The Dust Environment of Comets 22P/Kopff and 81P/Wild 2

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Abstract

In this work we present optical observations and Monte Carlo models of the dust environment of comet 22P/Kopff and a preliminary study of 81P/Wild 2. For the first one, we derived the dust loss rates, ejection velocities, and power law size distribution as functions of the heliocentric distance using pre- and post-perihelion imaging observations during the 2002 and 2009 apparitions. The best fit obtained is for an anisotropic ejection model. The asymmetries are in bound at $r_\text{a} = 2.34 \text{AU}$ and outbound at $r_\text{a} = 2.64 \text{AU}$ and they are compatible with a scenario where dust ejection is mostly seasonally-driven, coming mainly from regions near subolar latitudes at far heliocentric distances inbound and outbound but at intermediate to near-perihelion distances, the outgassing would much more extended latitude regions becoming nearly isotropic. The model has also been extended to the thermal infrared to be applied to available trail observations with IRAS and ISO spacecrafts of this comet. The resulting 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. For 81P/Wild 2 we run more than 8000 parameters combination for an isotropic particle emission pattern in a first step but an anisotropic ejection model is required to fit the complex structure shown by the comet. We include a rotating nucleus with active areas on it. In addition, we also include the asymmetry in the dust parameters respect to perihelion.

Results & Conclusions

We assume that the dust particles are described by spherical particles of density $\rho = 1036 \text{ g cm}^{-3}$ and glassy carbon composition (refractive index at $\lambda = 1.06 \mu \text{m}$).

A. 22P/Kopff

The nucleus size is $R_\text{n} = 1.8 \text{ km}$ and the geometric albedo is assumed $p_\text{g} = 0.036$ [2].

* Anisometric and asymmetric ejection model.

* Rotating spherical nucleus with active areas on it, with a rotation period of 12.3 hours [3]. The best rotational parameters found, previously described by [1] are $\theta = 109^\circ$ and $\phi = 60^\circ$.

* The location of the active areas is found to correlate with the subolar point position (Figure 1). The fraction of particles ejected isotropically and the cone width were derived as $\Delta \theta = 60^\circ$ for $r_\text{a} > 2.54 \text{AU}$ perihelion with no need for an isotropic ejection fraction and $\Delta \phi = 25^\circ$ for $r_\text{a} < 1.95 \text{AU}$ post-perihelion and 59% of particles being emitted isotropically.

* The modeled intensities are in agreement with GEMCOM observations at 2MASS $= 2.4 \mu \text{m}$, and at 2MASS $= 1.2 \mu \text{m}$, while the trail widths are significantly narrower than reported by [4]. However, they are similar to IRS data [5] when re-estimated by [4].

* The size distribution function is independent of the heliocentric distance, characterized by a constant power index of $-3.1$.

* Maximum and minimum particle radius between 1μm and 1 cm.

* The results of the synthetic observations compared with observations are shown in the figure 5.

* The total mass ejected per orbit is $7.3 \times 10^{20} \text{ g}$, with an average dust mass loss rate per orbital period of 40 kg s$^{-1}$ at $2.4 \times 10^{20} \text{ g}$ yr$^{-1}$ at $2.6 \times 10^{20} \text{ g}$ yr$^{-1}$. The minimum dust loss rate is about $2.6 \times 10^{19} \text{ g}$ yr$^{-1}$ at perihelion.

B. 81P/Wild 2

Only preliminary results are reported because the work is still going on.

* The nucleus size is near $R_\text{n} = 2.1 \text{ km}$ and the geometric albedo is $p_\text{g} = 0.040$ [6].

* With an isotropic and symmetrical particle emission model we estimate the lower and upper limits for the dust parameters. From our current simulation we obtain the dust loss rates in the range $3009 - 2009 \text{ g} \text{ cm}^{-2} \text{ s}^{-1}$, a maximum size of particles around 1 $- 3 \text{ cm}$, and ejection velocities for particles of 1 cm between $2 - 4 \text{ km s}^{-1}$ at heliocentric distance.

* A non-anisotropic and symmetrical ejection model will be implemented to improve the results. We include a rotating nucleus with active areas on it with a rotation period of 13.3 hours [7]. The fit shown in figure 4 corresponds to rotational parameters $\theta = 105^\circ$ and $\phi = 36^\circ$ with an active area located between $0^\circ - 30^\circ$ and the particles ejected isotropically 45%. The size distribution function is independent of the heliocentric distance, characterized by a constant power index of $-2.8$.

References


Obtain the full article version “Comet 22P/Kopff: Dust environment and grain ejection anisotropy from visible and infrared observations”. (Moreno et al. 2012)