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Characterization of Main Belt Comet P/2012 F5 (Gibbs)

R. Stevenson (1), E. A. Kramer (1,2), J. M. Bauer (1), J. R. Masiero (1) and A. K. Mainzer (1)
(1) Jet Propulsion Laboratory, Pasadena, CA USA, (2) University of Central Florida, FL, USA
(Rachel.A.Stevenson@jpl.nasa.gov)

Abstract

In this work, we characterize the recently-discovered asteroid P/2012 F5 (Gibbs), which displayed cometary behavior despite occupying an asteroidal orbit in the main belt. We use observations obtained on UT 2012 Mar. 27 to set an upper limit on the radius of the nucleus, estimate the scattering cross-section and mass of dust in the tail, and to constrain the date of the onset of activity.

1. Introduction

P/2012 F5 (Gibbs) is a recently discovered object with an asteroid-like orbit but comet-like activity. Its low eccentricity, low inclination orbit place it in the asteroid regime with a Tisserand parameter of T_J = 3.23 (Table 1), though it was discovered to have a narrow dust tail extending 7′ to the north-west [1]. We observed P/2012 F5 on UT 2012 Mar. 27 using the Large Format Camera mounted on the Hale 200" telescope atop Mount Palomar.

Table 1: Orbital Elements of P/2012 F5 (Gibbs)

Epoch	a [AU]	q [AU]	e	i [deg]
2012 Mar. 25	3.00	2.88	0.04	9.74

2. Results and Analysis

2.1. Photometry

Though the nucleus of P/2012 F5 was obscured by a dust coma, a bright condensation existed at the leading end of the tail. Using a 2″.1 radius aperture, we calculate apparent B-band and R-band magnitudes of m_B = 20.96 ± 0.04 mag and m_R = 19.93 ± 0.02 mag, respectively. Based on these results, we set an upper limit on the radius of the nucleus of 2.1 km. The B-R color of the innermost material is 1.03 ± 0.04 mag

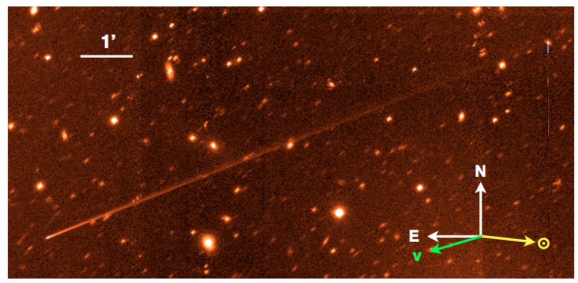

Figure 1: P/2012 F5 (Gibbs) as observed on UT 2012 Mar. 27 using the Large Format Camera mounted on the Hale 200" telescope atop Mount Palomar. The image was created from a median stack of 5 90 s R-band exposures taken while tracking the motion of P/2012 F5. The velocity vector, v, and the solar direction, $\odot$, are marked.

and is consistent with solar colors. The R-band apparent magnitude of the tail was found to be 16.25 ± 0.20 mag using a 518″× 14″ (8.0 × 10^5 km by 2.2 × 10^4 km) rectangular aperture aligned with its direction. The scattering cross-section of material in the tail was estimated to be ∼ 4 × 10^8 m^2, corresponding to a mass of ∼ 5 × 10^7 kg, equivalent to 0.01% of the nucleus. We analyze infrared images taken by the Wide-Field Infrared Survey Explorer to set an upper limit on the activity in September 2010.

2.2. Finson-Probstein Modeling of the Tail

The dust tail was modeled using the Finson-Probstein model [2] by parameterizing the motion of dust particles using the ratio of solar radiation pressure to solar gravity, commonly denoted by β. The results from the numerical integrations can be plotted as curves of particles with constant β released at a range of times (syndynes) or curves of constant release date with a range of particle sizes (synchrones). Figures 2 and 3 show that the observed morphology is best fit by particles that were released during a single event that occurred approximately 264 ± 20 days prior to our observations. It is difficult to reconcile the observed morphology with activity driven by the sublimation of surface volatiles given that dust tails and/or comae observed around active objects in the main belt are consistent with prolonged generation over a period of several months or more.

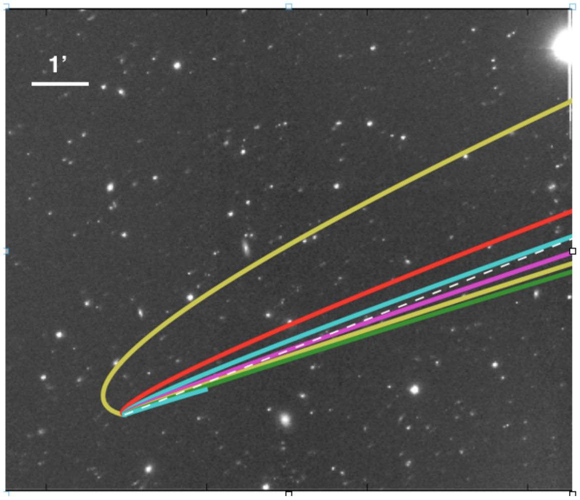

Figure 2: Syndynes tracing particles with β values varied between 0.0003 and 3.0 (bottom to top, cyan through yellow) are plotted over a stacked R-band image. 27. The syndynes do not recreate the observed morphology and diverage from the tail (highlighted by the white dashed line) at large nucleo-centric distances.

2.3. Dynamical Stability

Using numerial simulations to model test particle evolution, we investigated the stability of 100 clones of P/2012 on the Gyr-timescale. Clone starting positions and orbital elements were randomly assigned according to a Gaussian distribution with a FWHM equal to the 1-σ uncertainties in the osculating elements of P/2012 F5. The effect of non-gravitational forces are ignored for the purposes of this simulation as they are under-constrained. The orbital evolution of the clones is negligible over a Gyr, indicating that P/2012 F5 is dynamically stable and is likely to have originated in the main belt.

3. Summary and Conclusions

P/2012 F5 is dynamically stable and resident in the outer main belt on long timescales, suggesting an asteroidal, rather than cometary, origin. The morphology of the cometary activity is consistent with a single event that ejected $\sim 5 \times 10^7$ kg of dust on UT 2011 Jul. 7 $\pm$ 20 days.

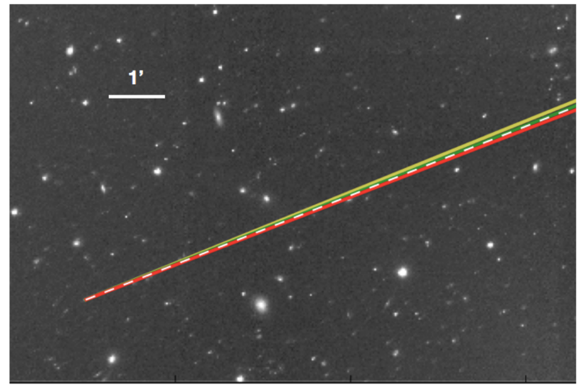

Figure 3: The best-fit synchrone (green) is plotted on the stacked R-band image with additional synchrones (red and yellow) representing the uncertainties based on the observed width of the tail. The position of the tail is marked by the dashed white line. Particles along the best-fit synchrone must have been released 264 $\pm$ 20 days prior to the observation, which corresponds to an ejection date near UT 2011 Jul. 7.

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