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SIZE AND FRACTION OF ACTIVE SURFACE AREA OF SOME JUPITER FAMILY COMETS: IMPLICATIONS WITH RESPECT TO THEIR PHYSICAL EVOLUTION

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RESUMEN

Se presenta el análisis de una muestra de magnitudes nucleares de cometas de la Familia de Júpiter (definida como aquellos cometas con períodos orbitales $P < 20$ años y parámetros de Tisserand $T > 2$). Se derivan parámetros físicos como los tamaños de los núcleos cometarios y las fracciones de área activa. A partir de estos resultados se intenta describir la evolución física y los posibles estados finales de esta población de objetos del Sistema Solar.

ABSTRACT

We analyze the sample of measured nuclear magnitudes of the observed Jupiter Family comets (taken as those with orbital periods $P < 20$ years and Tisserand parameters $T > 2$) to derive sizes of comet nuclei, fraction of active surface areas, as well as to try to gain insight about their physical lifetimes and end states.

Key Words: **COMETS — NUCLEAR MAGNITUDES — PHYSICAL EVOLUTION**

This is a continuation of a project started some years ago (Fernández et al. 1992). The sample of measured nuclear magnitudes has been taken from the MPCs, IAU Circulars, papers discussing some particular comets, and our own set of nuclear magnitudes (Licandro et al. 2001). We find a tendency of the derived absolute nuclear magnitudes to be fainter as Jupiter Family (JF) comets are observed with CCD detectors attached to medium- and large-size telescopes (e.g. Spacewatch Telescope). However, a few JF comets observed very far from the Sun (4-7 AU) show a very large scatter in their measured nuclear magnitudes. This suggests that either JF comets keep active all along the orbit so the reported unusually bright distant magnitudes were strongly contaminated by a coma, or some "nuclear magnitudes" measured closer to the Sun were grossly overestimated (i.e., underestimated brightness).

By combining water production rates derived by several authors from spectrophotometric and spectroscopic observations of OH and $O(^1D)$ in the visible region (Newburn & Spinrad 1989; A'Hearn et al. 1995; Fink & Hicks 1996) with our derived absolute nuclear magnitudes, we compute the fraction of the active surface area of a sample of 24 JF comets. Most of the JF comets of our sample are found to have fractions of active surface area smaller than 20%, which suggests that the surfaces of comet nuclei are covered to a large extent by insulating dust mantles. No JF comet with radius $\gtrsim 2.5$ km is found to have a large fraction of active surface area ($\gtrsim 20\%$), which may be due to the rapid formation on insulating dust mantles on large-sized nuclei. In particular, comet

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28P/Neujmin 1, with an estimated radius of $R = 9.14$ km, has a fraction of free-sublimating area of only 0.1 %, which suggests that its activity may arise from sublimating gases diffusing through a porous mantle.

The cumulative mass distribution of JF comets is found to follow a power-law of index -0.88 ± 0.12, suggesting a distribution similar to that for main-belt asteroids, but somewhat steeper than that for near-Earth asteroids (Raninowitz 1993). The cumulative mass distribution tends to flatten for absolute (visual) nuclear magnitudes $m_N(1, 1, 0) \gtrsim 16$, probably due to incompleteness of discovery of fainter comets and/or a real scarcity of small comets due, perhaps, to much shorter physical lifetimes. In particular, no JF comets fainter than $m_N(1, 1, 0) \sim 19.5$ are found in our sample, suggesting that the critical size for a comet to be still active may be of about 0.4 km radius for an assumed geometric albedo of 0.04. Possibly, smaller comet nuclei disintegrate very quickly into meteor streams. Most absolute nuclear magnitudes are found in the range 15-18, corresponding to nuclear radii in the range 0.8–3.3 km (for the same geometric albedo).

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