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# IMAGE PROCESSING TECHNIQUES FOR POSITION MEASUREMENTS OF URANUS' SATELLITES

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ABSTRACT. In this paper we describe a new procedure to determine the coordinates of the center of Uranus' satellites. Two different methods were used depending on how much the satellite light distribution is affected by that of the planet. Comparison with the results obtained from visual measurements suggests that the procedure proposed in this work does indeed provide much more accurate position measurements for all satellites.

Modern image processing techniques have allowed to extract more systematic and accurate information from photographic plates. Therefore, the primary motivation of this work is to examine how we can get a better determination of the sattelite center, making extensive use of these techniques. In this paper we briefly discuss the procedure used to carry out such measurements and present some preliminary results that confirm the reliability of the methodology employed.

The photographic plates analysed were taken using the Observatório Nacional (O.N.) 60-in. telescope (scale 13.0"$mm^{-1}$) with a 15.9 m focal length Cassegrain camera. These plates were scanned on a PDS 1010 A microdensitometer utilizing a 20 x 20μ slit and steps of 5μ. For each outer satellite (Ariel, Umbriel, Titania and Oberon) we obtained data arrays of typically 60 x 60 pixels while for the special case of Miranda a larger area (350 x 350 pixels) was scanned including both, satellite and planet.

Position measurements for the outer satellites were obtained by fitting

ellipses to several isodensity levels of each image and averaging the coordinates of the several centers. Isodensity maps for the outer satellites are illustrated in figure 1.

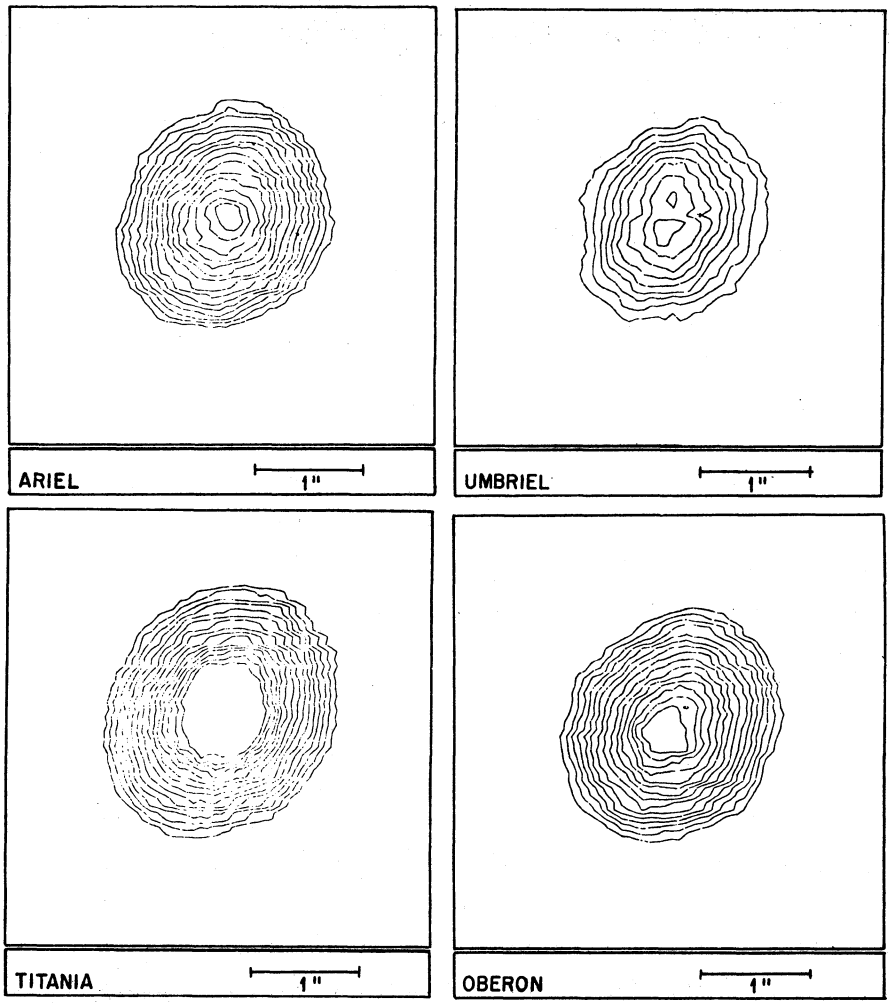


Figure 1. Isodensity maps of Uranus outer satellites.

The method described above cannot be used in the case of the satellite Miranda whose image is strongly affected by the light distribution of Uranus as can be seen in figure 2. We note that the light contribution from the planet causes a systematic error in the determination of the actual position of Miranda primarily along the direction connecting the two centers.

In order to minimize the error arising from the light contamination, the position for this close satellite was determined using the following procedure:

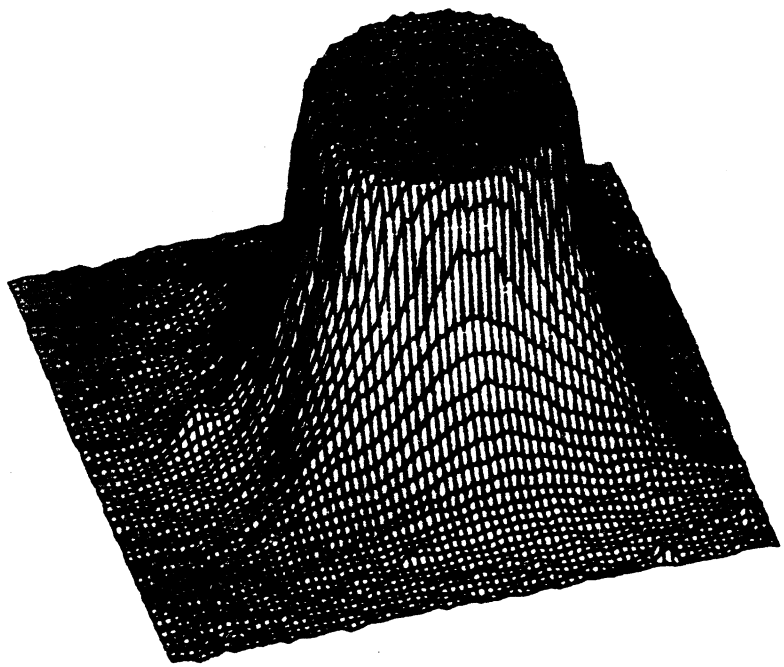

Figure 2. 3-D representation of the light distribution of the Uranus-Miranda system.

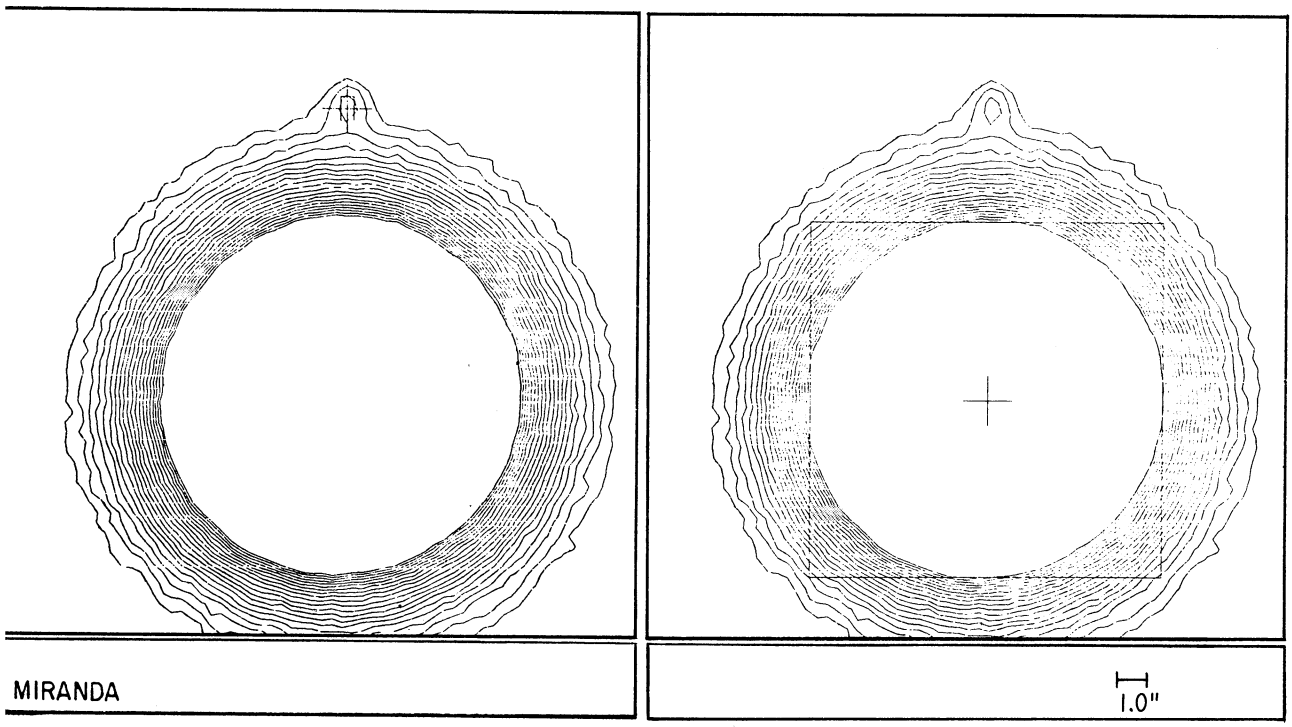


Figure 3. Preliminar center determination of Uranus and Miranda.

1. Uranus' center is accurately determined and a first guess for Miranda's center is obtained utilizing its innermost isodensity level, as shown in figure 3. Next using these centers we can derive the light profile along the planet-satellite direction.

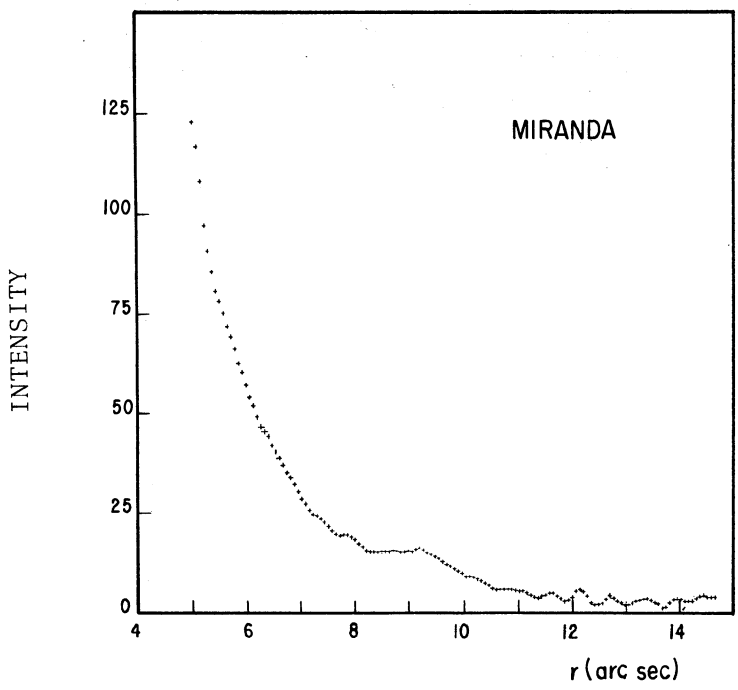


Figure 4. Profile of Uranus-Miranda system in the planet-satellite direction

2. We adjust a third order polynomial to the Uranus' light contribution and subtract this fitting from the planet-satellite light profile. The residual is the actual Miranda's profile (figure 5).

3. A second order polynomial is then fitted to Miranda's profile to determine its center (figure 6), using all points in the domain 7"-12".

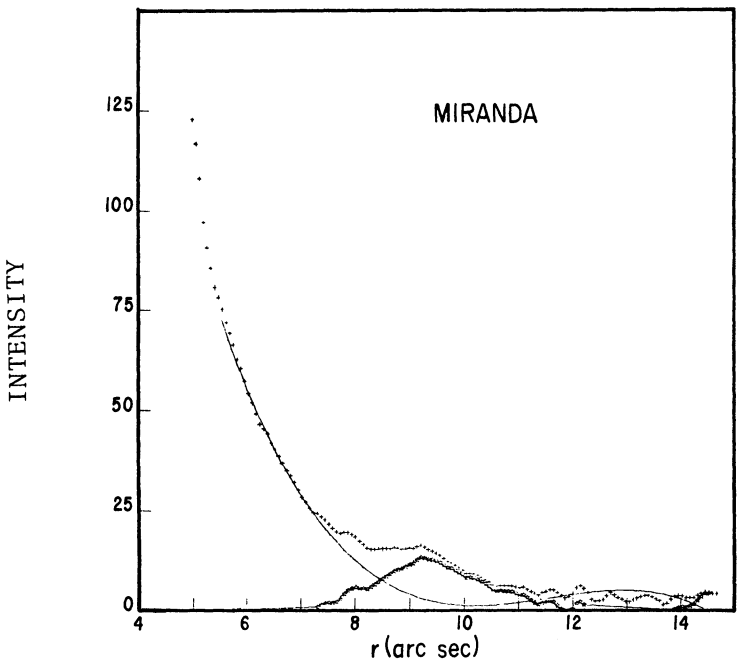


Figure 5. Subtraction of the Uranus' contribution. The symbols denote: (+) planet-satellite profile; (x) residual light profile. The solid line is the planet-satellite profile.

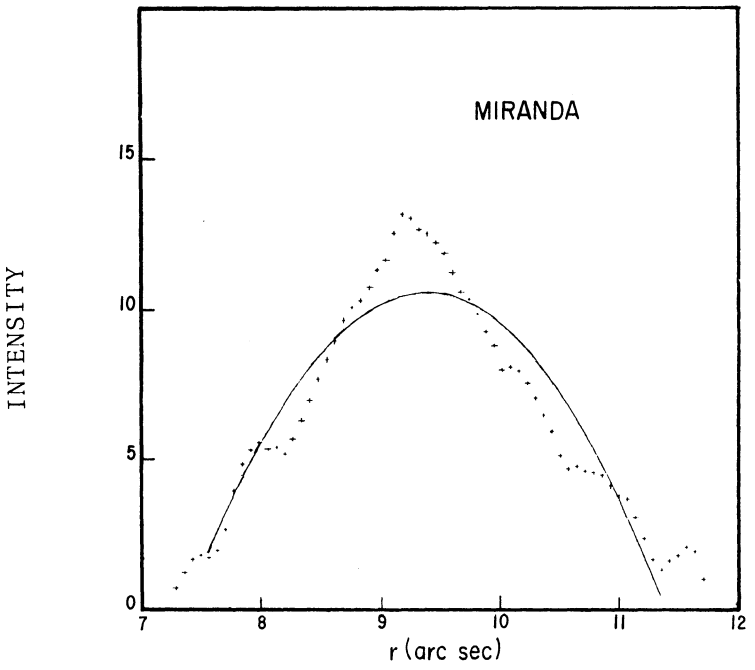


Figure 6. Determination of the center of Miranda.

Uranus' outer satellites were used to define a reference system to calculate Miranda's position. This was done utilizing the orbital parameters given by Veillet (1983). A comparison with visual determinations obtained with the Zeiss Ascorecord of the UFRJ-Observatório do Valongo is illustrated in table I. These results indicate that better position measurements can be obtained with the techniques described above.

TABLE I

| Plate No. | Emulsion | Seeing (arcsec) | Ascorecord $(O-C)_x$ | Ascorecord $(O-C)_y$ | PDS $(O-C)_x$ | PDS $(O-C)_y$ |
|---|---|---|---|---|---|---|
| 558 | IIIa-J | 1.2 | -0.017 | -0.166 | -0.041 | 0.008 |
| 587 | IIIa-J | 1.4 | 0.168 | 0.035 | 0.020 | 0.020 |
| 590 | IIa-O | 1.8 | 0.165 | -0.031 | -0.029 | -0.011 |
| 595 | IIa-O | 2.1 | 0.183 | -0.016 | -0.056 | -0.011 |

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