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Astronomy project

Observation of the moons of Jupiter

Objective:

We propose in this project to observe on successive days the position of each of the four major moons of Jupiter: Io, Europe, Ganymede and Callisto to deduce finally their orbital periods.

Materiel used:

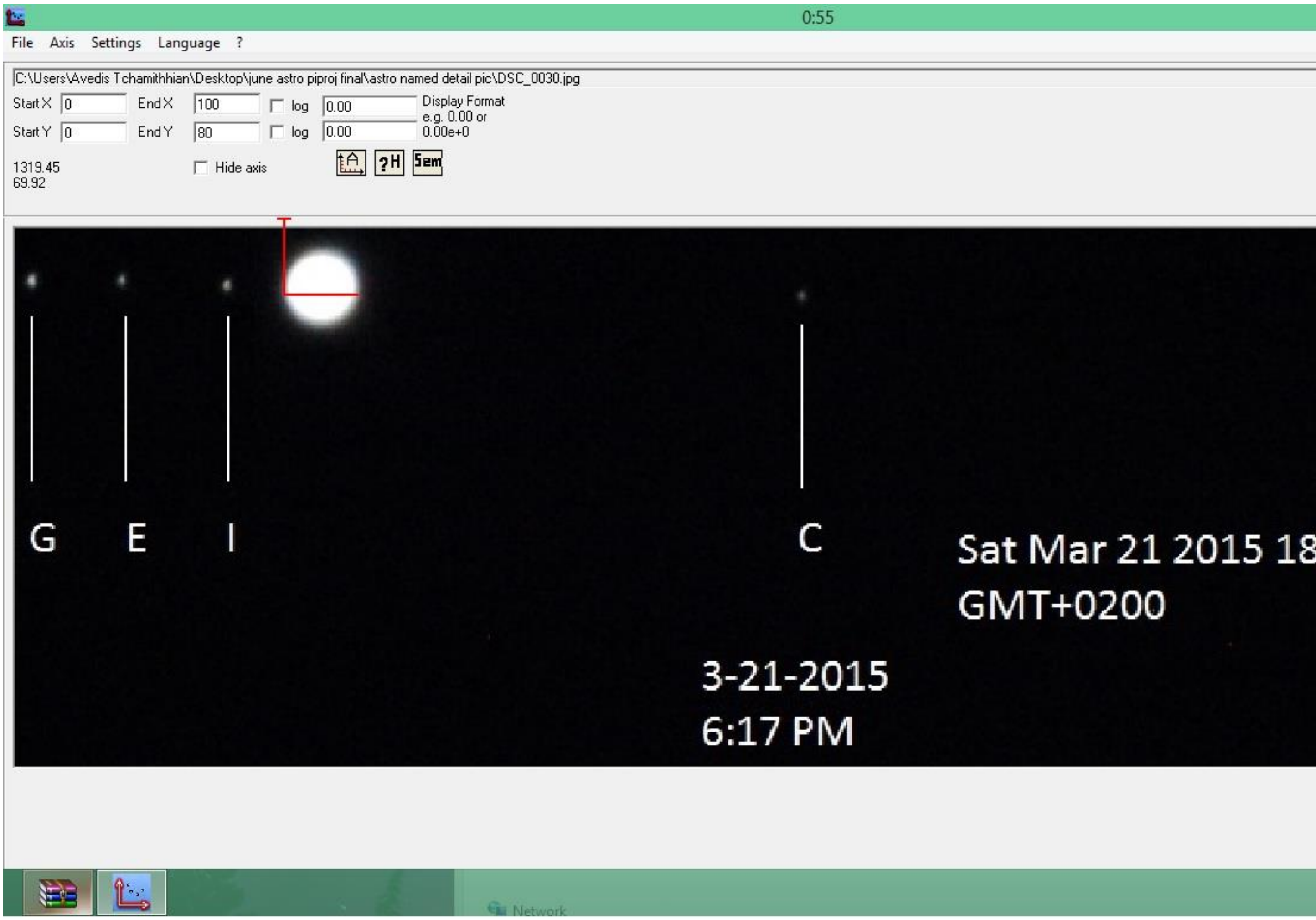
• Telescope (Celestron / CPC 800 GPS (XLT) Computerized 14" apertures)
• Camera (Canon EOS 500D)
•**Program used:** Matlab, Excel, Digitize Plot To Data Vhjlj2.2.1, PS Photoshop

Observations: We started to take some accurate shots of Jupiter extensively for about two weeks. More than once every time at the interval of 4 hours at least. And we retrieved the apparent distance of each Moon compared to Jupiter's surface, and we chose as unit D: The apparent diameter of Jupiter.

We have used ” Digitize Plot To Data Vhjlj2.2.1”that gave us a better accuracy of measurement.
We will only present some photos of the moons clearly.
And the Data that we took and analyzed with various programs that are already mentioned previously.

Analysis of observation:

Method: We will implement on a graph the different positions of each of the four satellites on various days.
1) By using” Digitize Plot To Data Vhjlj2.2.1” we were able to upload our shot in a coordinate system where we could accurately retrieve the coordinates of Jupiter and each of its moon's center.



2)After retrieving those coordinates, we've uploaded them on excel, and we've calculated the distance separation of each moon relative to Jupiter center.

ASTRO EXEL.xlsx - Excel (Product Activation Failed)

015 thur march 17 2015 18:12:56Gmt +2	x	y	Dirtance
Jupiter	40.15	119.36	
Ganimede	215.7	118.23	175.5536
Europa	-312.37	125	352.5651
Io	-133.97	121.62	174.1347
Calirta	840.82	113.73	800.6898
			424984

0042 wed march 18 2015 00:11:37 GMT +2	x	y	Dirtance
Jupiter	45.74	114.71	
Ganimede	368.95	120.5	323.261857
Europa	-308.33	114.71	354.07
Io	-189.32	113.55	235.062862
Calirta	991.87	126.3	946.200986
			446505

66 wed march 18 2015 19:08:37 GMT+2	x	y	Dirtance
Jupiter	43.91	147.61	
Ganimede	655.78	126.69	612.227
Europa	146.93	146.38	103.027
Io	299.9	138.99	256.135
Calirta	1149.01	111.92	1105.67
			5147

0012 B thu march 19 2015 23:53:56 GMT+2	x	y	Dirtance
Jupiter	45.79	107.49	
Ganimede	510.16	101.98	464.4027
Europa	308.64	103.36	262.8824
Io	-78.62	108.87	124.4177
Calirta	1090.19	95.08	1044.474
			618244

70 fri march 20 2015 19:24:46 Gmt+2	x	y	Dirtance
Jupiter	43.83	117.05	
Ganimede	125.54	114.19	81.7600373
Europa	-195.88	124.19	239.816312
Io	210.9	111.33	167.16789
Calirta	924.58	88.48	881.213259
			688494

0030 sat march 21 2015 18:17:37 gmt +2	x	y	Dirtance
Jupiter	45.33	126.9	
Ganimede	-344.58	135.79	390.011
Europa	-222.13	135.79	267.60
Io	-78.73	130.71	124.118
Calirta	697.85	119.28	652.564
			7708

25 thur march 21 2015 19:27:30 GMT+3 RAM	x	y	Dirtance
Jupiter	43.81	135.48	
Ganimede	105.72	135.48	61.91
Europa	-379.74	135.48	423.55
Io	-68.76	135.48	112.57
Calirta	-13.88	133.26	57.7327
			775058

0019 sat march 21 2015 22:55:37 gmt +2	x	y	Dirtance
Jupiter	44.04	111.63	
Ganimede	-453.62	85.43	498.34919
Europa	-97.9	108.87	141.966831
Io	117.64	115.77	73.7163455
Calirta	648.6	141.98	605.321333
			787605

12A sun march 22 2015 18:08:56 GMT +0200	x	y	Dirtance
Jupiter	52.39	171.8	
Ganimede	-698.7	188.82	751.282
Europa	438.78	164.99	386.450
Io	n	n	#VALUE
Calirta	410.56	168.4	358.186
			8567

118 sund march 22 2015 23:29:46 gmt+2	x	y	Dirtance
Jupiter	46.73	135.5	
Ganimede	-571.53	121.94	618.4087
Europa	432.49	142.28	385.8196
Io	-94.49	134.15	141.2265
Calirta	267.16	142.28	220.5342
			875994

0013 wed march 25 2015 18:29:56 GMT + 2	x	y	Dirtance
Jupiter	53.9	169.4	
Ganimede	733.28	156.06	679.510956
Europa	n	n	#VALUE!
Io	326.62	167.49	272.726688
Calirta	-963.96	197.97	1018.26088
			1117204

056 thur march 26 2015 18:20:37 GMT+2	x	y	Dirtance
Jupiter	45.3	124.51	
Ganimede	566.19	116.82	520.946
Europa	386.03	119.9	340.761
Io	-174.02	127.59	219.341
Calirta	-878.98	130.67	924.300
			12030

29 sun march 29 2015 19:21:46 gmt +3 ram +	x	y	Dirtance
Jupiter	49.27	144.19	
Ganimede	-588.14	141.33	637.4164
Europa	338.01	145.62	288.7435
Io	150.97	147.05	101.7402
Calirta	-771.55	139.9	820.8312

101 wed aprl 1 2015 19:32:56 gmt+3 Ram +2	x	y	Dirtance
Jupiter	43.04	113.59	
Ganimede	576.34	119.2	533.329506
Europa	-6.9	113.59	49.94
Io	242.81	116.4	199.789762
Calirta	421.17	117.8	378.153436

Chart Title

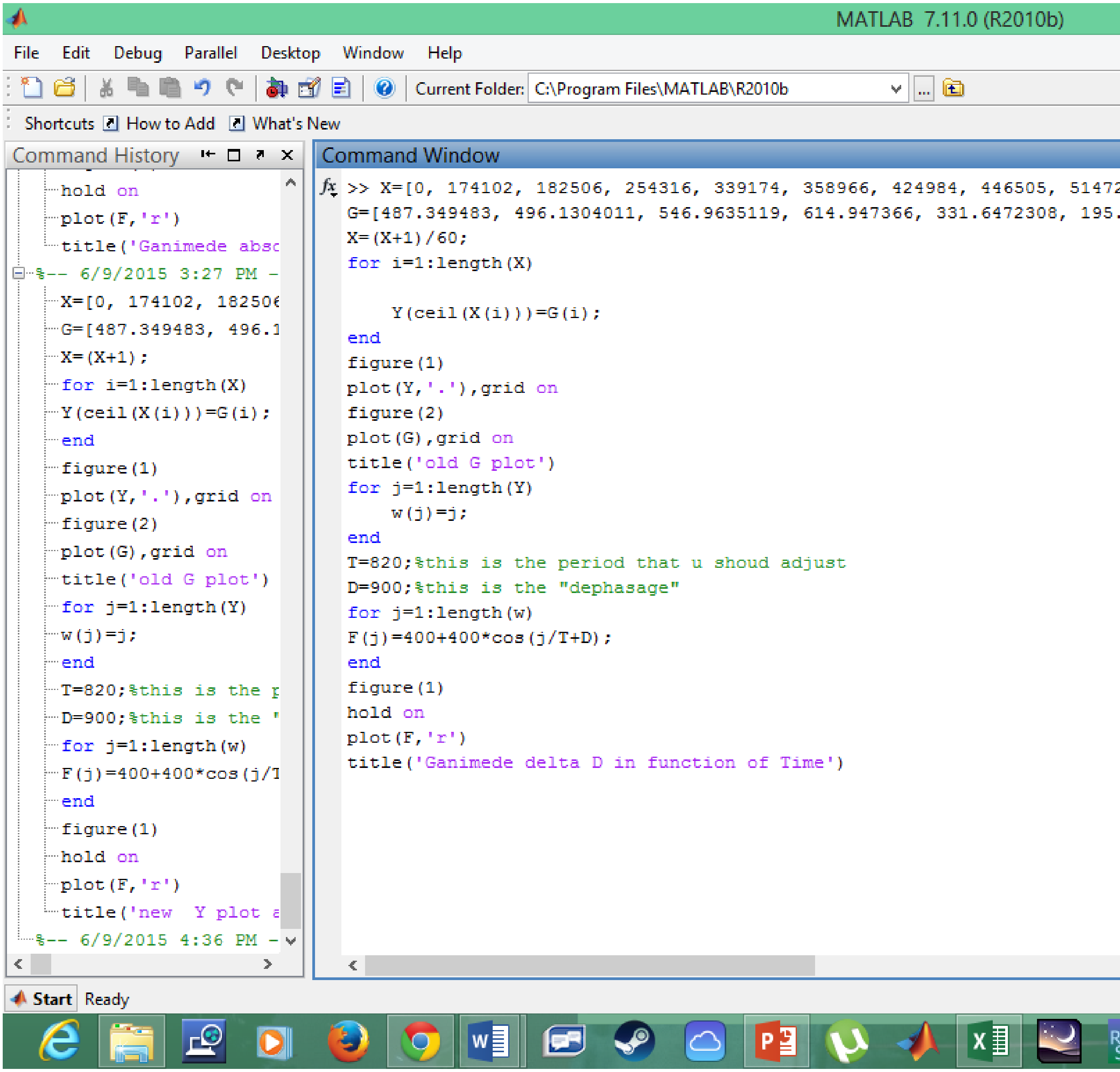
Sheet1 Sheet2

READY

42				
43–44		25 thus march 21 2015 19:27:30 GMT+3 RAM		
45		x	y	Distance
46	Jupiter	43.81	135.48	
47	Ganimede	105.72	135.48	61.91
48	Europa	-379.74	135.48	423.55
49	Io	-68.76	135.48	112.57
50	Calisto	-13.88	133.26	57.732699
51				775058

3) After calculating each distance variation in function of time for each moon relative to Jupiter, we've uploaded those data into mat lab.

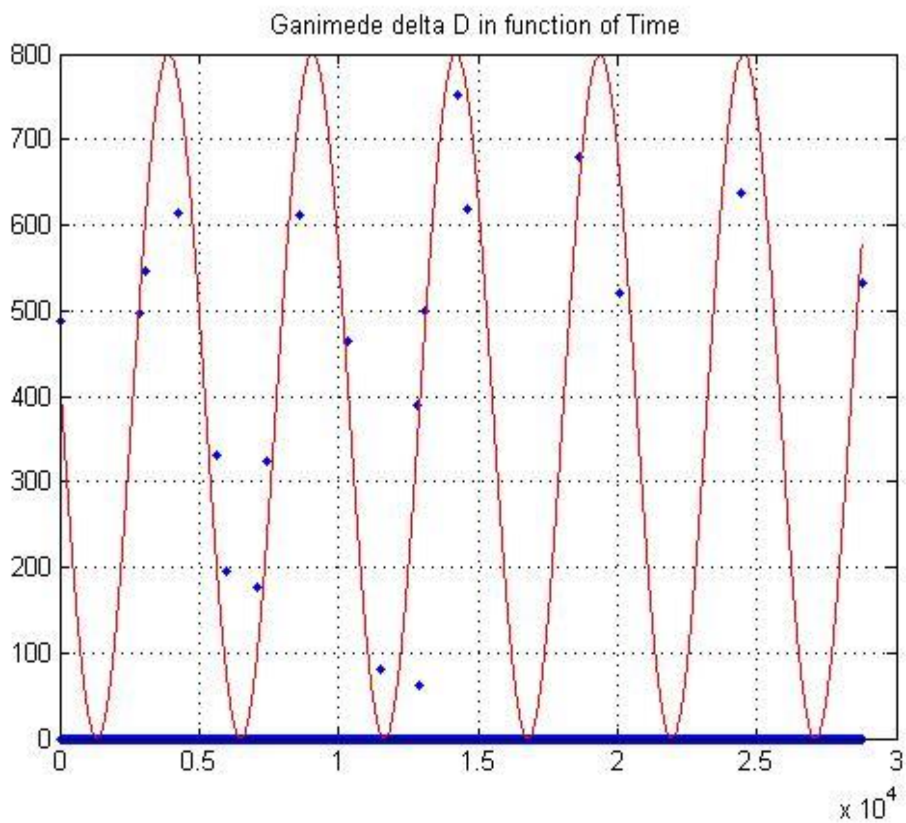
Then, we've wrote a program then plotted those distance variation data in function of time. We used the curve fitting operation to retrieve the equation of each graph, where we deduced that each graph have a sinusoidal shape.



For Example this is the code of the curve fit that we ve used to extract Ganimede sinusoidal function:

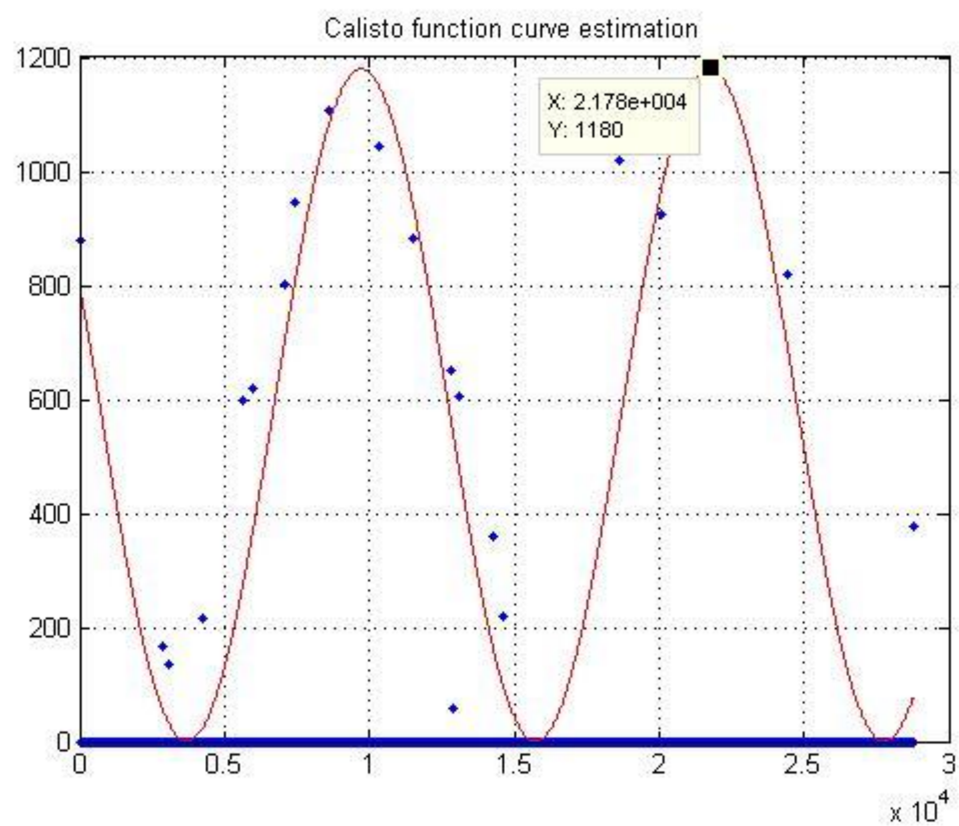
```
>> X=[0, 174102, 182506, 254316, 339174, 358966, 424984, 446505,
514725, 618244, 688494, 770865, 775058, 787605, 856744, 875994,
1117204, 1203045, 1465914, 1725784];
G=[487.349483, 496.1304011, 546.9635119, 614.947366, 331.6472308,
195.8742569, 175.553637, 323.261857, 612.2275258, 464.402688,
81.7600373, 390.0113334, 61.91, 498.3491904, 751.2828153, 618.408685,
679.5109565, 520.9467614, 637.416416, 533.3295061];
X=(X+1)/60;
for i=1:length(X)

    Y(ceil(X(i)))=G(i);
end
figure(1)
plot(Y,'.'),grid on
figure(2)
plot(G),grid on
title('old G plot')
for j=1:length(Y)
    w(j)=j;
end
T=820;%this is the period that u shoud adjust
D=900;%this is the "dephasage"
for j=1:length(w)
F(j)=400+400*cos(j/T+D);
end
```

```
figure(1)
hold on
plot(F,'r')
title('Ganimede delta D in function of Time')
```



4) Finally we've extracted each moon's period from each one's curve that we've already plotted them to mat lab:

•**Callisto:**



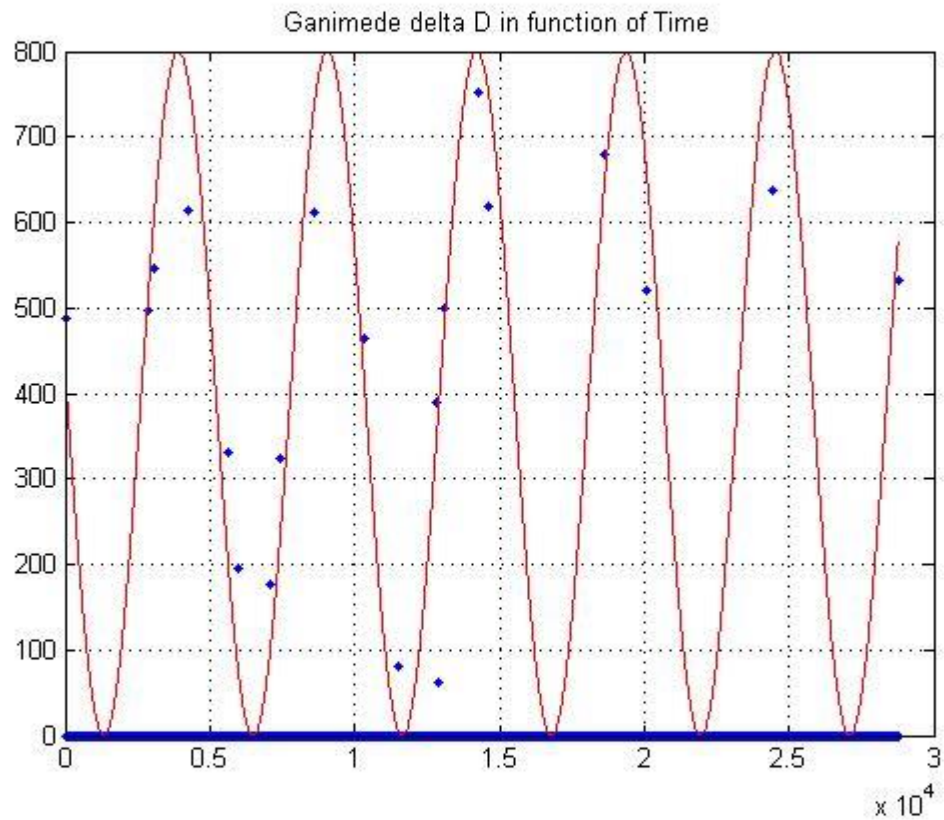
Scale: 1unit ->60s / 1unit -> 1D

For this satellite we were able only to capture 0.5 period before

T= 60x (2.178^4-9776)/(60^2x24)X2 = 16.672222 days

T $_{Calisto}$ = 16.672222 days

•Ganymede:



Scale: 1unit ->60s / 1unit -> 1D

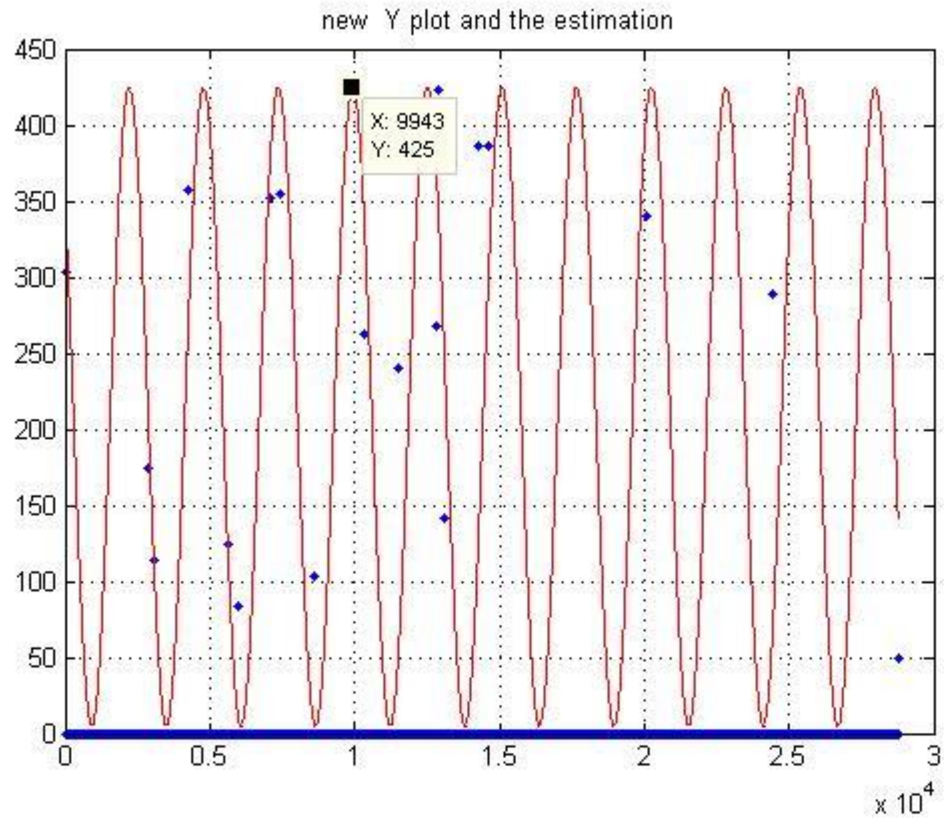
The more we capture periods, the results will be more accurate:

Periods of Ganymede: (takin 2 apogee repetition)

T= 60x (1.42210^4-3918)/(60^2x24) = 7.15416667 days

T $_{Ganymede}$ = 7.15416667 days

• **Europe:**

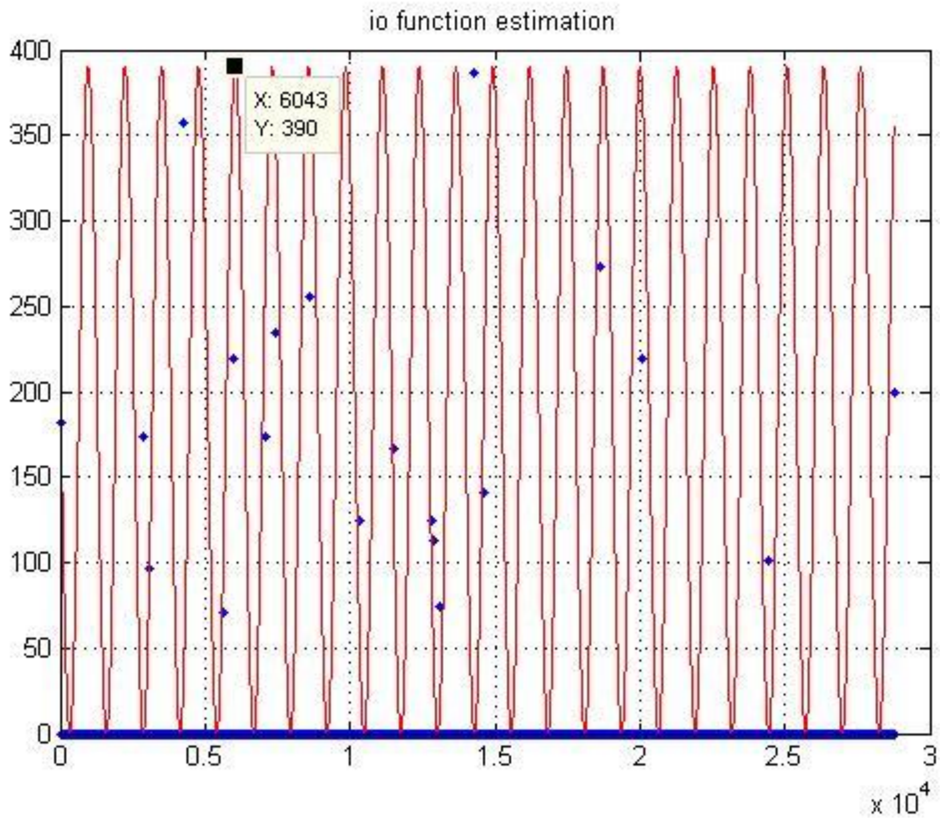


Scale: 1unit ->60s / 1unit -> 1D

T= 60x (9943-4794)/(60^2x24) = 3.57576388 days

T $_{Europe}$= 3.57576388 days

• **Io:**



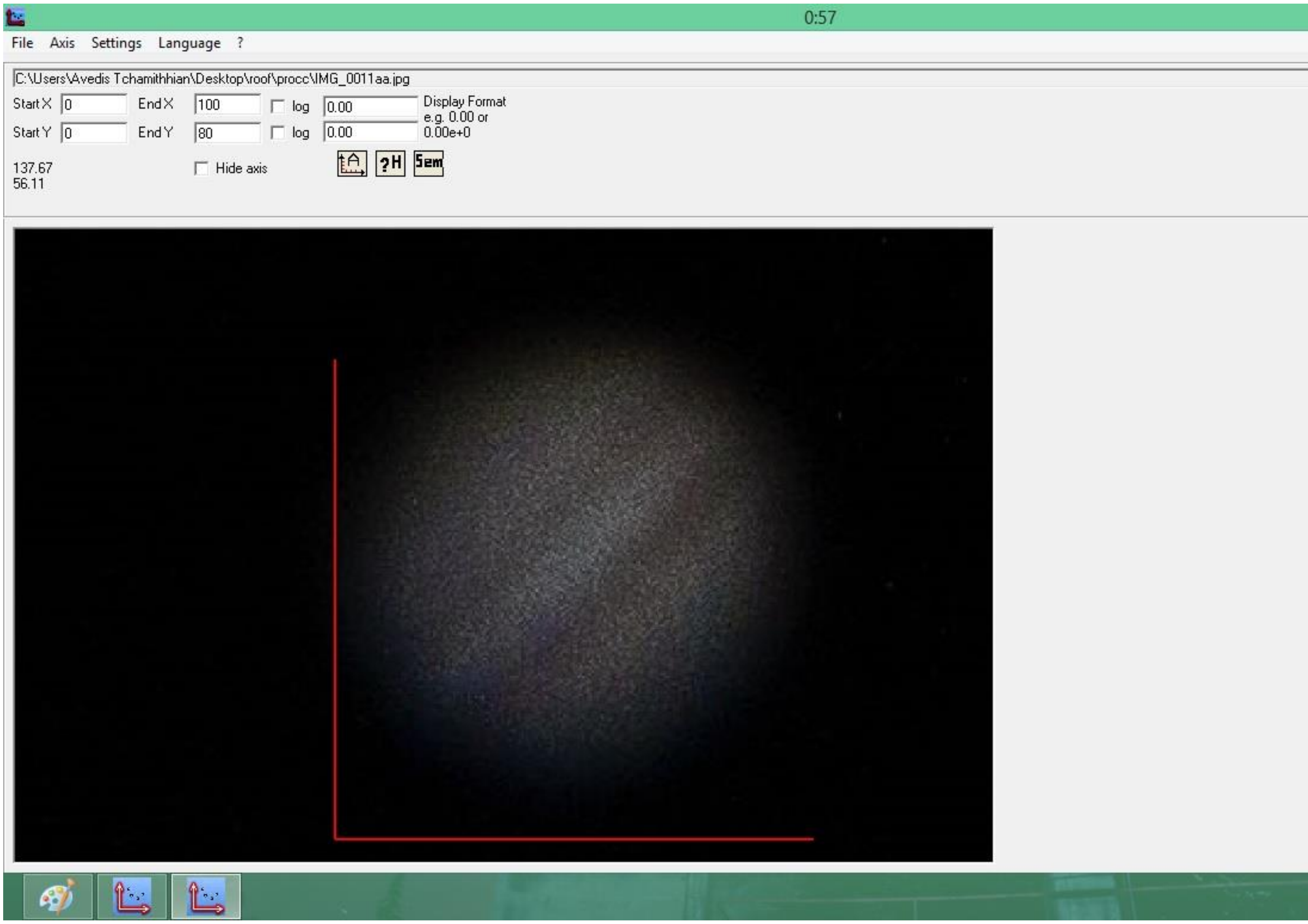
Scale: 1unit ->60s / 1unit -> 1D

The plot of the trajectory of Io was the most difficult considering that the samples are taken at an interval of 1 day, and this appeared superior to his half period (Shannon theorem for sampling). But analyzing it by using matlab was a piece of cake.

T =60x (6043-3535)/(60^2x24) = 1.741666667 days

T_{Io}= 1.741666667 days

Finally we have tried to calculate the period of rotation of Jupiter with the same method discussed previously in addition with some geometry by flowing extensively the motion of Jupiter s eye and finally got:



77					d from the center
78	8:40	53.39	35.81		
79		38.18	23.27		19.71283085
80					
81	9:32	54.42	36.56		13.72633236
82		66.61	42.87		
83					

T=7.9686511h

Official value T=9.925h

Results of accuracy of measurements:

- Official period of Callisto: 16.689 days
- Official period of Ganymede: 7.156 days
- Official period of Europe: 3.551 days
- Official period of Io: 1.769 days

Error calculation: $|T_{official} - T_{experimental}| / T_{official}$

$E_{Callisto}$ = 0.1005%

$E_{Ganymede}$ = 0.025619%

E_{Europe} = 0.697%

E_{Io} = 1.545%

EJUPITER=19.7%