The standard non-biological model of comets is woefully inadequate to account for eruptions at such large distances from the sun where surface temperatures are as low as 60 K.

## Keywords

Comets, Cometary Activity, Bacteria and Viruses, Panspermia

## 1. Introduction

On 30th October 1980 Fred Hoyle and the present author presented an invited paper to the 5th College Park Colloquium on Chemical Evolution, University of Maryland, College Park, Maryland, U.S.A., with the title "Comets—a vehicle for panspermia" thus launching the theory of cometary panspermia (Hoyle and Wickramasinghe, 1981) [1]. In this theory comets are posited to be the carriers, incubators and distributors of cosmic life in the form of bacteria and viruses throughout the galaxy (Hoyle and Wickramasinghe, 1985) [2]. We have argued that cometary bodies have radioactive nuclides that serve to maintain vast interior domains of liquid water for timescales in excess of the age of the solar system. The presence of such heat producing nuclides has recently been confirmed in carbonaceous meteorites affirming their role (as extinct comets) and suitable vehicles for microbial life (Hoover *et al.*, 2021) [3].

The explorations of comets after the dawn of the Space Age began with the Giotto Mission to Comet Halley in 1986 and culminated with the Rosetta Mission to comet 65P/C-G [4] [5]. Within the limits of the techniques deployed, and other studies have yielded results that are fully consistent with the cometary biology hypothesis [6] [7] [8].

One aspect of cometary behaviour that might serve to decide critically between a biological and non-biological model was already stressed by Wickramasinghe, Hoyle and Lloyd nearly 25 years ago (Wickramasinghe *et al.*, 1996) [9]. The profuse emission of gas and dust has generally been associated with comets as they approach perihelion. This is attributed to the brisk evaporation of frozen gases (mainly $H_2O$, $CO_2$) from the surface as the comets approach perihelion and the surface temperature rises above the sublimation temperature of $H_2O$ ice. A puzzle for a non-biological model of comets first turned up, however, with Comet Hale-Bopp erupting at a distance of 6.5 AU in 1983/84 long before it had reached perihelion in April 1997.

## 2. Post-Perihelion Eruptions of Comets

**Table 1** lists the perihelion distances of comets that are relevant to the discussion in the present article. In bold font are the three comets that we shall discuss in the present paper. All these comets have estimates of albedo A in the range 0.02 - 0.06, appearing darker than pitch at visual wavelengths. Among the best-known comets that that have come to recent attention have perihelia less than 1.5 AU at which distance the equilibrium temperature of the comet's surface is above the sublimation temperature of surface ices ($H_2O$, $CO_2$ and other volatiles).

A nearly spherical comet with such a low albedo rotating about an axis at a heliocentric distance R acquires an equilibrium temperature T that can be shown to be given by the equation (assuming $A \cong 0$):

**Table 1.** Cometary perihelion distances.

| | |
|---|---|
| Oumuamua (C/2017U1) | 0.25 AU |
| 2P/Encke | 0.35 AU |
| **1P/Halley** | **0.59 AU** |
| 5P/Temple1 | 1.5 AU |
| **Hale-Bopp (C/1995O1)** | **0.91 AU** |
| 73P/Shwassman-Wachmann3 | 0.94 AU |
| 67P/Churyamov-Gerasimenko | 1.29 AU |
| **29P/Shwassman-Wachmann** | **5.722 AU** |
| **C/2014UN271 Bernardinelli-Bernstein** | **10.95 AU** |

$$T \cong 279 \Big/ \sqrt{\left(R/1\text{AU}\right)} \deg \text{K} \quad (1)$$

From Equation (1) we calculate that at the distance of comet Halley's perihelion (**Table 1**) the surface temperature is ~363 K, while at a distance of comet Hale-Bopp's perihelion it is ~292 K. At such temperatures a brisk expulsion of volatile ices and dust could take place by thermal evaporation, thus explaining the dust tails and comas of most comets at perihelion.

The eruption of some comets that occurred *after* perihelion could also be explained without invoking any other hypothesis. Such an eruption happened in the case of Comet Halley in 1991 some 5 years after its perihelion in 1986 when it was ~14 AU from the sun and a dramatic explosion of activity was observed. This phenomenon, when the comet's surface temperature had fallen to 74.6 K (Equation (1)), could be explained as arising from the inward freezing of subsurface lakes that had become established by the transport of solar radiation during perihelion. If a thin surface frozen layer of the comet develops cracks and fissures, whilst interior liquid domains still remained, we might understand how such post-perihelion eruptions could occur (Hughes, 1991; Wickramasinghe, Wallis and Hoyle, 1992) [10] [11].

## 3. Pre-Perihelion Outbursts—Comet Hale-Bopp

Pre-perihelion eruptions of comets occurring at large heliocentric distances are, however, more difficult to explain with "standard" models. The last perihelion passage of Comet Hale-Bopp (C/1995 O1) was on 1st April 1997 when it was 0.914 AU from the sun. At least 3 distinct pre-perihelion outbursts of this comet were recorded in August, September and October 1995 when the comet was at a distance of 6.5 AU and the average surface temperature was ~109 K (Equation (1)). Further major eruptions followed on 10-11 September 1996 (Gu *et al.*, 2000) [12]. In a detailed analysis of the data relating to the Comet Hale-Bopp eruptions in 1995 the present author together with Fred Hoyle and David Lloyd concluded that non-biological explanations involving dust carried in evaporating ices from the surface are essentially non-viable and that a biological explanation was imperative [9].

Comet Hale-Bopp is believed to be a comet of a size (diameter ~30 km) for which a substantial fraction of the interior volume would have remained in a liquid state during its early history due to the presence of radio-active nuclides [2] [3]. We argued that much of the material within this liquified region may have become biogenically processed before re-freezing eventually occurred. Whilst the number of culturable microbial species is no more than a few thousand, millions of "dormant" species have been identified from studies of bacterial DNA in a variety of terrestrial samples [2] [7]. At the present time the full range of ambient conditions within which microbiology operates remains an open question.

The surface temperature of comet Hale-Bopp at 6.5 AU (~109 K from Equation (1)) does not permit the presence of liquid water at or near the surface.

However, transient subsurface lakes could develop from energy dissipated through bolide impacts. Chemoautotrophic microorganisms released from the ice into such "lakes" laden with high-grade organics could undergo enough doublings to exhaust available nutrients within the observed eruption times of a couple of days. (Heat loss from the surface would lead to an eventual re-freezing but only over a longer timescale of ~1 yr.) An initial melt of $10^5$ t may be extended further by the heat released through biochemical transformations. An average heat release of ~0.1 - 0.3 ev per atom in biological processes could easily lead to an increase of the melt volume by a factor ~10 - 30. Methane or carbon dioxide can be produced by bacteria from a variety of nutrients and such gases could build up substantial subsurface pressures that would eventually be expelled through fissures in the overlying ices. The situation in the comet is not unlike the popping of a cork in a bottle of wine where fermentation occurs.

## 4. Giant Comet Comet C/2014 UN271 (Bernardinelli-Bernstein)

The latest astronomical observations providing strong support for the eruption mechanism we discussed in section 3 for the case of Comet Hale-Bopp follows from the most recent observations of what is certainly a giant comet discovered in the coldest depths of interplanetary space (Wesolowski *et al.*, 2020) [13]. Comet C/2014 $UN_{271}$ (Bernardinelli-Bernstein), is estimated to have a diameter of ~150 km and was discovered accidentally by Bernardinelli and Bernstein who were examining archival images from an unrelated Dark Matter survey. When the object was first observed in October 2014, it was at a heliocentric distance of 29 AU (4.3 billion km) which was at the time a record distance at which any type of cometary object was discovered. The perihelion distance of Neptune has a similar value, close to 29 AU, where the comet would have an estimated surface temperature of only 52 K (from Equation (1)). The comet's orbit is almost orthogonal to that of Neptune, that is it is orthogonal also to the plane of the ecliptic.

The most astounding feature of Comet C/2014 UN272 (Bernardinell-Bernstein) that was discovered some 7 years later was that it was found to be active in producing a dust coma at the great heliocentric distance of ~20 AU where its surface temperature was 62 K from Equation (1). On 9 September 2021 a dramatic outburst of C/2014 $UN_{271}$ was observed and duly reported on 14 September by astronomers at the *Las Cumbres* Observatory (https://telegram.org/?read=14917). The comet had brightened by 0.65 mag (almost doubling in brightness) in a single day (Kelley, Lister and Holt, 2021) [14]. At the time, the comet was at a heliocentric distance of 19.89 AU at which the surface temperature was 62 K from Equation (1). The existence of a coma of dust surrounding the comet (**Figure 1**) has no easy explanation if we avoid the concept of cometary biology [1] [2].

Much further in than comet C/2014 UN272 is the comet 29P/Shwassmann-Wachmann that orbits between perihelion 5.72 AU and aphelion 6.25 AU and continues to baffle astronomers with its repeated episodes of activity. With its

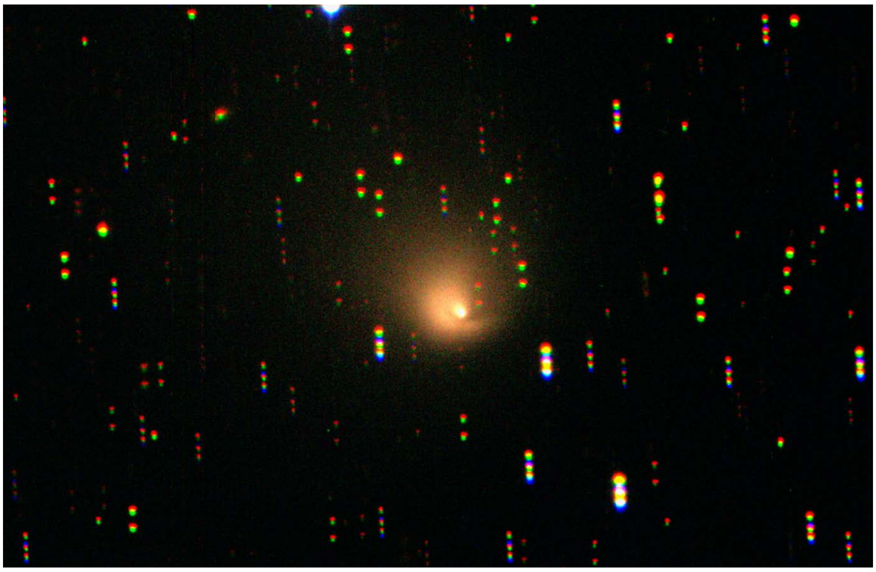

Figure 1. Eruption of Comet C/2014 UN272 (Bernardinell-Bernstein) (Courtesy Space.com (https://www.space.com/giant-comet-bernardinelli-bernstein-discovery-size-activity).

surface temperature oscillating in a narrow range between 117 K and 112 K (Equation (1)) purely thermal triggering of the eruptions seems unlikely and we are left only with the biological option. As we discussed for comet Hale-Bopp (at 6.5 AU) these episodes are likely to be initiated by impacts with smaller bodies. Comet 29P/Shwassmann-Wachmann has been spectacularly active recently with a near-continuous eruption being recorded since 25th September 2021 (https://www.astronomerstelegram.org/?read=14943). This new data adds further to the fast growing case for subsurface microbiological activity being the most likely cause of all cometary activity, particularly at large heliocentric distances.

We conclude by remarking that it is now high time we overcame cultural obstacles and accept that cometary panspermia has been overwhelmingly vindicated by a diverse range of facts. The time for a major paradigm shift in science in the author's view is long over-due [15].

## Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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