EPSC Abstracts
Vol. 8, EPSC2013-505, 2013
European Planetary Science Congress 2013

The Dust Environment of Short Period Comets

F.J. Pozuelos (1), F. Moreno (1), F. Aceituno (1), V. Casanova (1), A. Sota (1), and Cometas-Obs Team (2)
(1) Instituto de Astrofísica de Andalucía, Granada, Spain.
(2) Amateur Astronomical Association Cometas-Obs, Spain.
(pozuelos@iaa.es)

Abstract

In this work we present a characterization of the dust environment of various Short Period Comets, with the purpose to improve the knowledge on their physical properties. Among this comet family members, we focused over 30P/Reinmuth 1, 78P/Gehrels 2, 123P/West-Hartley and P/2011 W2 (Rinner). We analyze CCD imaging observations during the last three years in Sierra Nevada Observatory (OSN), and perform a Monte Carlo dust tail analysis in order to retrieve the dust environment that best fits the observations. The dust parameters that we obtain are the mass lost rate, ejection terminal velocities, size distributions, and ejection morphology. In addition, we derive from the models the $Af\rho$ curves as a function of the heliocentric distance and compare them with the ones provided by the astronomical association Cometas-Obs during the passage of these objects at dates close to perihelion. Three of the comets studied, 78P, 123P, and Rinner, can be accurately fitted by an isotropic ejection model. However, for 30P, an anisotropic ejection model is required, with active areas on the surface located between latitudes -30° to +30°. From our study we derive that 78P/Gehrels 2 is the most active comet at perihelion, with a dust production rate of $Q_d = 550$ kg/s, larger than the average of this comet family. The others three targets show a moderate dust loss rate.

1. Introduction

In order to report an accurate characterization of the dust environment of the analyzed comets, we used all the available observations covering several nights. Thus, for 30P/Reinmuth 1, we have pre- and post-perihelion observations, for 78/Gehrels 2 and 123P/West-Hartley, the observations are pre-perihelion on different nights, and for P/2011 W2 (Rinner) we have a set of post-perihelion images. We used our Monte Carlo dust tail modeling procedure developed by [4] which was used successfully on previous studies as [5]. This model allowed us to derive the essential dust parameters: mass lost rate, ejection velocities, size distribution, and ejection morphology. In addition, we benefited from $Af\rho$ data from amateur observers (the Spanish astronomical association *Cometas-Obs*) and we use it as an input to the model to be constrained, in a similar way to [1] in the study of the dust environment of comet 67P/Churyumov-Gerasimenko.

2. Observations

The observations were taken by the 1.52 m telescope of Sierra Nevada Observatory (OSN) in Granada, Spain. We used a 1024×1024 pixel CCD camera with a Johnson red filter. The pixel size in the sky was 0.46" so the field of view was 7'.8×7'.8. To improve the signal-to-noise ratio the comets were imaged several times using integration times in the range 60-300 sec. To complement the observations, we benefited from $Af\rho$ data from observations carried out by astronomical association *Cometas-Obs*. The $Af\rho$ measurements are presented as a function of the heliocentric distance and are referred to an aperture of radius 10^4 km projected on the sky at each observation date. This is the same aperture value used in the OSN observations, so that we can compare directly both values.

3. Results

In order to model the images some assumptions are needed: the particles are assumed to be spherical grains of density $\rho_d = 10^3$ kg m^{-3} and having a glassy carbon composition with refractive index at red wavelengths $m = 1.88 + 0.71i$. The corresponding value of the geometric albedo is $p_v = 0.04$, i.e., a Halley-like type. The nucleus density is assumed at $\rho_c = 600$ kg m^{-3}. We obtain for each target the size distribution of particles, dust production rate, and ejection velocities as functions of the heliocentric distance, and we also determine the ejection morphology. The results obtained are in very good agreement with the measured $Af\rho$ values (Fig. 1), with the observed images (Fig. 2), and also with the few previous studies made by others authors such as [2] and [3]. One of the comets, 30P, present anisotropic dust emission, having some 50% of the activity concentrated on the region from latitudes -30° to +30°. Nevertheless, the rest of the comets can be well represented as having isotropic dust ejection. Also, it is remarkable the singular behavior of 78P. This comet present an early and low activity, but around 2.5 AU the activity increases strongly and shows little and erratic periods of either decreasing or increasing activity as a function of the heliocentric distance. These fluctuating periods are linked to those on the $Af\rho$ curve approximately on the same dates. The analysis of the comets activity denote that the most active is 78P, which has a very strong emission at perihelion, with a maximum dust loss rate of $Q_d = 550$ kg/s, followed by 123P ($Q_d = 108$ kg/s), 30P ($Q_d = 70.5$ kg/s), and Rinner ($Q_d = 28$ kg/s). 123P, 30P and Rinner present average loss rates in the Jupiter family, while the activity of 78P is greater than the average at similar heliocentric distances. To clarify these results we present the comparison of the $Af\rho$ curves derived from the models for each comet along 300 days around perihelion. It is noted that $Af\rho$ for 78P is quite larger than the rest of the comets, being comparable to that of 29P when near perihelion [4], so one can wonder on the origin of the difference. A unique answer is clearly not possible, since there are many factors that can contribute to this discrepancy. Thus, size of nuclei, compositional differences giving distinct gas-to-dust ratio, or dynamical history can possibly contribute to these differences. We are currently seeking whether a different dynamical evolution could contribute to this phenomenon, given that the estimated nucleus sizes are similar among these comets.

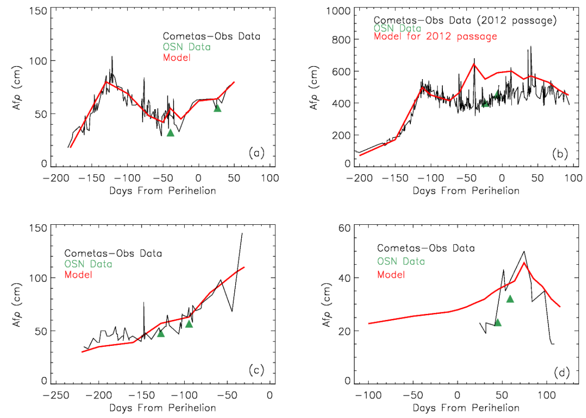

Figure 1: $Af\rho$ curves. (a) 30P, (b) 78P, (c) 123P, and (d) Rinner. Black lines correspond to Cometas-Obs data, green triangles those obtained with OSN images, the red lines with the model proposed. $\rho = 10^4$ km.

Acknowledgments

This research was based on data obtained at the Observatorio de Sierra Nevada (OSN), which is operated by the Instituto de Astrofísica de Andalucía, CSIC. We thank the staff members of the OSN for their assistance and the Cometas-Obs Team for providing us with Afρ data on the comets.

References

[1] Fulle, M., Colangeli, J., Agarwal, A., et al., A&A, 522:A63, 2010.

[2] Krolikowska, M. Sitarski, G. & Szutowicz, S., Acta Astronomica, 48:91-102, 1998.

[3] Mazzota Epifani, E., & Palumbo, P., A&A, 525:A62, 2011.

[4] Moreno, F., Ap.J. Suppl., 183:33-45, 2009.

[5] Moreno, F., Pozuelos, F., Aceituno, F., et al., Ap.J., 752:136-148, 2012.

Figure 2: Single examples of the model proposed for each comet. The observation date of each image is as follows: 30P/Reimuth 1 (2010-05-15), 78P/Gehrels 2 (2011-12-19), 123P/West-Hartley (2011-02-26), and P/2011 W2 (Rinner) (2012-01-04). The observations are in black isophotes, and the model proposed in red. Vertical bars represent 10000 km. The imaged are projected to the (N,M) coordinate system.