The extreme Centaur 2013 AZ_{60}

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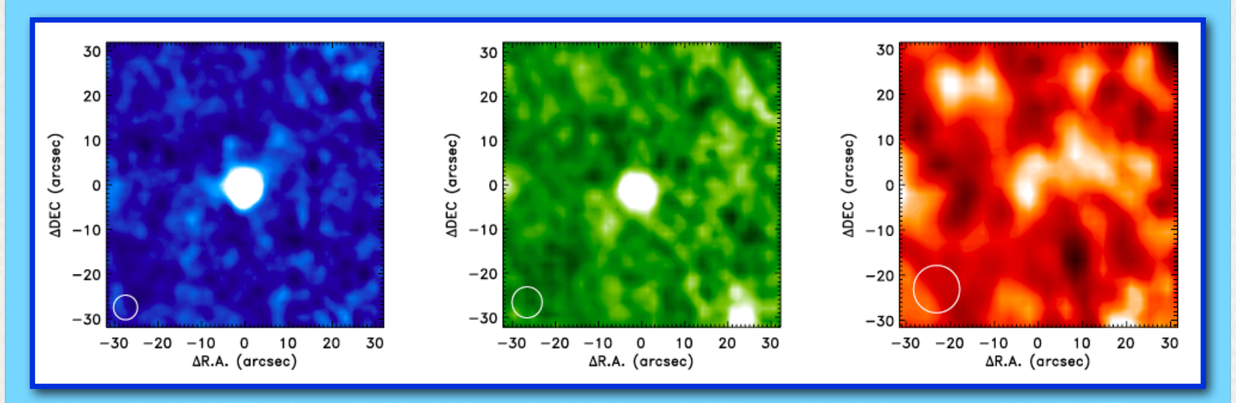
Abstract

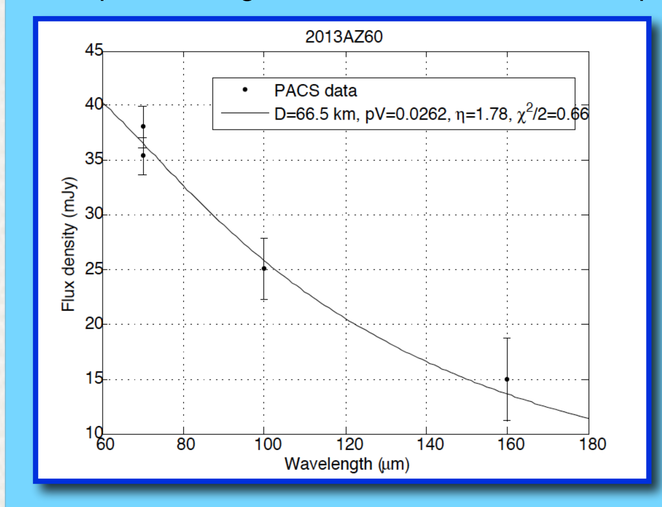
2013 AZ_{60} is an extreme Centaur moving on a highly eccentric orbit of e = 0.9922, with a semi-major axis of 1021.09 au, and a perihelion distance of 7.91 au. 2013 AZ_{60} was observed with the PACS camera of the Herschel Space Observatory, and we were able to derive an effective size of D=66.5±3.7 km and a geometric albedo of p_V = 0.026 ± 0.003. Photometric measurements revealed a low-amplitude light curve (0.045±0.007 mag in the r' band) with a likely full period of P = 9.39 h. A dynamical analysis shows that the orbit of 2013AZ_{60} is highly unstable, with a 50% probability the target will be ejected from the Solar System within ~700 kyr. This high level of instability indicates that 2013AZ_{60} may just have recently been captured to its current orbit. Investigating the total time the target could have spent at small heliocentric distances (< 100 au), it seems to be likely that this has only been at most 100 to 1000 years and it has a low probability that the target could reach Earth-crossing orbits (i.e., < 1 au). As the likely origin of this target is the Oort Cloud, these together suggests a relatively unaltered, pristine surface, in contradiction with the very low albedo (2.6%) derived from the thermal infrared measurements. The low albedo and red colours rather indicates an "extinct cometary" surface.

Herschel observations



Herschel-PACS 70um (left), 100um (middle) and 160um (right) images of 2013 AZ_{60}

- We observed 2013AZ_{60} with the PACS photometer of the Herschel Space Observatory at two epochs using the time of a dedicated DDT proposal (DDT_ckiss_3) in April, 2013.

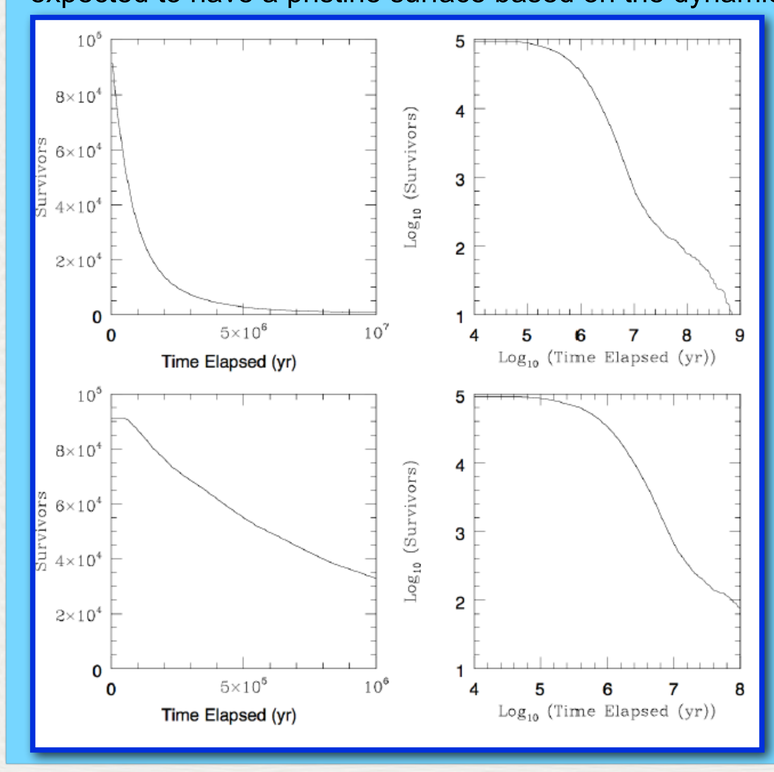


Far-infrared flux densities of 2013 AZ_{60}, obtained with the PACS photometer of the Herschel Space Observatory. The solid line indicates the best-fit NEATM thermal emission model

- A NEATM model fit to the thermal emission of the target provides an effective diameter of D=66.5±3.7 km and a geometric albedo of p_V = 0.026 ± 0.003 with a floating beaming parameter of η=1.78 using H_V=10.46±0.44.
- Using the same input data and an assumed thermal inertia of Γ = 5 J m^2 s$^{1/2}$ K^{-1}, a thermophysical model (Müller & Lagerros, 2002, A&A 381, 324) provides an effective diameter of D=56.1±2.2 km and p_V = 0.037±0.002, assuming an equator-on configuration.
- With a 5σ detection limit of ~6mJy at 22μm we were not able to identify the source on the Wide-field Infrared Survey Explorer (WISE) images.

Dynamical behaviour

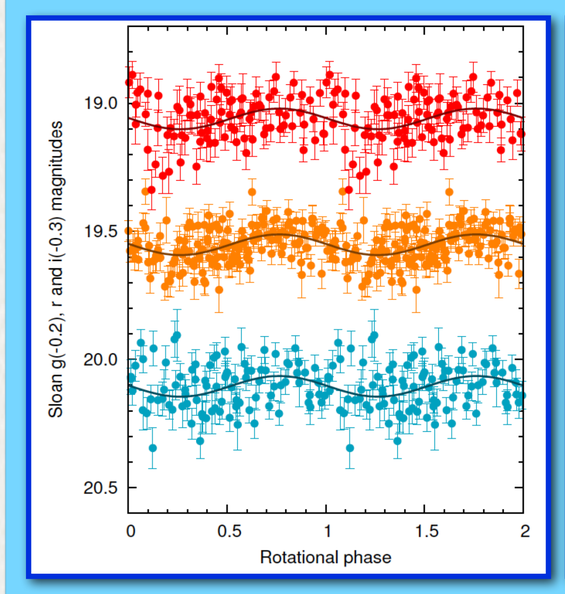
- The dynamical history is assessed by using the Hybrid integrator within the n-body dynamics package MERCURY, using 45x45x45=91125 clones, distributed uniformly in the {*q, e, i*} space
- The population of clones is highly unstable, ~64% of the clones are removed in the first million years, either by ejection from the Solar System or by a collision with one of giant planets or the Sun.
- 2013 AZ60 was likely recently captured into its current orbit and is likely originated from the Oort cloud.
- Two-third of the clones spent less than a thousand years within 100 au — the target is expected to have a pristine surface based on the dynamical calculations



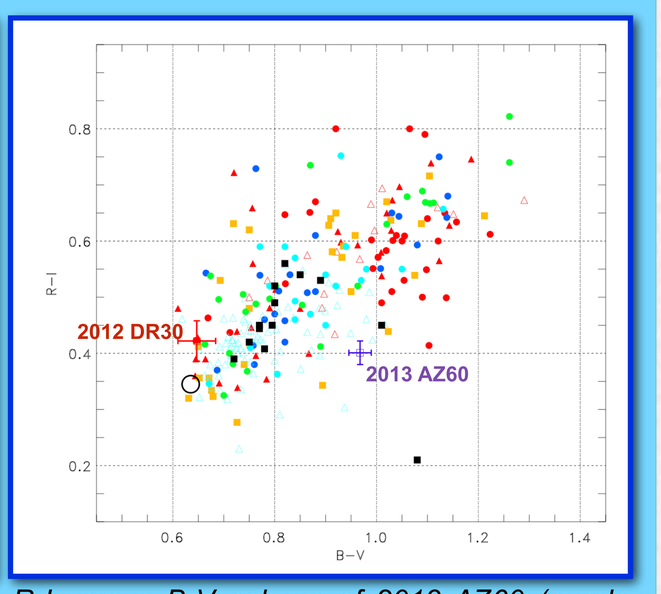
The decay of the population of 91125 clones as a function of time elapsed in our integrations.

Visual light curve, colours and reflectance

- g', r' and i'-band photometry was obtained with the IAC80 telescope (Teide Observatory, Tenerife) in 6 nights in November/December 2013 — these measurements also provided the light curve in these bands
- We identified a light curve period of 4.696h — the true rotation period is probably twice as long, i.e. 9.39h
- Our target has quite red colours: B-V=0.968±0.022, V-R=0.554±0.022, B-V=0.401±0.021
- J, H and K-band photometry was obtained with the LIRIS instrument on the William Herschel Telescope in September, 2013.
- The NIR colours are: J-H=0.34±0.07 and H-K=0.28±0.11

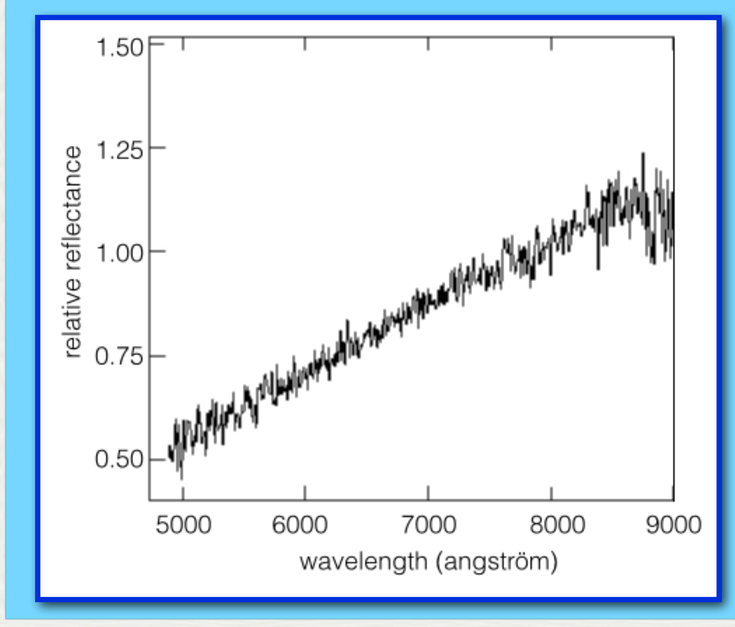


Folded optical light curves of 2013 AZ_{60}. The folding frequency is n = 5.11 d^{-1}.



R-I versus B-V colours of 2013 AZ60 (purple cross), 2012 DR30 (red cross, Kiss et al., 2013, A&A 555, A3) and other objects taken from the MBOSS2 database (Hainaut et al., 2012, A&A 546, L115). The large open circle marks the solar colours.

- Reflectance spectrum was obtained in January 2014 with the OSIRIS instrument on the Gran Telesopio CANARIAS
- The spectrum is red, in agreement with the photometric colours, and featureless up to ~900nm, similar to that of a D-type asteroid



Reflectance spectrum of 2013 AZ60, taken with the OSIRIS spectrometer on the GTC in January, 2014.

Conclusions

- 2013 AZ_{60} is very different from 2012 DR_{30}, a Centaur previously identified in a similarly eccentric and high semi-major axis orbit (Kiss et al., 2013, A&A 555, A3)
- The surface of 2013 AZ60 is much redder and much darker than that of 2012 DR30 — 2013 AZ_{60} could be an "extinct comet"
- 2013 AZ_{60} would fit into the group of Damocloids (Jewitt, 2005, AJ, 129, 530) based on its colours, dark surface and eccentric orbit, but its Tisserand-parameter (T_J=3.3) is quite different from that of this group (T_J<2)
- Signs of activity (outgassing) may still be expected near to its perihelion in November 2014 (q=7.91 au)

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