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Density Estimation of Comet 103P/Hartley 2

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Abstract

The observed smoothness and curvature of Hartley's inter-lobe 'neck' region may be the result of either depositional processes, such as in-falling material collecting in a gravitational low and/or the in situ fluidization of regolith induced by outflowing gas [1]. If some form of frictionless, fluidized flow is responsible for the formation or modification of this region it should represent a 'flat' surface such that it lies along an equipotential with respect to the combined forces of both gravity and rotation. The density of the nucleus can thus be estimated by fitting potential contours to the observed neck geometry [2].

The net potential as a function of body density is calculated for each surface element of the comet's polygon shape model. The variance in net potential within the neck region is minimized when the observed surface best approximates a constant equipotential surface. The metric used for the minimization is weighted to account for uneven spatial distribution of surface elements and a systematic increase in variance as the applied body density increases.

Our analysis was constrained to the region of the neck that was directly imaged and well illuminated during the encounter. A homogeneous density and a rotation period of 18.34 hours are assumed. Only rotation about the principal axis was accounted for. The principal rotation period was likely shorter on timescales effective for surface modification [2]. Additionally, spin components about minor axes introduce a further degree of error. A global minimum is found for a bulk density $\rho = 220\ kg\ m^{-3}$ (one sigma = 130-620 $kg\ m^{-3}$) which corresponds to a comet mass of m = 1.84 x 10^{11} kg (one sigma = 1.51-5.18 x 10^{11} kg). This is lower than, but within error ranges of, previous comet density estimates (sec. 4.2 of [3]).

References

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