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New Astrometric Observations of Deimos with the SRC on Mars Express

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Abstract

We present a new set of astrometric data for Deimos, obtained by the SRC camera on Mars Express. New techniques have been developed involving the Deimos shape model to improve accuracy of our measurements. The observations are in agreement with current Martian satellite orbit models within a few km.

1. Introduction

Deimos, the smaller outer Martian satellite, revolves in a near-circular, near-equatorial orbit at a mean distance of about 23.458 km from its parent planet. While the origins of the Martian satellites are uncertain, astrometric observations represent a key for the modelling of their orbital evolutions and dynamics.

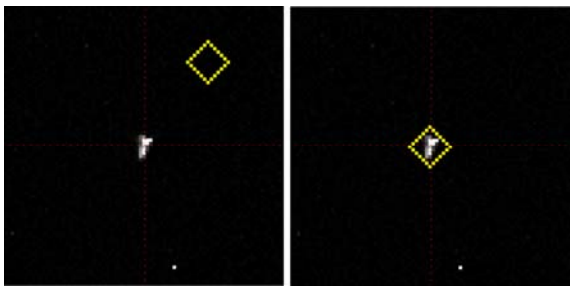

Figure 1: By squaring the predicted star position (yellow rhombus) with the observed star position we obtain the image offset in sample/ line coordinates

2. Deimos Images

From October 2004 to May 2011 Mars Express had about 50 approach maneuvers at ranges between 9.500 and 14.200 km. The spacecraft is equipped with the SRC (Super Resolution Channel) framing camera [4], taking images at resolutions between 87.2 and 128.7 m per pixel during these approaches. Typically, SRC obtains sequences of eight images, the first and the last of which are long-time exposures to capture background stars. These are used to verify and improve the camera pointing by comparisons with predicted star positions from catalogues, e.g. Hipparcos (Fig. 1).

3. New Astrometric Measurement Technique

Generally, two to four of the images of one sequence contain Deimos and are used to determine its precise position in sample and line coordinates. The Deimos shape model [2] is projected into the image to derive predicted limb and terminator positions in the image. The Deimos' centre of figure is determined by fitting the predicted limb to the observed limb. While we have previously used ellipsoidal shape models [3] to predict satellite limb positions, the use of a full shape model yields positional measurements at considerably improved accuracy (Fig. 2). Astrometric measurement techniques on the basis of surface control points, as have been demonstrated for Phobos [5], are not suitable, as Deimos is small and shows little surface detail.

4. Results

Following correction of the camera pointing and the reduction via coordinate transformations we obtain a dataset of 105 observations of Deimos in spacecraft-centered, inertial J2000, equatorial coordinates. The accuracies of the observations are estimated as a function of the error in the limb fitting procedure and the errors in pointing and position of the spacecraft [1]. They vary between 0.003° and 0.016°, which corresponds to an accuracy of 0.69 to 3.49 km in

Deimos position. The results appear to be in agreement with current orbit models at km-level [6], with remaining small systematic offsets being under investigation.

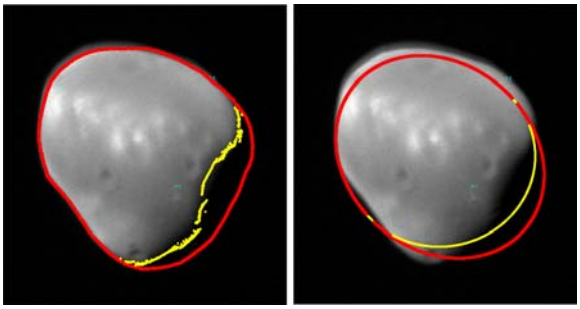

Figure 2: Left image shows the fitted predicted limb as derived from the Deimos shape model and right image shows the corresponding position of the theoretical limb based on the Deimos tri-axial ellipsoid

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