JFC Reflectivity Reassessed: Preliminary Albedos and Statistical Trends

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Key Takeaways: We present preliminary geometric albedos for 57 Jupiter-family comets (JFCs), 6 of which are derived from multiple epochs of observations. The current average albedo value from our investigation is 0.04 ± 0.008. We aim to create the largest ever database of albedos as a stepping-stone for investigating ensemble JFC surface evolution. We are in the process of analyzing dozens of epochs of imaging photometry, and aim to have the completed database of ~100 albedos submitted for publication by Jan. 2027.

1. Introduction:

Historically, albedo is not thoroughly studied for comets because it is difficult to obtain. In fact, literature provides albedo values for only 19 JFCs [1]. Deriving geometric albedos for a statistically significant population of JFCs would allow us to verify if the assumed average albedo value of 4% is accurate, and investigate what the actual distribution of albedos is. In addition, it would let us compare the JFC albedo distribution trends with those of their theorized progenitors (Centaurs and Trans-Neptunian Objects). Last, analyzing an albedo in conjunction with other properties like shape, color, rotation period, gas abundance ratios, density, or surface heterogeneity could provide deeper insights into a comet's structural changes over time.

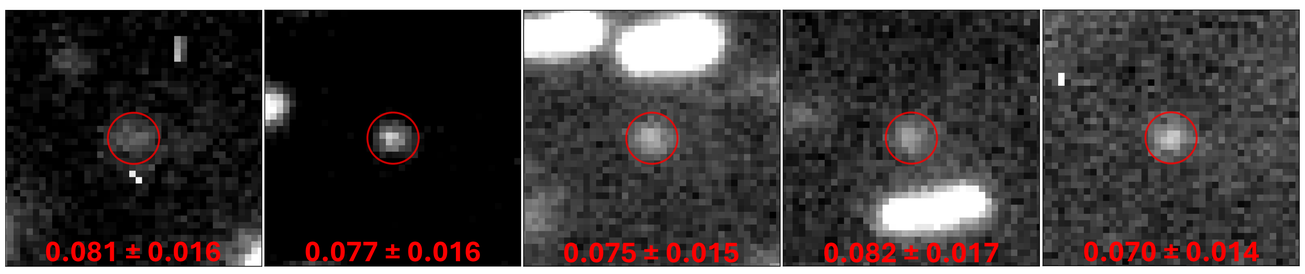

Fig. 1 – Individual image stacks of 152P and its p_r - 0°, shown with a 4-pixel radii aperture

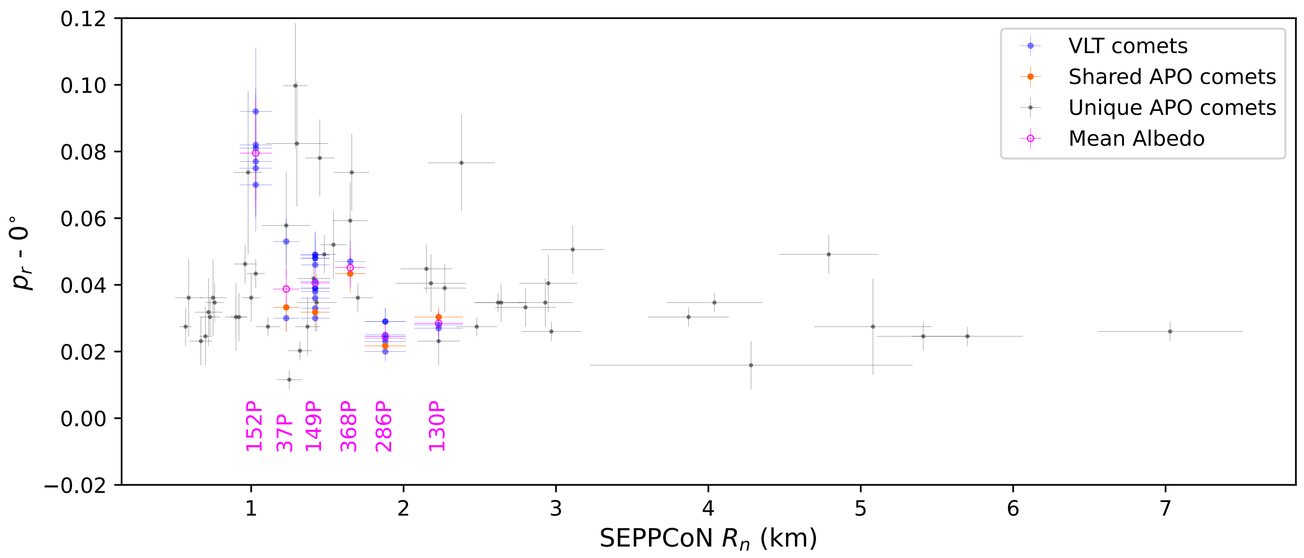

Fig. 2 – Overview of radius vs. albedo scatterplot for our 57 comets

2. Methods:

Our approach to deriving albedos is to use visible image photometry of nuclei that have known radii thanks (mainly) to Spitzer's SEPPCoN (Survey of Ensemble Physical Properties of Cometary Nuclei) [2]. All our targets were observed in R-band, primarily by 3-8 meter telescopes, when they were 3-5 au from the Sun to maximize the chance of observing a bare nucleus. In total, we have observed roughly 100 comets – many at multiple epochs – that we intend to pursue geometric albedo values for.

3. Data:

- We present preliminary p_r estimates for 57 JFC nuclei using data from 2 ground observation facilities: the 3.5 meter ARC telescope at Apache-Point Observatory (APO) and the 8.2 meter Very Large Telescope (VLT) at Paranal Observatory
- 51 comets were observed with APO only, 1 was observed with VLT only, and 5 were observed by both telescopes
- Comets observed by APO have been previously analyzed (preliminarily) [3], so we focus on the 6 new additions from the VLT data: 37P, 130P, 149P, 152P, 286P, 368P
- VLT data was collected on January 23rd, 24th, and 25th of 2009
- These results summarize our albedo estimates for comets that presented with no activity in our observations, and we therefore consider them as bare nuclei

4. Results:

Overview

- We reference our mean albedos for each comet to 0° and 10° phase angles assuming a linear phase coefficient of 0.04 mag/deg
- We calculate an overall p_r - 0° of 0.040 ± 0.008, which perfectly agrees with the typically assumed value. See **Fig. 3** for the distribution of albedos
- We report the first estimate of a geometric albedo for 152P, which is higher than average at 0.080 ± 0.016. We found no previous literature detailing 152P's albedo. See **Fig. 1** for example epochs of 152P
- For the remaining 5 comets our APO albedos are the only other reference values, except for 149P – which has a reported p_v = 0.030 ± 0.005 [1]

Radius vs. Albedo

- **Fig. 2** showcases the albedo values for each VLT epoch and how the APO albedo compares. In general, there is good agreement between each of the VLT epoch albedos (blue) and with the APO albedo (yellow), which reinforces our overall mean values (magenta)
- There is no apparent trend of radius with albedo

Comparison to Centaur Population

- **Fig. 4** highlights where our 6 VLT p_r albedos fall in comparison to a recent distribution of Centaur p_v albedos [4]. As expected, the JFCs tend to be darker than the Centaur population, which reflects the fact that they are more thermally processed objects

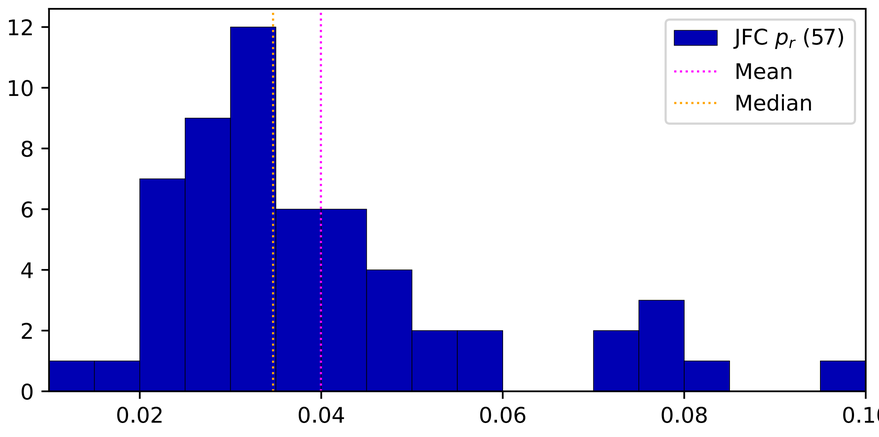

Fig. 3 – Histogram of our 57 preliminary albedo values

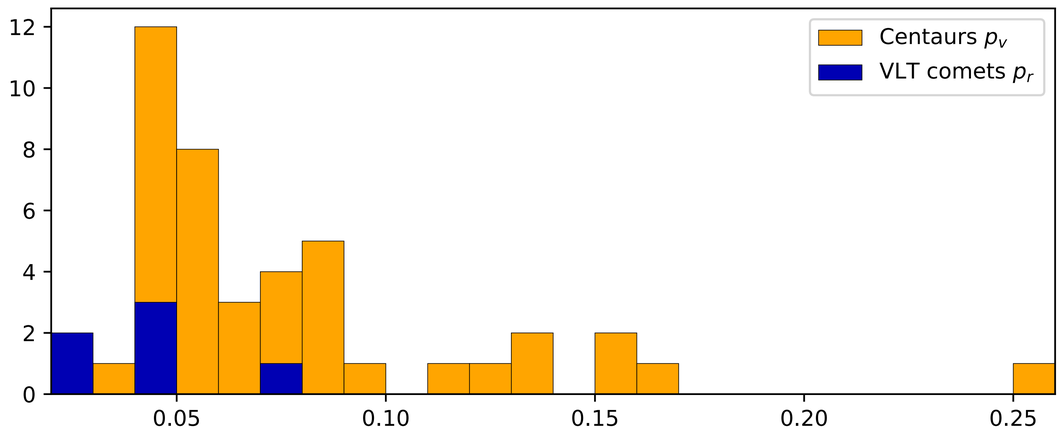

Fig. 4 – Histogram comparison of Centaur and preliminary VLT albedos

5. Future Work:

- We will continue to use our current methods to derive geometric albedo estimates for the remaining bare nuclei comets in our ground-based datasets
- We will begin deriving albedos for those comets who may show some minimal activity. We plan to apply a well-established coma minimization technique [5]
- Once we have gathered albedo values for all possible comets within our dataset we will report on the final statistical trends and overall distribution. Then, we will compare the JFCs to other small bodies populations
- In the future we look forward to applying our methods to new data collected from Vera Rubin/LSST and NEO Surveyor

PRELIMINARY

VLT and APO Overall Mean Albedos

Object	p_r - 0°	p_r - 10°
6P	0.023 ± 0.007	0.016 ± 0.005
7P	0.035 ± 0.006	0.024 ± 0.004
14P	0.040 ± 0.009	0.028 ± 0.006
16P	0.032 ± 0.010	0.022 ± 0.007
22P	0.045 ± 0.007	0.031 ± 0.005
31P	0.059 ± 0.012	0.041 ± 0.008
32P	0.077 ± 0.014	0.053 ± 0.010
37P	0.039 ± 0.006	0.027 ± 0.004
47P	0.051 ± 0.007	0.035 ± 0.005
48P	0.026 ± 0.003	0.018 ± 0.002
57P	0.026 ± 0.003	0.018 ± 0.002
62P	0.036 ± 0.012	0.025 ± 0.008
68P	0.033 ± 0.006	0.023 ± 0.004
77P	0.074 ± 0.012	0.051 ± 0.008
79P	0.025 ± 0.009	0.017 ± 0.006
89P	0.035 ± 0.009	0.024 ± 0.006
94P	0.039 ± 0.007	0.027 ± 0.005
107P	0.078 ± 0.012	0.054 ± 0.008
113P	0.036 ± 0.004	0.025 ± 0.003
118P	0.082 ± 0.019	0.057 ± 0.013
119P	0.074 ± 0.025	0.051 ± 0.017
121P	0.030 ± 0.003	0.012 ± 0.002
123P	0.040 ± 0.009	0.028 ± 0.006
124P	0.035 ± 0.003	0.024 ± 0.002
127P	0.030 ± 0.010	0.021 ± 0.007
130P	0.028 ± 0.004	0.019 ± 0.003
131P	0.027 ± 0.003	0.019 ± 0.002
137P	0.035 ± 0.003	0.024 ± 0.002
138P	0.035 ± 0.006	0.024 ± 0.004
139P	0.027 ± 0.009	0.019 ± 0.006
143P	0.049 ± 0.006	0.034 ± 0.004
146P	0.046 ± 0.006	0.032 ± 0.004
149P	0.041 ± 0.005	0.028 ± 0.004
152P	0.080 ± 0.016	0.055 ± 0.011
162P	0.026 ± 0.003	0.018 ± 0.002
163P	0.020 ± 0.003	0.014 ± 0.002
169P	0.027 ± 0.003	0.019 ± 0.002
171P	0.012 ± 0.003	0.008 ± 0.002
172P	0.025 ± 0.003	0.017 ± 0.002
173P	0.016 ± 0.007	0.011 ± 0.005
197P	0.030 ± 0.007	0.021 ± 0.005
215P	0.100 ± 0.019	0.069 ± 0.013
219P	0.036 ± 0.007	0.025 ± 0.005
221P	0.043 ± 0.004	0.030 ± 0.013
223P	0.035 ± 0.007	0.024 ± 0.005
228P	0.058 ± 0.016	0.040 ± 0.011
256P	0.036 ± 0.012	0.025 ± 0.008
260P	0.052 ± 0.010	0.036 ± 0.007
286P	0.025 ± 0.004	0.017 ± 0.002
300P	0.023 ± 0.007	0.016 ± 0.005
306P	0.027 ± 0.006	0.019 ± 0.004
309P	0.049 ± 0.006	0.034 ± 0.004
315P	0.025 ± 0.004	0.017 ± 0.003
344P	0.042 ± 0.007	0.029 ± 0.005
368P	0.045 ± 0.006	0.032 ± 0.004
371P	0.030 ± 0.006	0.021 ± 0.004
378P	0.027 ± 0.014	0.019 ± 0.010
Mean:	**0.040 ± 0.008**	**0.028 ± 0.005**

References: [1] M. M. Knight, et al., *Comets III*, 2024, pp. 361-404. [2] Y. R. Fernández, et al., *Icarus*, 226(1):1138–1170, Sept. 2013. [3] Y. R. Fernandez, et al. 47th Meeting of DPS, abstract 415.07, Nov. 2015. [4] T. Müller, et al., *The Trans-Neptunian Solar System*, pages 153–181. 2020. [5] P. L. Lamy and I. Toth. *A&A*, 293:L43–L45, Jan. 1995

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