3-DIMENSIONAL RECONSTRUCTION OF ASTEROID 2867 STEINS. S. BESSE[1], O. GROUSSIN[1], L. JORDA[1], P. LAMY[1], M. KAASALAINEN[2], G. GESQUIERE[3], E. REMY[3], and the OSIRIS Team, [1]Laboratoire d'Astrophysique de Marseille (LAM), Marseille, France, sebastien.besse@oamp.fr, Dept of Mathematics, University of Helsinki, Finland, [3]Laboratoire des Sciences de l'Information et des Systèmes (LSIS), Arles, France

Introduction: The OSIRIS [1] imaging experiment of the Rosetta spacecraft will image comet 67P/Churyumov-Gerasimenko in 2014-2015. During its journey, OSIRIS has imaged asteroid 2867 Steins on 5th September 2008. The fly-by was successful and returned more than 100 resolved images of the body as shown on Figure 1 [2]. The diamond's shape of the body is remarkable. The surface presents several small craters and two very large ones, one having a diameter of approximately 2 km. We can also distinguish a chain of impact crater on the right of Figure 1 which is very rare feature on such a small body.

Figure 1: WAC image of 2867 Steins at closest approach (ESA ©2008 MPS for OSIRIS Team, MPS/UPD/LAM/IAA/RSSD/INTA/UPM/DASP/IDA)

OSIRIS data: Asteroid Steins was observed both with the Narrow Angle Camera (NAC) and the Wide Angle Camera (WAC) of the ORISIS experiment [1]. 59 images of the WAC with large convergence angles (angle between two different observation) and different resolution (from 200 m/pixel to 80 m/pixel) and one NAC image (resolution of 80 m/pixel) were used to reconstruct the shape of Steins.

Method: We have combined three methods to retrieve the shape model based on automatic procedures. The first method uses limbs (illuminated edge of the body) detection of the body to constrain the shape even when the body is poorly resolved (Figure 2). The edge of the terminator is estimated manually in an iterative process, insuring that the shape match all images. The limb method provides only a convex hull of the shape, this is why stereo techniques are required as a second step. The second method uses the detection of Point of Interest and the determination of their 3D coordinates. These points are then called Ground Control Points (GCP) [3] and define the local elevation of a pixel in the body reference frame. The automatic match of the Point of Interest between different images is the key point of this fully automatic procedure and it is performed using a raytracing approach. Only three WAC images were used with this approach. The 22 Points of Interests that we determined are presented on Figure 3 and are mainly associated with photometric anomalies on the surface or remarkable features (central peak, rim, ejecta).

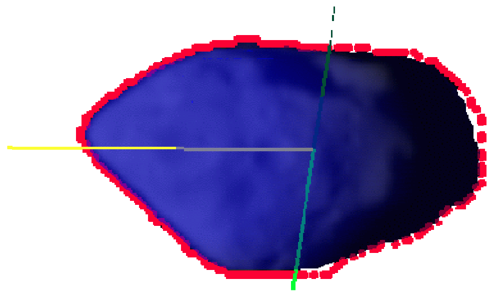

Figure 2: Superposition of the shape and the WAC image with the limb technique. The contour of the body is in red, the projected direction of the pole axis in green, the shape in blue and the projected direction of the sun in yellow.

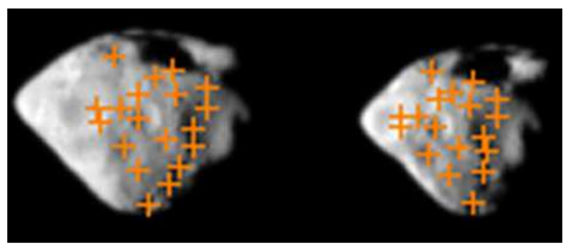

Figure 3: Points of interest detected between two images of the WAC and paired using our automatic procedure.

The third method uses inversion techniques from light curves [4] to constrain the non-observed part of the asteroid during its fly-by. Finally, we combine all the information from each methods (e.g limb, GCP, light curves) to derive the shape model. For this purpose, a 3D constrained deformation method based on simplex mesh is used [5].

Results: Figure 4 illustrate the reconstructed shape of Steins. The mean radius is 2.7±0.3km, for a volume of 78±30km^3 and a surface of 98±25km^2

The main uncertainty on the size comes from the limb method that tent to ignore concavities such as the large crater on top of Figure 1.

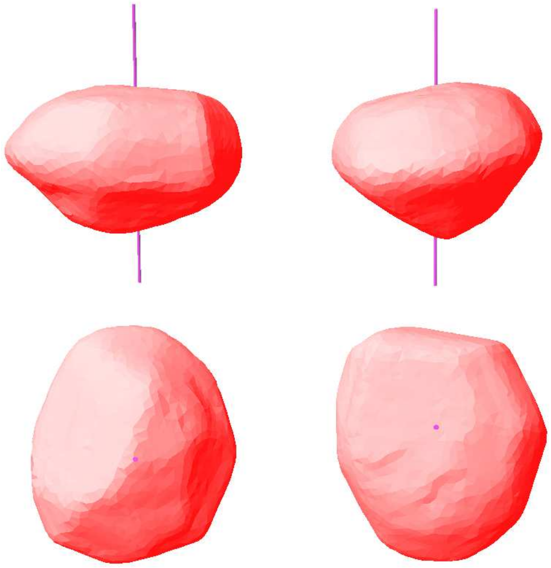

Figure 4: Shape model derived from limb and light curves. The purple axis defines the poles of the body. Top: two views from the equator (north is down), Bottom left: view from north hemisphere, Bottom right: view from south hemisphere.

As presented on Figure 5, before we apply the simplex deformation, most of the GCP's are inside the shape. This makes sense since the limb approach only gives the maximum convex envelop of the body and overestimate the shape of the asteroid. The final shape model, including deformations with the GCP, is under process and will be presented at the conference.

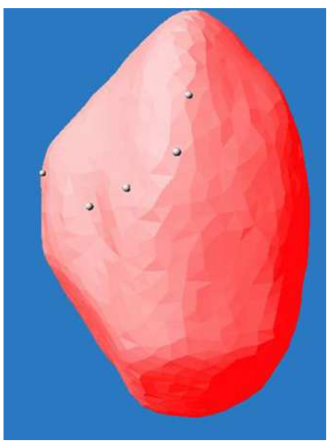

Figure 5: Shape model derived from limb and light curves and position of GCP. Only five points are visible and lie on the surface, the other 17 points are inside this shape. (North hemisphere is at the left)

Conclusion: We have obtained a 3D shape of asteroid Steins. This shape is in agreement with previous size estimates from ground based observations [4]. All methods used to derive the shape model of Steins were performed successfully and automatically. This approach for shape reconstruction will be used for the next targets of the Rosetta mission: asteroid 21 Lutetia in July 2010 and comet 67P/Churyumov-Gerasimenko in 2014.

References: [1] Keller et al, 2007, Space Science Reviews, [2] Keller et al, 2008, 40Th Division for Planetary Sciences, [3] Besse et al, 2008, 40Th Division for Planetary Sciences, [4] Lamy et al, 2008, Astronomy & Astrophysics, [5] Delingette, 1999, International Journal of Computer Vision

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