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Stereo Topography of KBO (486958) 2014 MU_{69}

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Abstract

During the New Horizons flyby of KBO (486958) 2014 MU_{69} [1] only a limited number of observations were possible as the spacecraft raced by the object. Porter et al. [2] demonstrate the process by which the observations are used to solve for a whole body shape and the rotational pole.

Here we describe the observations that were used for a stereo topographic solution and characteristics of the terrain and its relation to the whole body shape.

1. Stereo Observations

Due to the high-speed trajectory of New Horizons past MU_{69}, our ability to capture observations with varied perspectives was limited. In addition, due to the spacecraft velocity relative to our target, long exposures were not possible, so many individual LORRI images were taken with short exposures and combined to improve the signal to noise. This also allowed for deconvolution algorithms to improve identification of features.

Table 1 describes the observations that we used to build stereo terrain. Observations before CA04 had similar photometric angles, but poorer resoution. Observation CA07 was taken after closest approach, and looks back on the lit crescent of MU_{69}.

Table 1: Stereo Observations

Observation	Phase angle (°)	Ground Scale (m/pixel)
CA04	12.9	140
CA05	15.8	80
CA06	32.5	30

These observations can be combined into two pairs: CA04 & CA06 and CA05 & CA06. You might assume that the CA05 & CA06 pair would be superior, because of the better ground scale of CA05 over CA04. However, due to the faster relative target motion during CA05 relative to CA04, there is more smear in the resulting image stack for CA05. The parallax angle of CA04 & CA06 (19.6°) is better than the CA05 & CA06 pair (16.7°). These factors resulted in the quality of the CA04 & CA06 model being better.

2. Technique

We used the NASA Ames Stereo Pipeline [ASP, 3, 4] to select interest points and perform bundle adjustment of the images. We then used the ASP's Semi-Global Matching algorithm to create a stereo point cloud (Fig. 1). Co-author Schenk's LPI "Z" stereogrammetry software also produces broadly similar results.

The technique used to generate the whole body shape model [2] is most constrained around the MU_{69} equator that effectively corresponds to the limb and terminator in the observations, and least constrained along the Z axis. Inversely, stereogrammetry with this image set has better constraints on the shape of the ventral surface, but stereo data become poor towards the limb and terminator because the curvature of MU_{69} increases there.

We applied an iterative closest point algorithm [5, 6] to fit these rigid skins to the ventral surface of the whole body shape model (Fig. 2).

3. Results

The stereo model fits well against the whole body model, providing an independent validation of the rough shape of the ventral surface of MU_{69}. The stereo

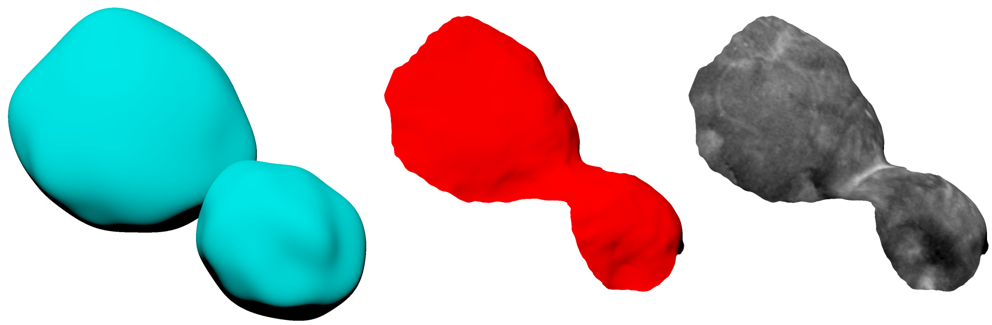

Figure 1: The cyan rendering on the left is the whole body shape model[2], the red rendering in the center is the ASP stereo model, and the rendering on the right is with the CA04 observation on the ASP model as a texture.

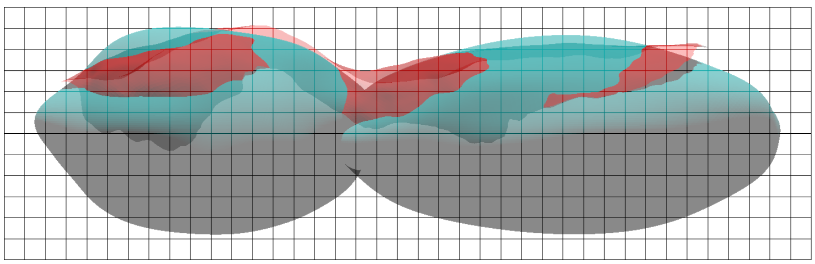

Figure 2: This orthographic view shows the two models after ICP fitting. The grid squares are 1 km in size.

model has discrepancies near its edges, as expected. It also shows that the Ultima lobe is even more flattened than the whole body model predicts, but the difference is within the predicted uncertainty in the Z axis of the whole body model. At this time, fine detail is not present in the stereo models.

Overall, the stereo topography is showing a relatively smooth, continuous surface at the scale of hundreds of meters, consistent with the whole body model and limb measurements, indicating that it is likely a mature, evolved surface without significant geologic upheaval.

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