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The cometary activity very far from the Sun: the case of C/2007 D1 (LINEAR) and other stories of comets

E. Mazzotta Epifani (1), M. Dall'Ora (1), L. Di Fabrizio (2), J. Licandro (3), P. Palumbo (4) and L. Colangeli (5)
(1) INAF - OAC, Napoli, Italy, (2) INAF - Fundación G. Galilei, TF, Spain, (3) Instituto de Astrofísica de Canarias, TF, Spain, (4) Università Parthenope, Napoli, Italy, (5) SRE-SM, ESA-ESTEC, Noordwijk, The Netherlands
(epifani@na.astro.it/ Fax: +39-081-298384)

Abstract

We report on the unusual distant activity of the Long Period Comet C/2007 D1 (LINEAR), observed at r = 9.7 AU post-perihelion. This comet is particularly interesting because of its quite large perihelion distance (r_q = 8.8 AU). The comet is very active: the $Af\rho$ value is measured to be 1983 ± 81 cm for an aperture of radius = 2.2''. A dust mass-loss rate of dMd/dt = 5.3 × 10^2 kg/s is measured. The variability of the very distant activity phenomenon among the LPC family and the possible difference between the *inward* and *outward* orbital branch is investigated and presented.

1. Introduction

Long Period Comets are thought to have formed in the region where giant planets presently orbit (the Jupiter-Neptune zone) and then been scattered towards the Oort cloud region, from which they are occasionally injected towards their first passage close to the Sun. These "new" comets were observed to be intrinsically more active at large distances from the Sun than the periodic ("old") comets [5,6]. Significant H_2O sublimation could occur even out to r = 5-6 AU, where there is sufficient gas flux from sublimating water ice to lift small grains off the surface [7]. Beyond this region, the sublimation of hypervolatiles such as CO or CO_2 has been invoked as the main driver for cometary activity, likely trapped as gas in the nucleus interior. Post-perihelion activity beyond 5 AU could be caused by perihelion heat wave that penetrates into volatile-rich depths in the nucleus. Anyway, the discovery of active comets that have never been close to the Sun enough to experience significant heating requires a different mechanism.

This is exactly the case for comet C/2007 D1 (LINEAR) (hereinafter D1) [4]. We observed it in the course of an observational program designed to investigate the distant dust environment of a number of long period comets at very large heliocentric distances, beyond the "water" zone.

2. Observations

The comet D1 was observed on May 29, 2009 with the 3.52 m Telescopio Nazionale Galileo (TNG) at the Observatorio del Roque de los Muchachos (La Palma, Canary Islands), when it was at the heliocentric distance of r = 9.7 AU and the geocentric distance of Δ = 9.33 AU. The images were obtained with the TNG-DOLORES (Device Optimised for the LOw RESolution) instrument, equipped with the broadband filters V and R of the Johnson-Cousin system. Fig. 1 shows the images obtained in the two filters.

3. Observational results

Despite its large heliocentric distance at the time of observation, comet D1 appears to be a very active object with a well-developed coma and a broad tail-like structure, extending in the S-E quadrant approximately in the anti-solar direction. The data obtained during the observations allow us to perform an analysis of the coma colours of comet D1. The dust colour of the coma is slightly redder than the Sun at all nucleus distances, and is 0.505 ± 0.093 at the photometric aperture of φ = 2.2".

The $Af\rho$ value [1], where A is the average grain albedo, f the filling factor in the aperture field of view, and ρ the linear radius of the aperture at the comet, i.e., the sky-plane radius, is usually used as a proxy for the cometary dust production. The very high values of the cometary $Af\rho$ (e.g., 1983 ± 81 cm for an aperture of φ = 2.2") are consistent with a very active object. The dust production rate of D1 has been computed by means of the "photometric model",

used by [3] to compute the dust production rate of active Centaurs in the region between 5 and 12 AU. The method is based on the image photometry: the apparent magnitude of the pure coma m_d in a coma annulus is converted into the total dust cross-section and then into total dust mass, under realistic assumptions on the dust size distribution. Then, the dust production rate is computed taking into account a realistic value for the dust velocity in the coma annulus. The model results in a quite high value of $dMd/dt = 5.3 \times 10^2$ kg/s, indicating a very active comet, similar to the "paradigm" comet C/1995 O1 (Hale-Bopp), for which a dMd/dt ~500 kg/s was obtained by modelling at $r = 13$ AU [2].

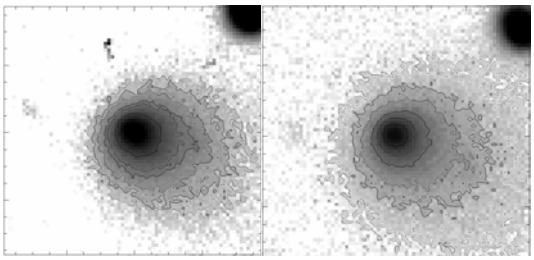

Figure 1: Coadded images of the comet C/2007 D1 (LINEAR) in the R (left) and V (right) filters. The linear scale is 6.8×10^4 km. N is up, E is right. The faintest plotted isophote corresponds to 25.37 and 25.12 mag arcsec^{-2} for the V and R filters, respectively.

4. Conclusions and future perspectives

The post-perihelion activity of comet D1 is very intense, despite, in its recent orbital history, it never passed at heliocentric distances smaller than $r = 8.8$ AU. This poses interesting constraints on theoretical models that should be able to explain the distant activity of minor bodies orbiting in the outer part of the Solar System. In particular, it will be interesting to investigate the variability of the distant activity phenomenon among the LPC family (for this reason, other LPCs have been studied during the same TNG run, and preliminary results will be also presented) and most of all it is needed to investigate the distant activity of far-perihelion LPCs before their first passage in the inner Solar System (for this reason, an observational program has been submitted to get images and model dust production rate of distant incoming LPCs).

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References

[1] A'Hearn, M.F., Schleicher, D.G., Feldman, P.D., Millis R.L., and Thompson, D.T.: Comet Bowell 1980b, AJ, 89, 579-591, 1984.

[2] Fulle, M., Cremonese, G., and Böhm, C.: The pre-perihelion dust environment of C/1985 O1 Hale-Bopp from 13 to 4 AU, AJ, 116, 1470-1477, 1998

[3] Jewitt, D.C.: The active Centaurs, AJ, 137, 4296-4312, 2009

[4] Lehman, G., Ticha, J., Tichy, M., et al., MPEC 2007-D22, 2007

[5] Meech, K.J.: Light curves of Periodic vs Dynamically New Comets as a function of B, BAAS, 20, 835, 1988

[6] Meech, K.J., in "Comets in the Post-Halley Era", R.L.Newburn Jr., M.Neugebauer & J.Rahe Eds., Kluwer Acad. Pub, 1991

[7] Meech, K.J., and Svoren, J.: Physical and chemical evolution of cometary nuclei, in "Comets II", M.Festou, H.U.Keller & H.A.Weaver Eds., Univ. Arizona Press, Tucson, 2004.