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# Astrometric Observations of (1665) Gaby, and (1565) Lemaître Asteroids at TUBITAK National Observatory (TUG)

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## 1. Introduction

In this study, we are providing the accuracies and precisions of our observations made with a 100 cm in diameter telescope (T-100) at TUBITAK National observatory (TUG) located in Antalya, in order to determine the efficiency of T-100 telescope for GAIA's ground base observations. In this respect, we have studied 1565 (Lemaitre) and 1665 (Gaby) which are well-known main belt asteroids using T100 telescope and by obtaining new orbital parameters of Lemaitre with a fit with RMS around 0.2 for both asteroids, respectively. Our results indicate that T100 telescope and our observational equipments are sufficient to participate GAIA follow up ground base observational tasks. T100 and capacity of other observational equipments seem very convenient for astrometric observations.

## 2. Site Characteristics and Observational Equipments at TUG

All of the observations of Lemaître and Gaby were obtained by using the remote control T-100 telescope which has 1 meter R-C type mirror with 10 meters focal distance, 0.3 arc sec pixel scale and 22 arc minutes field of view (see ref.1). T100 telescope located in TUG (TUBITAK National Observatory) Bakirlitepe Mountain (2500 meters high above the sea level) close to Antalya, which has 260 clear nights in a year and 0.8 arc sec median seeing (Fig.1).



Fig. 1: T-100 Telescope Technical Specifications

We have used 1100 series 4K x 4K CCD camera attached with V, R and Clear bands and limiting magnitude interval for moving objects is 14-20 magnitude.

### 3. Observations

We have observed Lemaître in 27 nights and obtained 654 frames in V, R and E (empty) bands (Table 1). The minimum altitude of Lemaître was 20 degrees.

NIGHTS	NUMBER OF FRAME	ALTITUDE OF OBJECT	FILTER
20110826	19	52-58	V
20110827	20	20-25	E-V-R
20110828	19	30-37	E-V-R
20110829	12	27-37	E-V-R
20110830	19	40-45	E-V-R
20110925	18	64-70	E-V-R-ND0.5
20110926	50	45-56	E
20110927	21	47-53	ND0.5-V-R
20110928	21	45-50	ND0.5-V-R
20110929	21	53-59	ND0.5-V-R
20111021	15	73-81	ND0.5-V-R
20111022	30	66-70	E-V-R
20111023	7	67-74	E-V
20111024	60	74-79	E-V-R
20111025	20	78-80	E-V-R
20111123	34	58-67	E-V-R
20111124	30	70-73	E-V-R
20111125	40	70-72	E-V-R
20111126	27	67-80	E-V-R
20111127	20	65-67	V-R
20111214	15	65-66	E
20111225	40	53-45	E-V-R
20120122	20	28-33	E
20120123	17	48-52	E
20120211	19	48-52	E
20120224	32	48-58	V-R
20120319	8	20-27	V-R
<b>27 Nights</b>	<b>654 Frames</b>		

**Table 1:** Observational Data for Lemaître.

We have observed Gaby in 19 nights and obtained 594 frames in V, R and E (empty) bands (Table 2). The minimum altitude of Lemaître was 27 degrees. We also have used ND0.5 filter during the observations.

NIGHTS	NUMBER OF FRAME	ALTITUDE OF OBJECT	FILTER
20111021	24	56-58	ND0.5-V-R
20111022	47	53-58	E-V-R
20111023	40	41-55	E-V
20111024	61	49-56	E-V-R
20111025	40	47-55	E-V-R
20111123	15	32-37	E-V-R
20111124	36	41-53	E-V-R
20111125	34	49-55	E-V-R
20111126	36	49-55	E-V-R
20111127	33	42-52	E-V-R
20111214	16	31-34	E
20111225	20	27-32	V-R
20120211	40	51-64	E-V-R
20120212	25	29-43	E-V-R
20120223	41	43-50	V-R
20120224	28	56-66	V-R
20120318	36	28-44	V-R
20120319	22	39-41	V-R
<b>19 Nights</b>	<b>594 Frames</b>		

**Table 2:** Observational Data for Gaby

#### 4. Reduction Method

We have used Astrometrica software for reduction of the data for both asteroids. We selected UCAC2 catalogue for reference stars. More than 150 reference stars were detected per frame, the fourth order of the polynomial was used and standard errors were around 0.10 to 0.20, respectively.

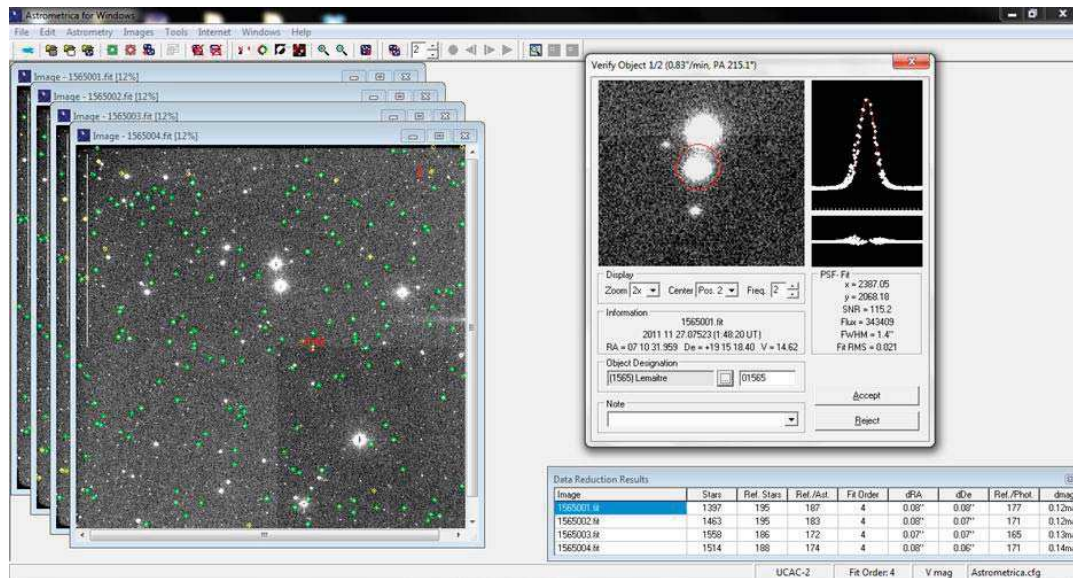


Fig. 2: Astrometrica software

#### 5. Data Analysis

We have obtained ephemeris and MPC report for Lemaître and Gaby using Astrometrica, send these reports to NASA Horizon e-mail address (See ref. 3) to calculate all (O-C) values. Below, Fig 3 shows our observations and distribution of (O-C) values for Ra. and Dec. for Lemaître and Gaby. Were X, Y axes imply the mean (O-C) values for Ra. and Dec., respectively. Each point in Fig.3 represents the mean value of all (O-C) in both coordinates

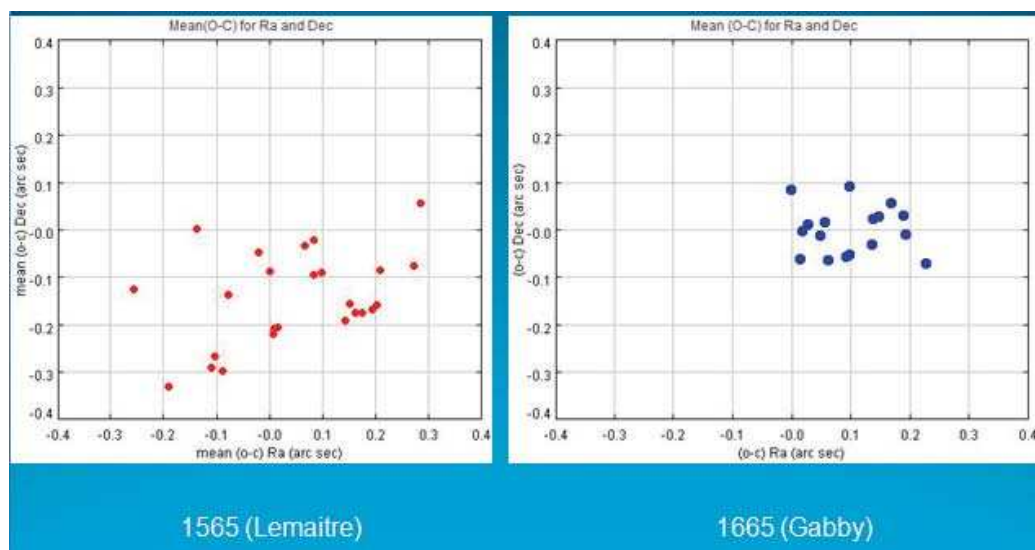


Fig. 3: Distribution of mean (O-C) values for Ra and Dec for Gaby and Lemaître

Figure 4 shows the standard errors obtained in this study in Ra. and Dec. with respect to the magnitude for Lemaitre and Gaby asteroids. As can be seen, most of the errors are less than 0.15 arc sec in both coordinates.



**Fig. 4:** Standard errors for Ra and Dec

## Conclusion

We made total of 1248 observations; 654 observations in 27 nights for Lemaitre, and 594 observations in 19 nights for Gaby. In our study, systematic error for both asteroids was about 0.2 arc sec while the previous studies have 0.47 arc sec RMS error values for Lemaitre, and 0.53 arc sec for Gaby as listed in the Horizon web site(see ref.2). Our low fit RMS error values listed in Fig. 3 and Fig.4 indicate that our observational facilities, with both quality of equipment, methodology, and experience of our personnel are very promising to carry out these task as GAIA ground based follow up mission.

## References

- [1] [http://www.tug.tubitak.gov.tr/t100\\_si\\_ccd.php](http://www.tug.tubitak.gov.tr/t100_si_ccd.php)
- [2] <http://ssd.jpl.nasa.gov/sbdb.cgi>
- [3] [horizons@ssd.jpl.nasa.gov](mailto:horizons@ssd.jpl.nasa.gov)