
Introduction: On 2 January, 2004, the Stardust spacecraft flew by the nucleus of comet 81P/Wild 2 with a closest approach distance of 240 km, allowing the first close-up view of the Stardust Optical Navigation Camera (ONC) obtained 72 images of the nucleus with exposure times alternating between 10 ns (near-optimal for most of the nucleus surface) and 100 ns (used for navigation, and revealing additional details in the coma and dark portions of the surface [1,2]. Phase angles varied from 72° to near zero to 103° during the encounter, allowing the entire sunlit portion of the surface to be imaged. As many as 20 of the images near closest approach are of sufficiently high resolution to be used in mapping the nucleus surface; of these, two pairs of short-exposure images were used to create the nucleus shape model and derived products reported here.

The best image resolution obtained was ~14 m/pixel, resulting in ~300 pixels across the nucleus. The Stardust Wild 2 dataset is therefore markedly superior to stereomapping perspective to the Deep Space 1 MICAS images of comet Borrelly [3]. The key subset of the latter (3 images) covered only about a quarter of the surface; of these, two pairs of short-exposure images were used to create the nucleus shape model and derived products reported here. The best image resolution obtained was ~14 m/pixel, resulting in ~300 pixels across the nucleus. The Stardust Wild 2 dataset is therefore markedly superior to stereomapping perspectives to the Deep Space 1 MICAS images of comet Borrelly [3]. The key subset of the latter (3 images) covered only about a quarter of the surface; of these, two pairs of short-exposure images were used to create the nucleus shape model and derived products reported here.

Methodology:

Topography and Slopes:

The stereoscopically determined coordinates of the surface points were translated and rotated to a body-centered system with X, Y, and Z axes along the long, middle, and short axes of the fitted ellipsoid, respectively.
Planocentric latitudes and longitudes as well as elevations measured normal to the reference ellipsoid could then be computed. Figure 1c shows the elevation data viewed from the direction of closest approach, and Figure 2 shows four views along the -X, ±Y, and ±Z axes of the ellipsoid (the remaining two views are omitted because they contain few points). Elevations range from ~400 m in the depression referred to (unofficially; see [1]) as Shoemaker basin to +250 m nearby, with a mean of 0, mode of ~50 m, and RMS variation of 86 m. The distribution of elevations is smooth and unimodal (though slightly skewed); although there is some suggestion of layering in the images, this does not translate into a resolvable preference for some absolute elevations over others, indicating that the layering is not globally consistent.

Figure 1c. Depletions computed. Figure 2 shows the elevation data viewed from the principal axes of the ellipsoid, whose outline is shown in light blue.

A quantitative assessment of the properly area-weighted probability distribution of surface slopes on the nucleus is challenging because the known points are spaced very irregularly on the ellipsoid, which is itself, highly nonspherical. As a first look at slopes, we have isolated profiles across the nucleus and computed elevations and arc lengths with respect to a best-fit ellipsoid, which is, itself, highly nonspherical. As a first look at slopes, we have isolated profiles across the nucleus and computed elevations and arc lengths with respect to a best-fit ellipsoid, whose outline is shown in light blue.

The most prominent features in the Wild 2 stereo topographic model are quasi-circular craters, which range in diameter from a few hundred meters to several kilometers. We measured the depths d and diameters D of 23 depressions >200 m that could be identified based on the on-axis views of the topography (Fig. 2) without reference to the images. Diameters were measured as the three-dimensional straight-line distance between two selected points on the opposite rims of the crater; this process is somewhat subjective in that visibility of the crater edges is affected by the false-color scheme used. It also results in significantly larger diameters for the largest basins (e.g., 2.4 vs. 1.6 km for Shoemaker basin) than the two-dimensional estimates in [1]. Depths were computed as the difference between the ellipsoid-relative height at the deepest point in the crater interior and that of a representative point on the rim. Results are shown in Figure 3. The D/D ratio, which is essentially independent of size, is comparable to that of fresh, bowl-shaped lunar craters [9] (as well as small fresh craters on the terrestrial planets), and substantially greater than for craters on other small bodies [10]. It is important to note that Fig. 3 includes measurements of both flat-floored and more complex "pit-halo" craters [1], which are morphologically distinct from one another and from bowl-shaped impact craters. The figure also includes measurements for the features "Left Foot" and "Right Foot", which were described in [1] as complex and potentially highly modified by nonimpact processes. In the Z-axis view (Fig. 2, center), these features each appear to consist of two partially overlapping, nearly circular, flat-floored depressions. We therefore feel justified in treating the "sole" and "heel" of each foot as a separate crater. In any case, the D/D ratios obtained do not, by themselves, distinguish different classes of craters. The depth of craters on Wild 2 will hopefully serve as a useful constraint on future theories of their formation and modification.

References: