

No catastrophic collisions in the outer Solar System

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The fractal dust particles observed by Rosetta cannot form in the physical conditions observed today in comet 67P/Churyumov-Gerasimenko (67P hereinafter), being instead consistent with models of the pristine dust aggregates coagulated in the solar nebula. Since bouncing collisions in the protoplanetary disc restructure fractals into compact aggregates (pebbles), the only way to preserve fractals in a comet is the gentle gravitational collapse of a mixture of pebbles and fractals, which must occur before their mutual collision speeds overcome 1 m/s. This condition fixes the pebble sizes to <1 cm, as confirmed by CIVA (Comet Nucleus Infrared and Visible Analyser) onboard Philae. Here we show that the flux of fractal particles measured by Rosetta constrains the 67P nucleus in a random packing of cm-sized pebbles, with all the voids among them filled by fractal particles. This structure is inconsistent with any catastrophic collision, which would have compacted or dispersed most fractals, thus leaving empty most voids in the reassembled nucleus. Comets are less numerous than current estimates, as confirmed by lacking small craters on Pluto. Bilobate comets accreted at speeds <1 m/s from cometesimals born in the same disc stream.
