EPSC Abstracts
Vol. 7 EPSC2012-76 2012
European Planetary Science Congress 2012

Comet 22P/Kopff: Dust environment and grain ejection anisotropy from visible and infrared observations

F. Moreno(1), F. Pozuelos(1), F. Aceituno(1), V. Casanova(1), A. Sota(1), J. Castellano(2), and E. Reina(2)
(1) Instituto de Astrofísica de Andalucía, CSIC, PO Box 3004, 18008 Granada, Spain, (2) Amateur Astronomical Association Cometas-Obs (fernando@iaa.es / Fax: +34-958-814530)

Abstract

We present optical observations and Monte Carlo models of the dust coma, tail, and trail structures of comet 22P/Kopff during the 2002 and 2009 apparitions. Dust loss rates, ejection velocities, and power-law size distribution functions are derived as functions of the heliocentric distance using pre- and post-perihelion imaging observations during both apparitions. The 2009 post-perihelion images can be accurately fitted by an isotropic ejection model. On the other hand, strong dust ejection anisotropies are required to fit the near-coma regions at large heliocentric distances (both inbound at r_h=2.5 AU and outbound at r_h=2.6 AU) for the 2002 apparition. These asymmetries are compatible with a scenario where dust ejection is mostly seasonally-driven, coming mainly from regions near subsolar latitudes at far heliocentric distances inbound and outbound. At intermediate to near-perihelion heliocentric distances, the outgassing would affect much more extended latitude regions, the emission becoming almost isotropic near perihelion. We derived a maximum dust production rate of 260 kg s^{-1} at perihelion, and an averaged production rate over one orbit of 40 kg s^{-1}. An enhanced emission rate, accompanied also by a large ejection velocity, is predicted at $r_h >$2.5 pre-perihelion.

The model has also been extended to the thermal infrared in order to be applied to available trail observations with IRAS and ISO spacecrafts of this comet. The modeled trail intensities are in good agreement with those observations, which is remarkable taking into account that those data are sensitive to dust ejection patterns corresponding to several orbits before the 2002 and 2009 apparitions.

A full paper describing the observations and models is given in [4].

1. Introduction

In order to report an accurate characterization of the comet dust environment, an extended set of observations covering a large fraction of the comet's orbit is needed. In this paper we combine post-perihelion image observations of 22P/Kopff obtained during the last 2009 apparition with pre- and post-perihelion archived images from the previous revolution around the Sun, the 2002 apparition. In addition, CCD lightcurves and Afρ data from amateur observers (the astronomical association *Cometas-Obs*), corresponding also to the 2002 and 2009 apparition, have been taken into account. We used our Monte Carlo dust tail modeling procedure in an attempt to fit the complete image set, which allows us to derive the dust parameters: size distribution, ejection velocities, mass loss rate, and ejection pattern. In addition, a modified version of our Monte Carlo code has been implemented to calculate dust infrared fluxes and compare with trail observations by ISO and IRAS satellites.

2 Observations

We acquired images of the comet through a Johnson's R bandpass using a 1024×1024 CCD camera at Sierra Nevada Observatory (OSN) in Granada, Spain, at several epochs after the 2009 perihelion (2009-May-25.218). For our modeling purposes, we also considered images from the previous comet orbit, i.e., images from the 2002 apparition. Specifically, we considered coma/trail images obtained at large heliocentric distances by Masateru Ishiguro at Kiso 1.05-m Schmidt telescope in Nagano, Japan, and Canada-France-Hawaii 3.6-m telescope (CFHT), previously described in [2]. M. Ishiguro made kindly available to us the Kiso data, while the CFHT data were downloaded from the CFHT archive server.

In addition to the image data just described, we have also benefited from amateur observations carried out by the astronomical association *Cometas-Obs* (see http://www.astrosurf.com/Cometas-Obs), from both the 2002 and 2009 apparitions, providing a CCD lightcurve and Afρ measurements as a function of heliocentric distance.

3 Model results

In order to model the images, we used a direct Monte Carlo dust tail code, which is based on previous works of cometary dust tail analysis [3]. We first assumed the most simple model to fit the observations, i.e., an isotropic ejection model. However, this model was unable to fit the whole set of observations from the two 2009 and 2002 apparitions, and an anisotropic ejection model was implemented. This model considers a rotating nucleus with active areas on it. The best fits corresponded to rotational parameters Φ=180°, and I=60°, so that the rotational axis points to either $RA = 3°$, $DEC = 25°$ (prograde), or the opposite direction for retrograde rotation, $RA = 183°$, $DEC = -25°$, since the sense of rotation is unconstrained. The location of the active area is found to be correlated with the subsolar point. Both the CCD lightcurve and Afρ observations from OSN and *Cometas-Obs* indicate a brightness excess at 100 days from perihelion which is clearly correlated with the phase angle, and therefore indicative of a brightness opposition effect. The linear phase coefficient is 0.028$\pm$0.002 mag deg^{-1}. The modeled images at that date show an intensity level below the observations, a consequence of the assumption of large size parameter spherical absorbing grains in the model, as their phase function do not show any backscattering enhancement. The maximum dust loss rate is about 260 kg s^{-1} at perihelion.

In order to compare with infrared trail intensities obtained by IRAS and ISO satellites, a modified version of the Monte Carlo code has been developed to produce synthetic thermal images. The modeled intensities are in agreement with ISOCAM observations at various locations of the trail [4].

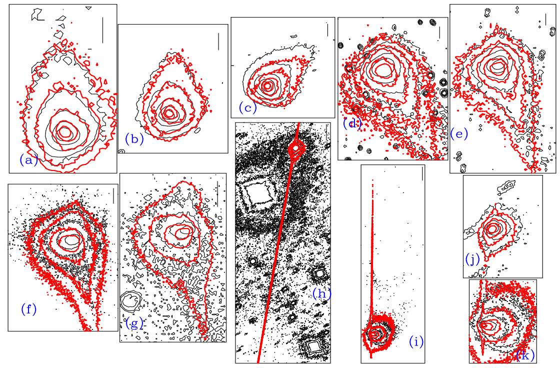

Figure 1: 22P/Kopff observations (black isophotes) and anisotropic grain ejection model (red isophotes). Images (a) to (g) correspond to the 2009 apparition, and were obtained using a CCD camera at the 1.52-m telescope of the Observatorio de Sierra Nevada in Granada, Spain. The observation date of each image is as follows: (a), 2009-07-31; (b), 2009-08-15; (c), 2009-08-28; (d), 2009-09-21; (e), 2009-10-12; (f), 2009-11-09; (g), 2009-11-24. Panel (h) corresponds to Kiso observatory, acquired on 2002-05-12, and panel (i) corresponds to the CFHT observation on 2003-07-31 [2]. Panels (j) and (k) are zoomed regions of images (h) and (i) near the comae. In all panels, vertical bars correspond to 20000 km on the sky, except for panel (h), where the bar represents 80000 km.

Acknowledgements

This research was based on data obtained at the Observatorio de Sierra Nevada, which is operated by the Instituto de Astrofísica de Andalucía, CSIC.

We are grateful to M. Ishiguro, who granted access to Kiso Observatory 105-cm Schmidt telescope images. This research used the facilities of the Canadian Astronomy Data Centre operated by the National Research Council of Canada with the support of the Canadian Space Agency. We are indebted to the amateur astronomers of the association *Cometas-Obs* for providing us with 22P/Kopff observations.

References

[1] Davies, J.K., Sykes, M.V., Reach, W.T., et al., 1997, Icarus, 127, 251

[2] Ishiguro, M., Sarugaku, Y., Ueno, M., Miura, N., Usui, F. Chun, M.-Y., and Kwon, S. M., 2007, Icarus, 189, 169

[3] Moreno, F., Lara, L.M.; Licandro, J., et al., 2011, ApJ, 738, L16

[4] Moreno, F., Pozuelos, F., Aceituno, F., et al., 2012, ApJ, in press (http://arxiv.org/abs/1204.3998).

[5] Sykes, M.V., & Walker, R.G., 1992, Icarus, 95, 180