EPSC Abstracts
Vol. 11, EPSC2017-569, 2017
European Planetary Science Congress 2017

Evidence for low tensile strength in comet nuclei

R. Kokotanekova (1,2), C. Snodgrass (2), P. Lacerda (3), S. C. Lowry (4), Y. R. Fernández (5), S. F. Green (2), C. Tubiana (1), A. Fitzsimmons (3) and H. H. Hsieh (6,7)
(1) Max Planck Institute for Solar System Research, Germany, (2) The Open University, UK, (3) Queen's University Belfast, UK, (4) The University of Kent, UK, (5) University of Central Florida, USA, (6) Planetary Science Institute, USA, (7) Institute of Astronomy and Astrophysics, Academia Sinica, Taiwan (kokotanekova@mps.mpg.de)

Abstract

We provide an updated study of the collective properties of Jupiter Family comets (JFCs) by increasing the sample of comets with well-studied rotation periods and surface characteristics. To collect the sample, we review the properties of 35 JFCs with published rotation rates and add new lightcurves and phase functions for nine JFCs observed between 2004 and 2015. We use the extended sample of 37 comets to characterise the bulk density, tensile strength, collisional history and surface properties of JFCs. Using the model for stability of rotating solid biaxial ellipsoids [1], we conclude that none of the observed JFCs require tensile strength larger than 10-25 Pa to remain stable against rotational breakup.

1. Introduction

Time-series photometric observations of comet nuclei can be used to derive the comets' lightcurves and phase functions. Lightcurves are a rich source of information on the spin and shape properties of comets, and can be used to constrain the collisional history, density and strength of JFCs. Deriving the phase functions and albedos of the nuclei allows us to study the surface properties of JFCs and to compare them to other small-body populations in the Solar system.

The collective properties of JFCs were reviewed over a decade ago [3, 5]. In this work, we update the sample of JFCs with known rotation properties with the results published since the last review [5] and add our newly obtained results on nine comets.

The newly analysed comets were observed with a number of ground-based telescopes as part of the Survey of Ensemble Physical Properties of Cometary Nuclei (SEPPCoN, [2]) as well as during devoted phase function observing campaigns. In order to combine the different datasets we developed a method for absolute photometric calibration using stars from the Pan-STARRS survey. This approach allowed us to combine data sets taken at different epochs and instruments with photometric precision down to 0.03 mag.

2. Results and Conclusions

We review the properties of 35 JFCs with previously studied rotation rates and present the analysis of ground photometric observations of nine comets. The total number of comets in the updated sample is 37. The main results of this work are as follows:

- We improve the rotation periods for comets 14P/Wolf, 47P/Ashbrook-Jackson, 94P/Russell, and 110P/Hartley 3 and determine the rotation rates of comets 93P/Lovas and 162P/Siding-Spring for the first time.
- We determine the phase functions for seven of the examined comets and derive albedos for eight of them.
- The new extended sample confirms the known cut-off in bulk density at ~ 0.6 g cm^{-3} [3] assuming that JFCs are strengthless bodies.
- Assuming the model of [1] for prolate ellipsoids with typical density and elongations, we determine that JFCs require tensile strength not larger than 10-25 Pa to remain stable against rotational instabilities (Fig. 1).
- Using the newly derived albedos and phase functions, we determine that the median linear phase function coefficient for JFCs is 0.046 mag/deg and the median albedo is 4.2 per cent.
- We find evidence for an increasing linear phase function coefficient with increasing albedo (Fig. 2).

These findings allow us to compare JFCs to other populations in the Solar System in a search for evidence for JFC origins.

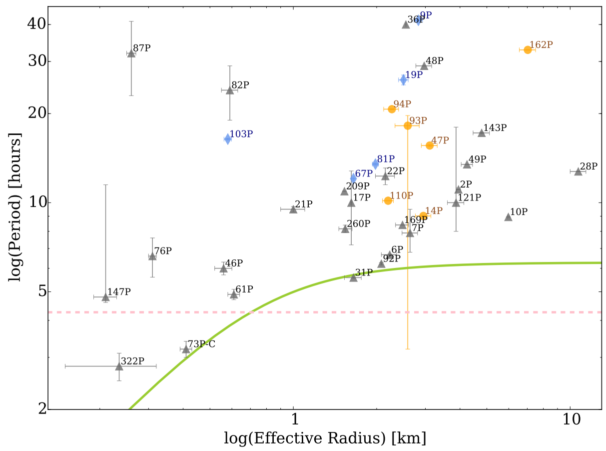

Figure 1: Rotation period against effective radius of the JFC nuclei. The blue diamonds correspond to comets visited by spacecraft; the grey triangles are comets observed from ground and the orange circles are the JFCs added in this work. The dashed pink line shows the minimum possible rotation rate for strengthless spherical bodies with density $\rho = 0.6$ g cm^{-3}. The green curve is derived from the model for prolate ellipsoids stable against rotational instability [1]. The curve shows the model for density $\rho = 532$ kg m^{-3}, axial ratio $a/b = 2$ and tensile strength $T = 15$ Pa, which corresponds to the parameters measured for 67P from Rosetta. We can conclude that for typical densities and axial ratios, the observed comets do not require tensile strength larger than 10-25 Pa in order to remain stable against rotational splitting.

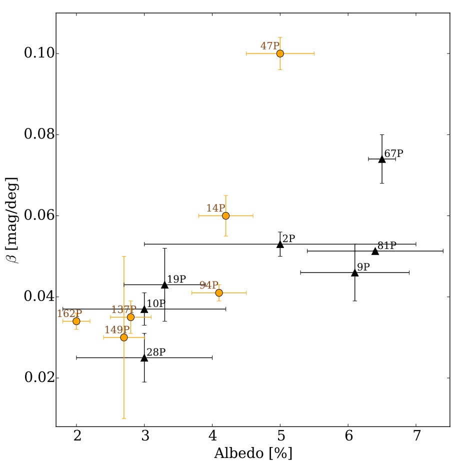

Figure 2: Phase function slope versus albedo of all JFCs with known radius, albedo and phase function. The orange circles correspond to comets with properties derived in this work. There is an indication for a trend of increasing phase function slope with increasing albedo.

References

[1] Davidsson, B. J. R.: Tidal splitting and rotational breakup of solid biaxial ellipsoids, Icarus, Vol. 149, pp. 375–383, 2001.

[2] Fernández, Y. R., Kelley, M. S., Lamy, P. L., Toth I. et al.: Thermal properties, sizes, and size distribution of Jupiter-family cometary nuclei, Icarus, Vol. 226, pp. 1138–1170, 2013.

[3] Lamy, P. L., Toth, I., Fernandez, Y. R. and Weaver, H. A.: The sizes, shapes, albedos, and colors of cometary nuclei, Comets II, University of Arizona Press, pp. 223-264, 2004.

[4] Lowry, S. C. and Weissman, P. R.: CCD observations of distant comets from Palomar and Steward Observatories, Icarus, Vol. 164, pp. 492–503, 2003.

[5] Snodgrass, C., Lowry, S. C. and Fitzsimmons, A.: Photometry of cometary nuclei: rotation rates, colours and a comparison with Kuiper Belt Objects, Monthly Notices of the Royal Astronomical Society, Vol. 373, pp. 1590–1602, 2006.