The observation and the reduction of the mutual events

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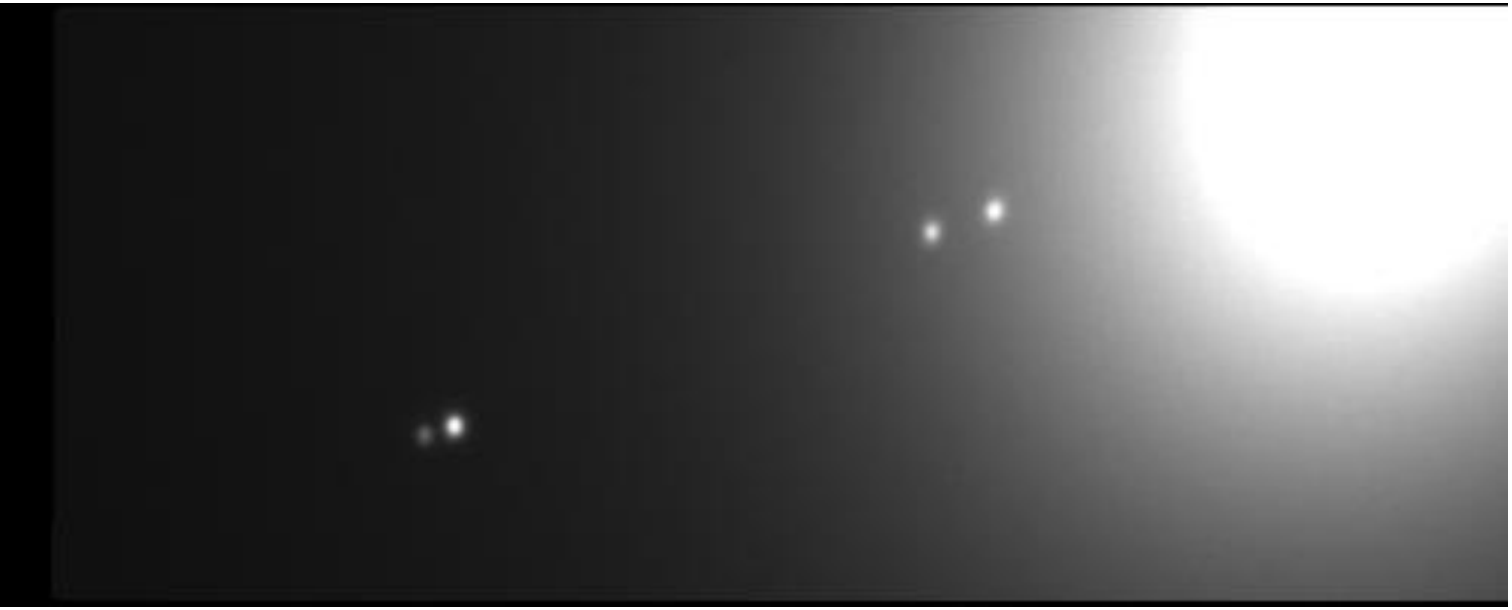
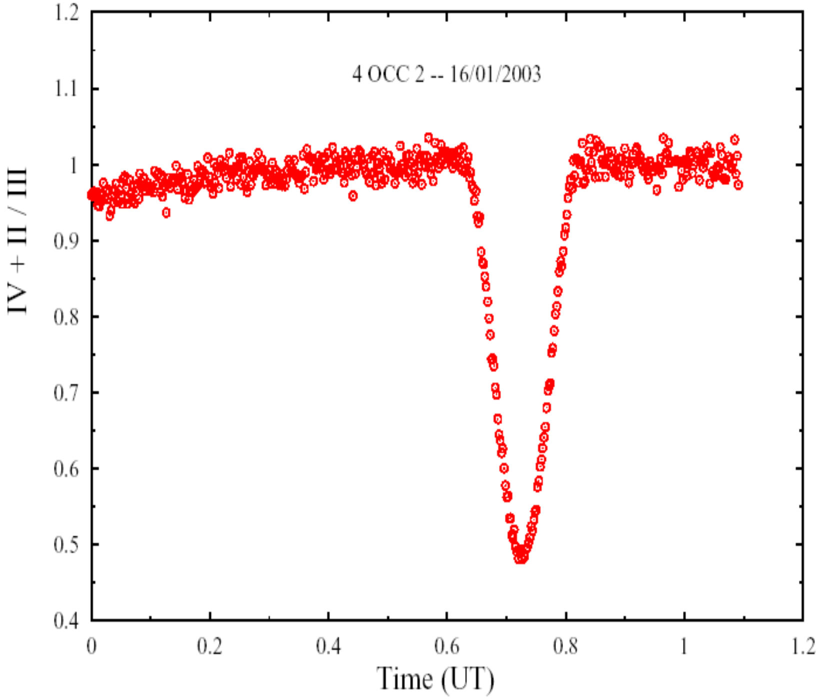
Observing the mutual events

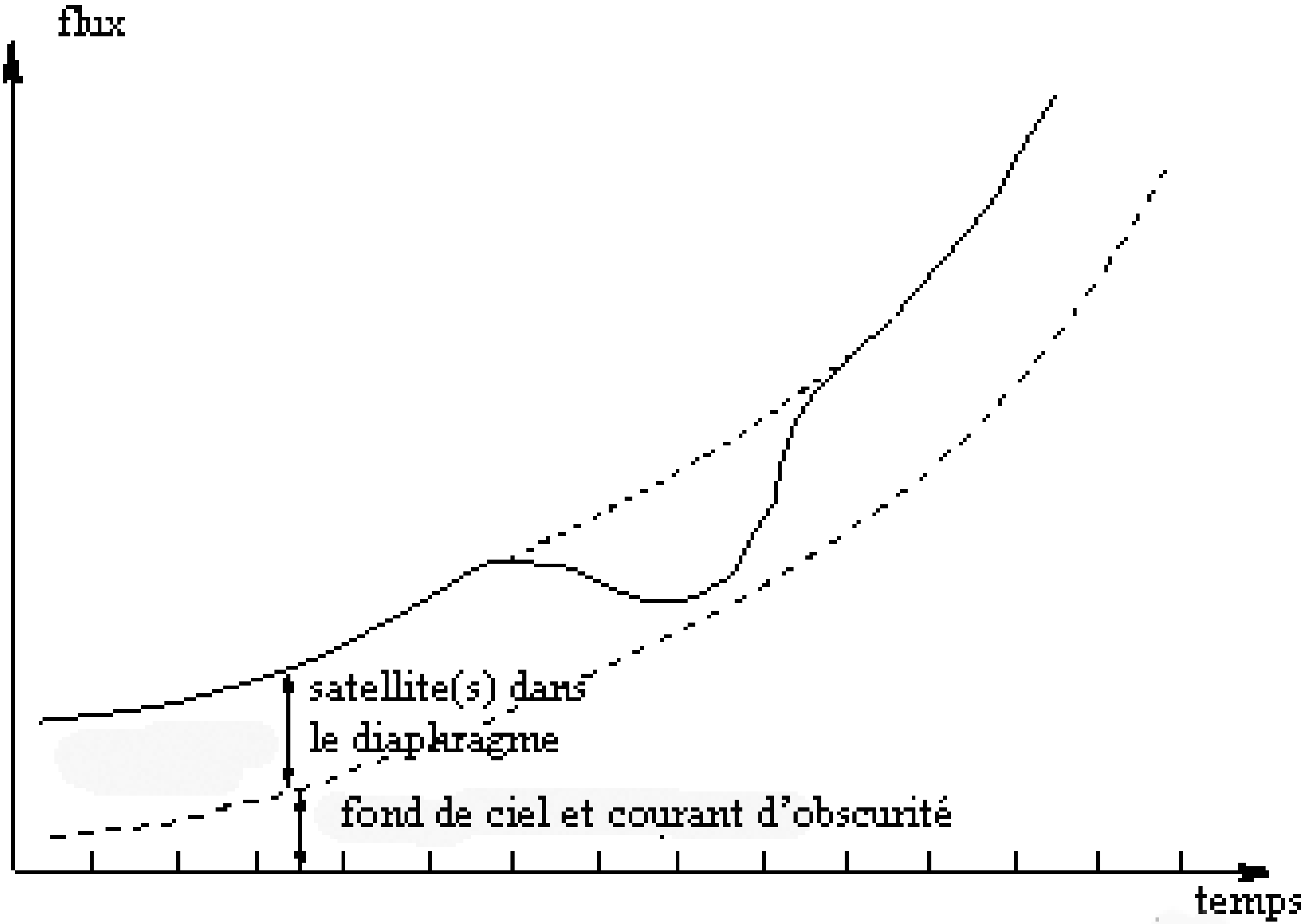




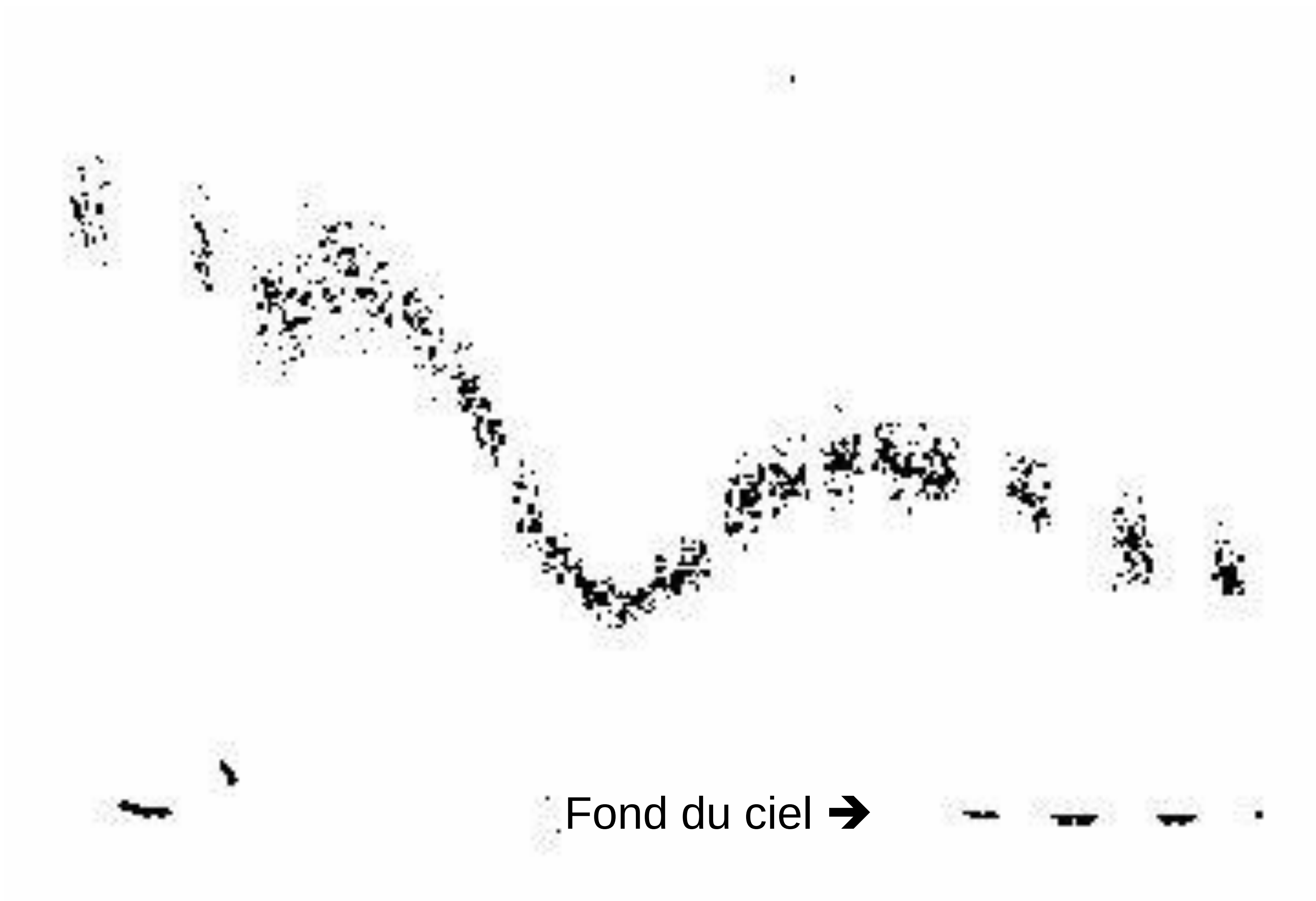
The Galilean satellites

A photometric timing:
0,1 sec = 1 km
An astrometric measurement:
0.1 arcsec = 300 km

Photometric errors: the sky background during twilight

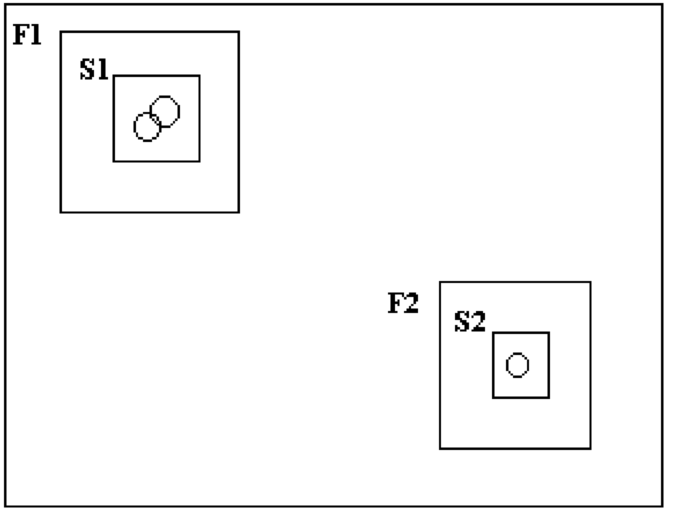


Photometric errors: the absorption

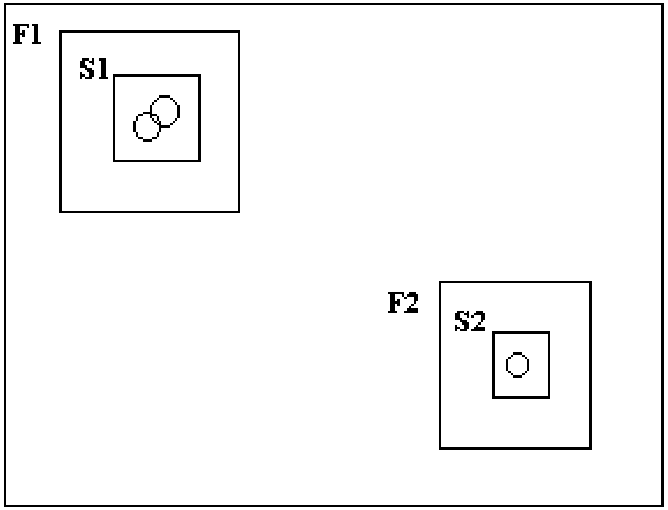


Correction of the photometric observation (absorption, sky background)

The interest of 2-D CCD images:
A constant reference object may be observed together with the occulted or eclipsed satellites

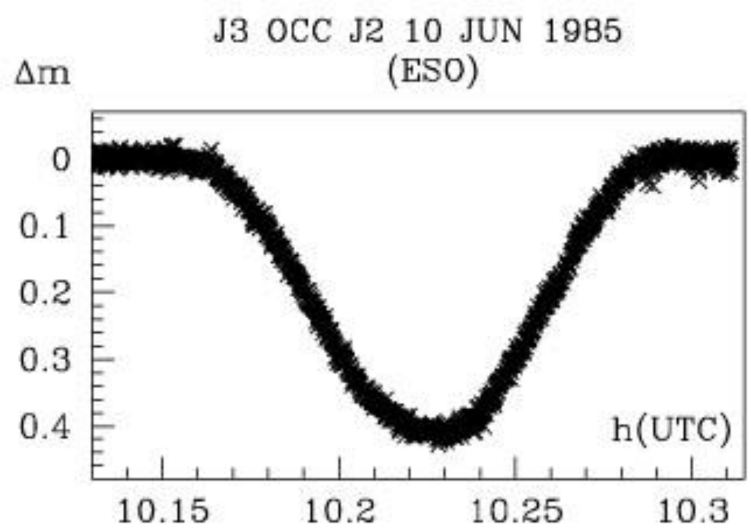


- If a reference object is present in the field (generally another Galilean satellites, rarely a bright solar-type reference), we will calculate its light flux for each image. This flux is supposed to be a constant. If Flux2 is the light flux of the reference object S2, the light flux of the occulted or eclipsed satellite S1 will be:
- **Flux of satellite S1 = (Flux1 / Flux2) * FM2**
- where FM2 is the average flux of reference S2 , used in order to normalized the calculated flux of S1.
- Then we obtain:
- **Flux of satellite S1 = ((S1/N1 - Fond1) / (S2/N2) - Fond2)) * FM2**

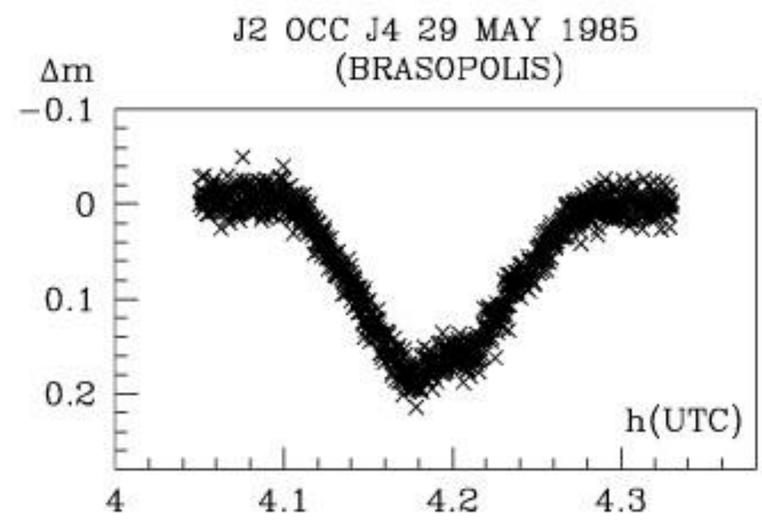


- This technique allows to observe events in difficult conditions: proximity of Jupiter (the background
- Fond1 and Fond2 may be very different), variation of the absorption or transit of light clouds
- (Flux1/Flux2 remains a constant), twilight (the sky background varies exponentially but is removed from each image).

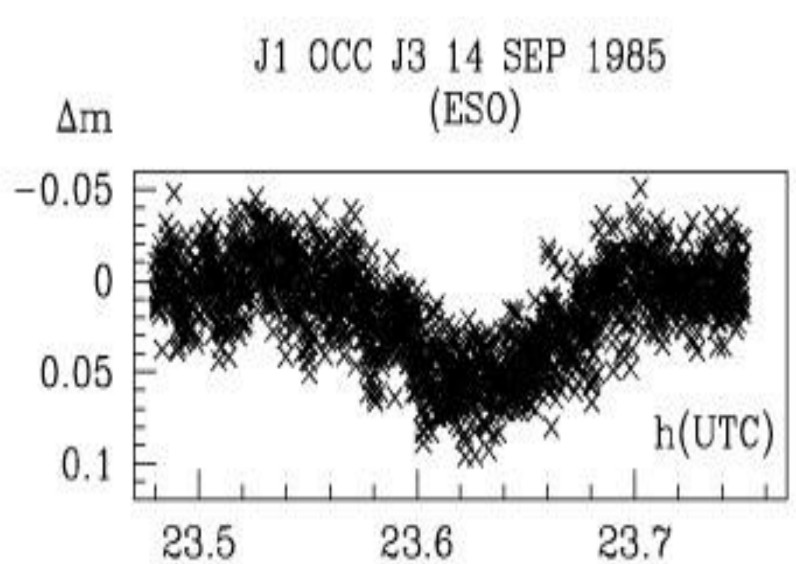
Examples of light curves in V or R band



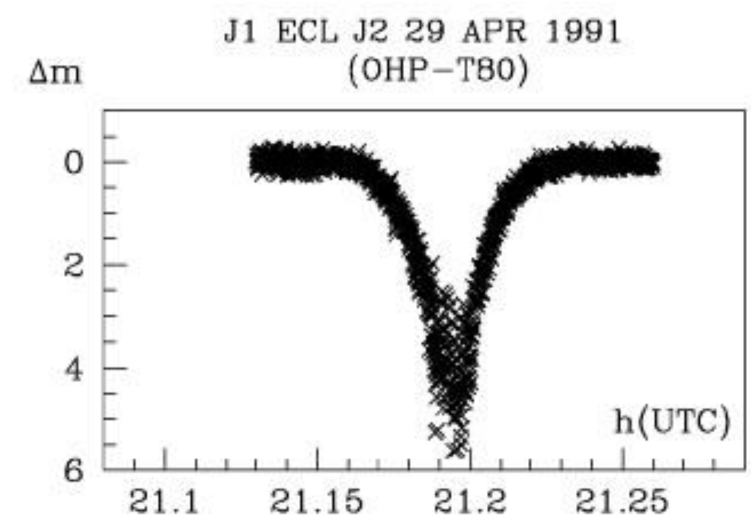
Symetrical light curve



Not symetrical light curve

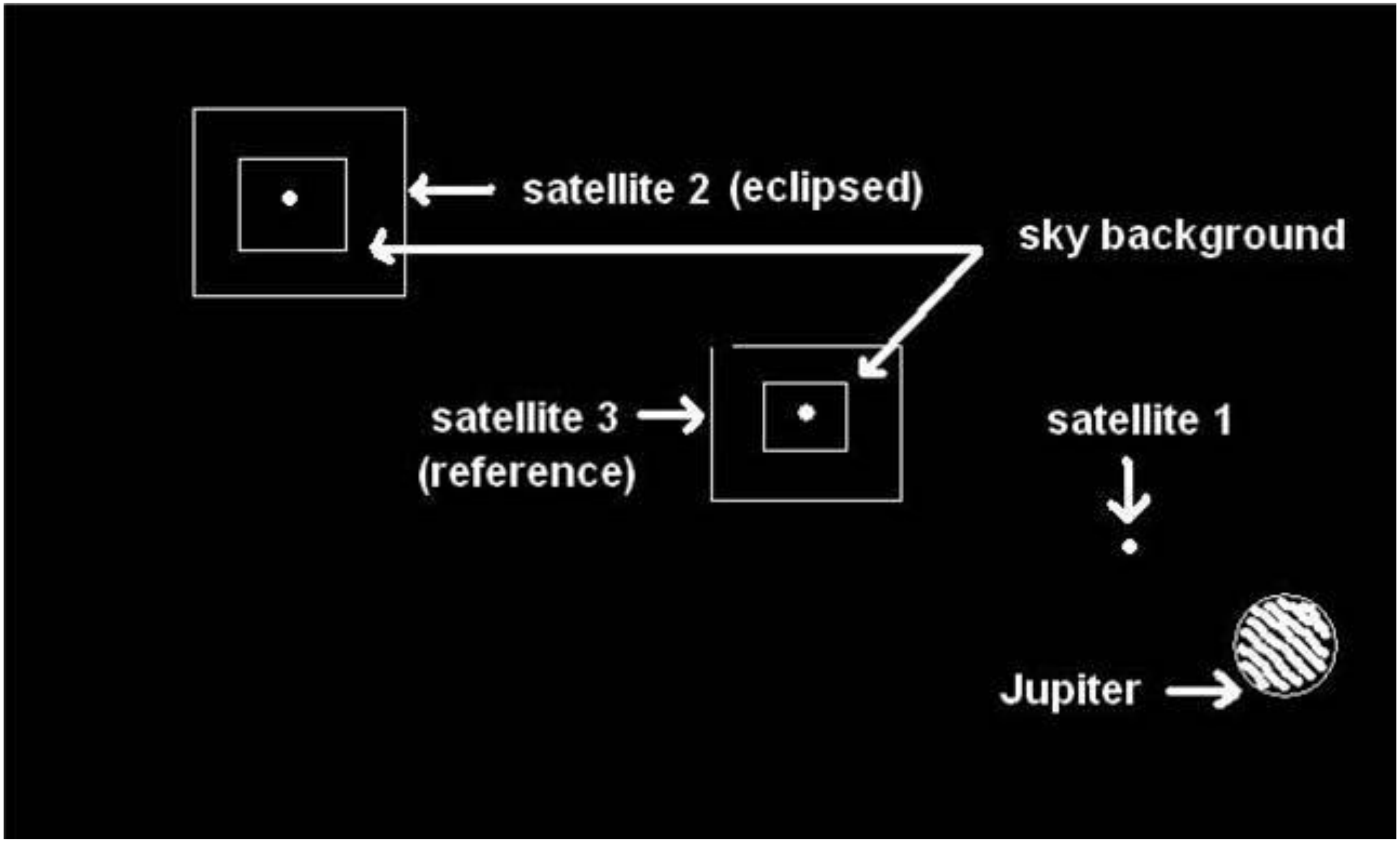


Grazing event

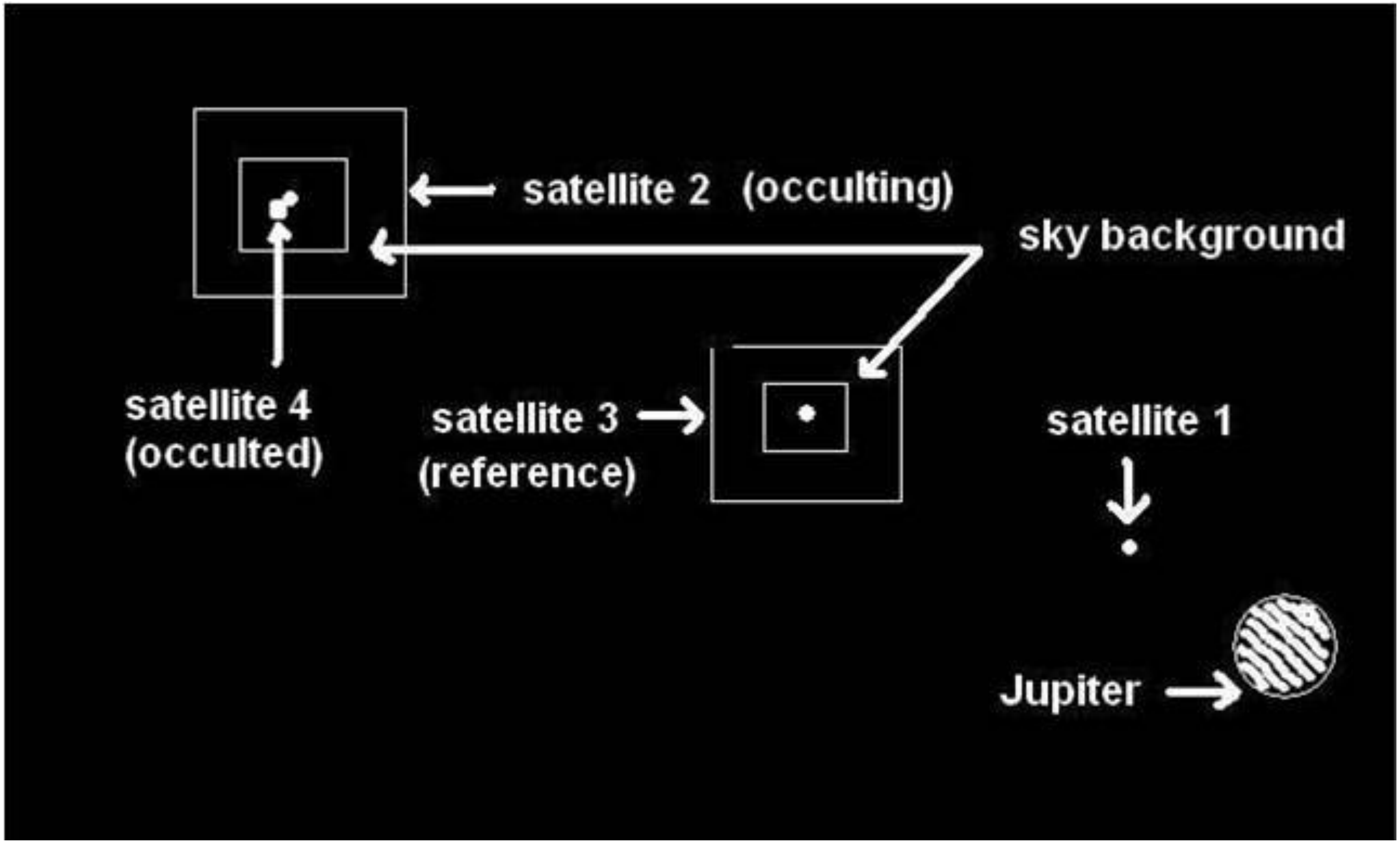


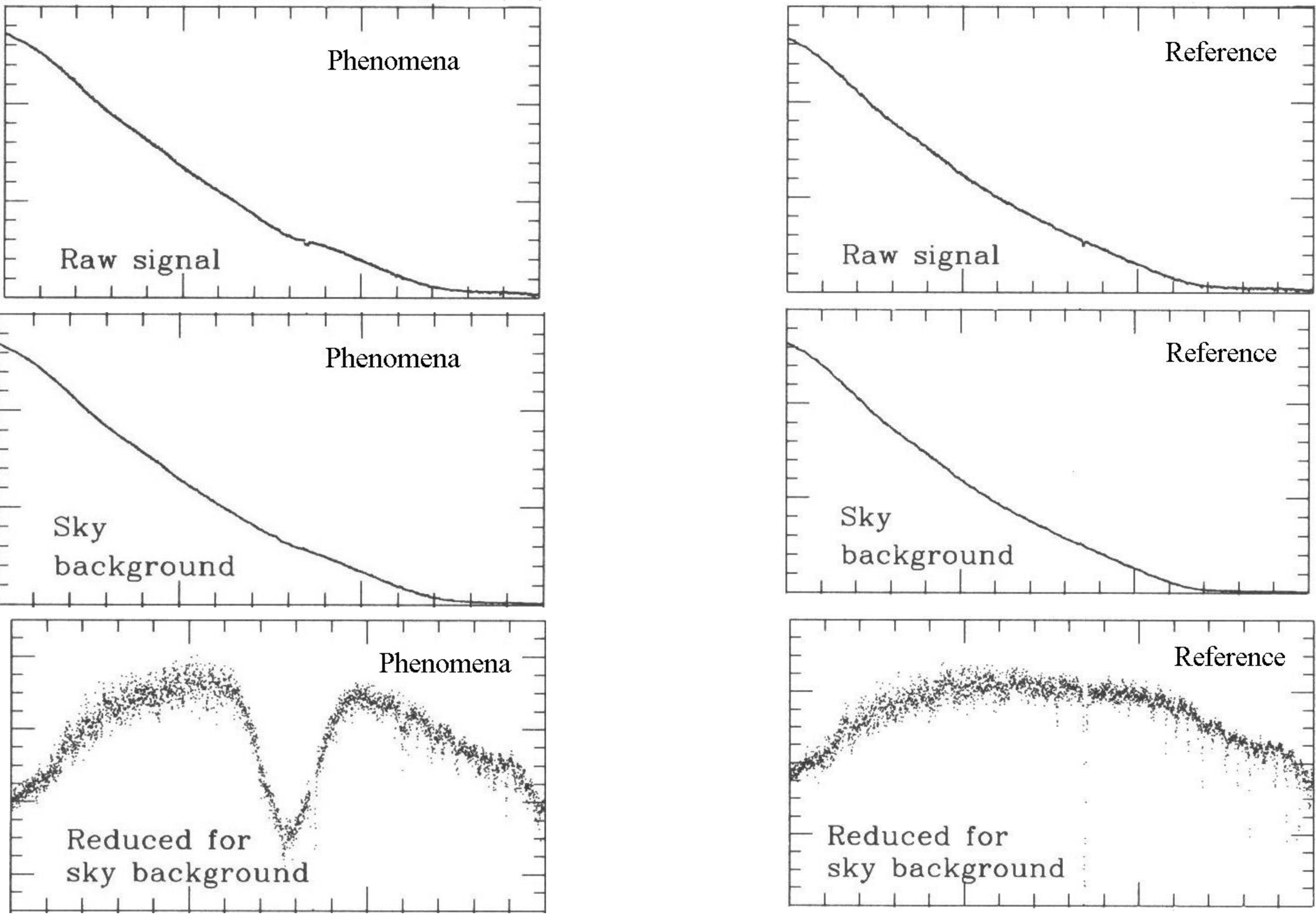
Total event

The observation: 2-D photometry

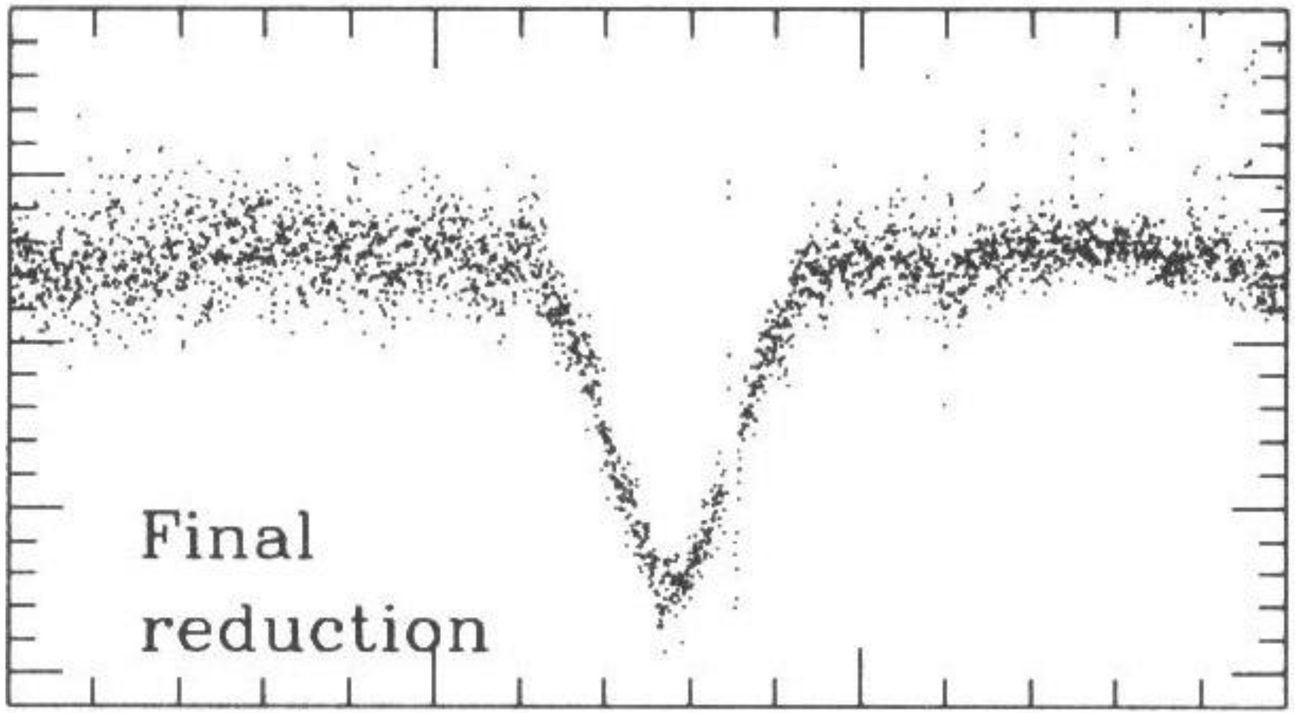


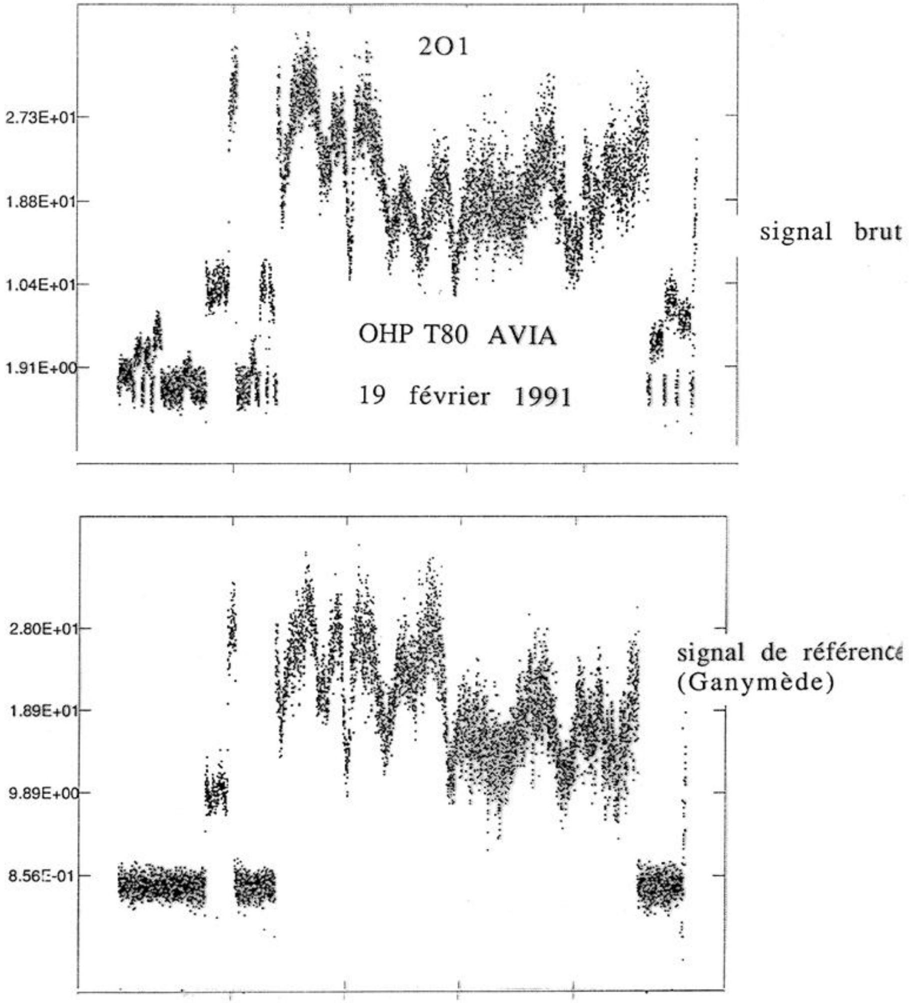
The observation: 2-D photometry

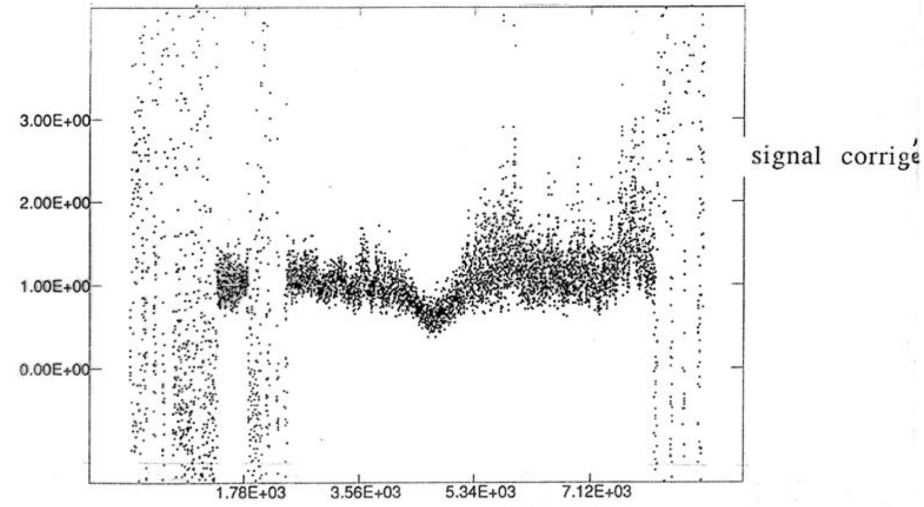




Phenomena
Raw signal
Reference
Raw signal
Phenomena
Sky
background
Reference
Sky
background
Phenomena
Reduced for
sky background
Reference
Reduced for
sky background

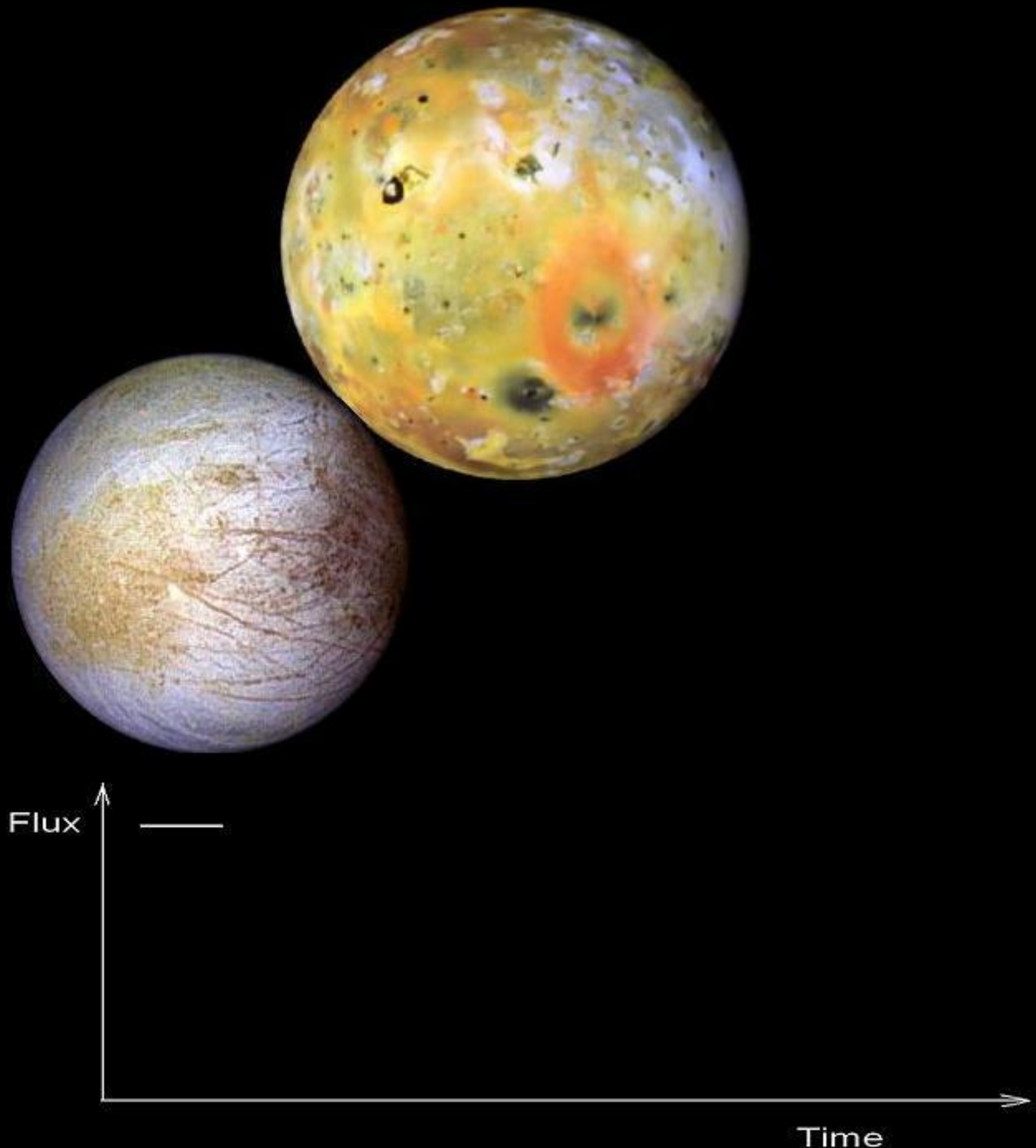

Final
reduction

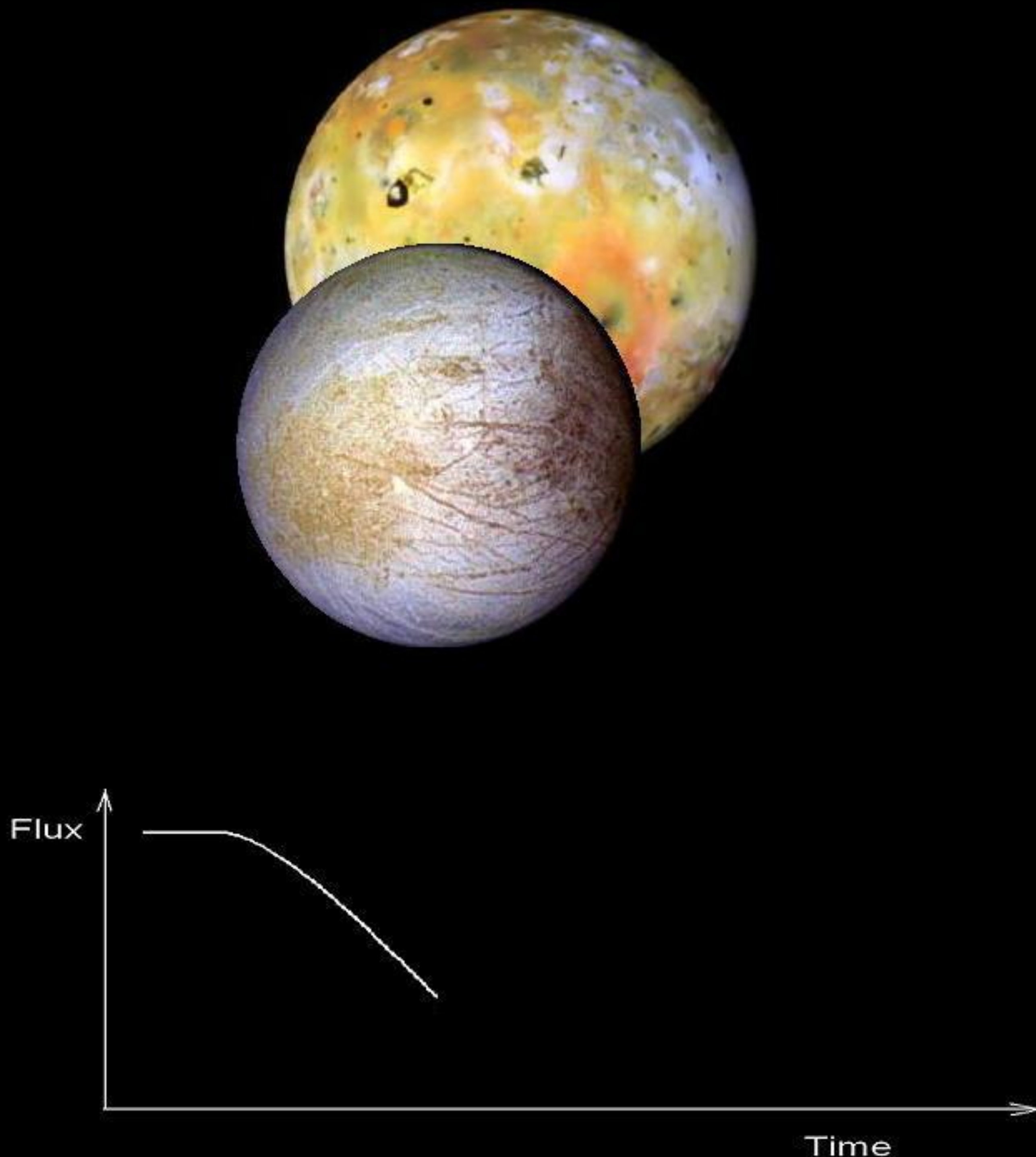


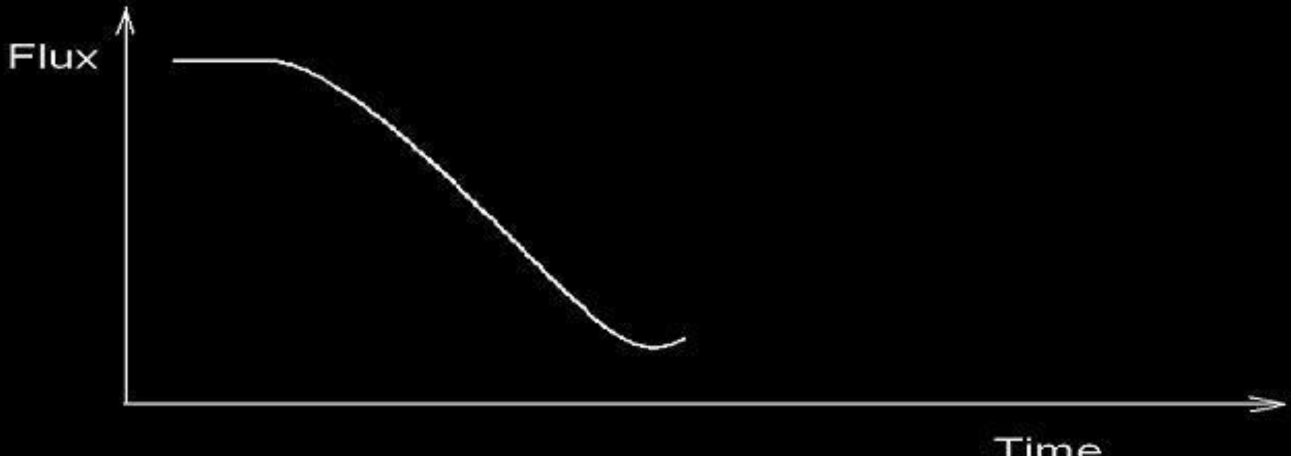


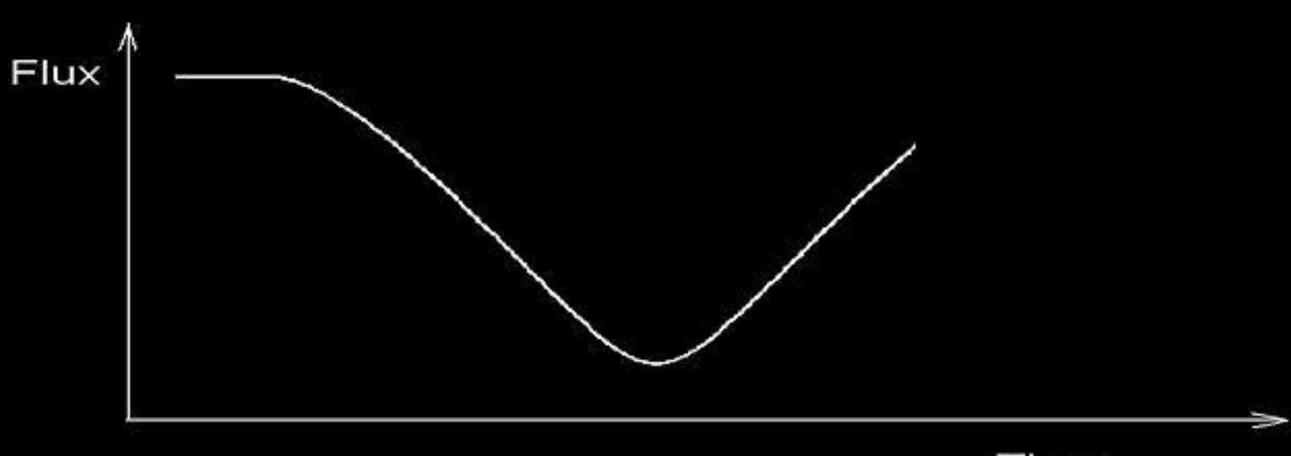
An event observed through clouds!

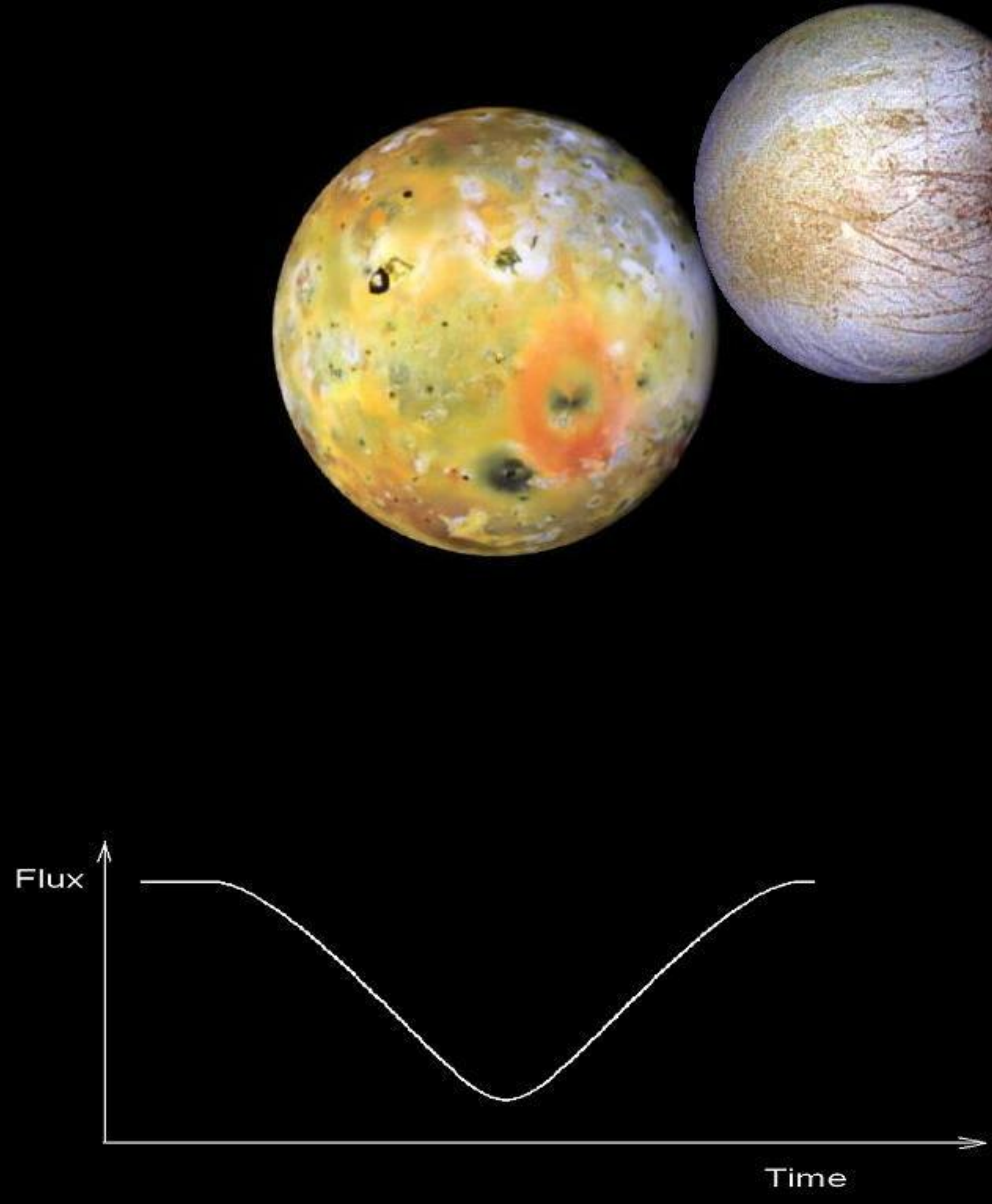
The inversion of the light curve

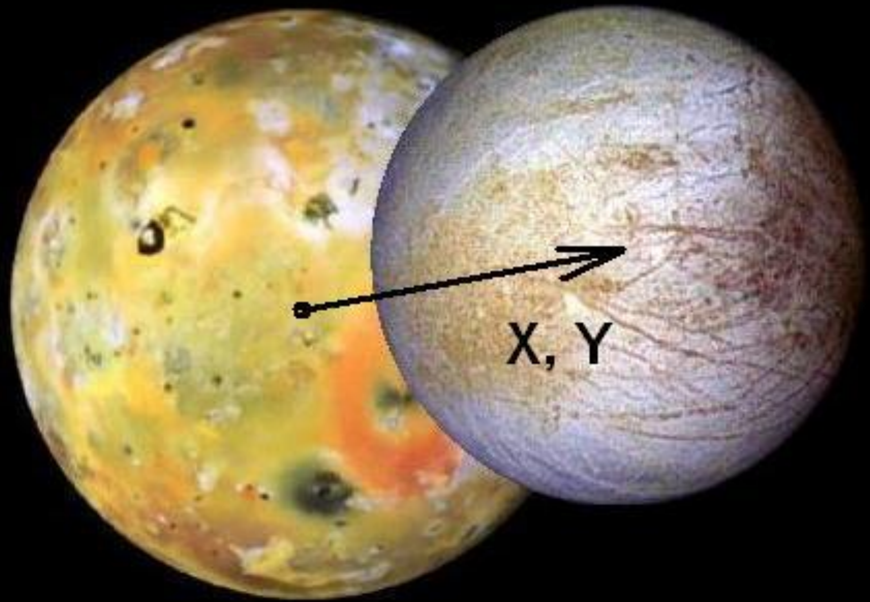

Flux
Time

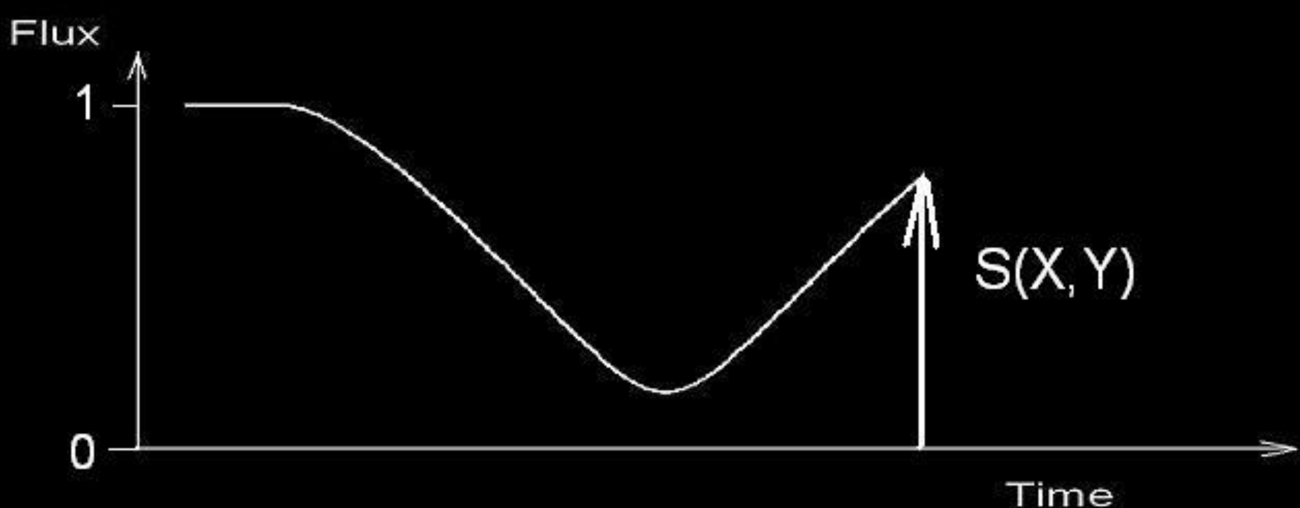

Flux
Time


Flux
Time


Flux
Time


Flux
Time


X, Y


Flux
1
0
S(X,Y)
Time

The photometric modeling

Extracting the astrometric parameters from the observed flux

The function S(X,Y)

A very simple geometry

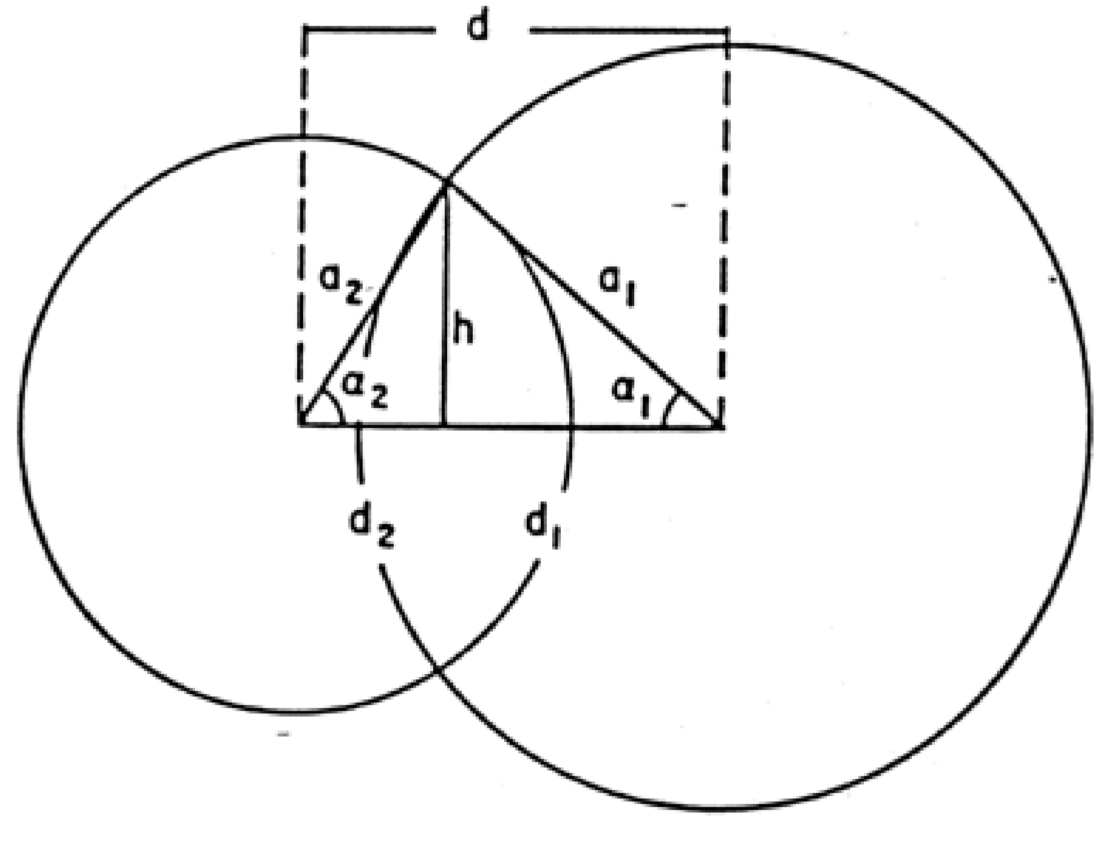
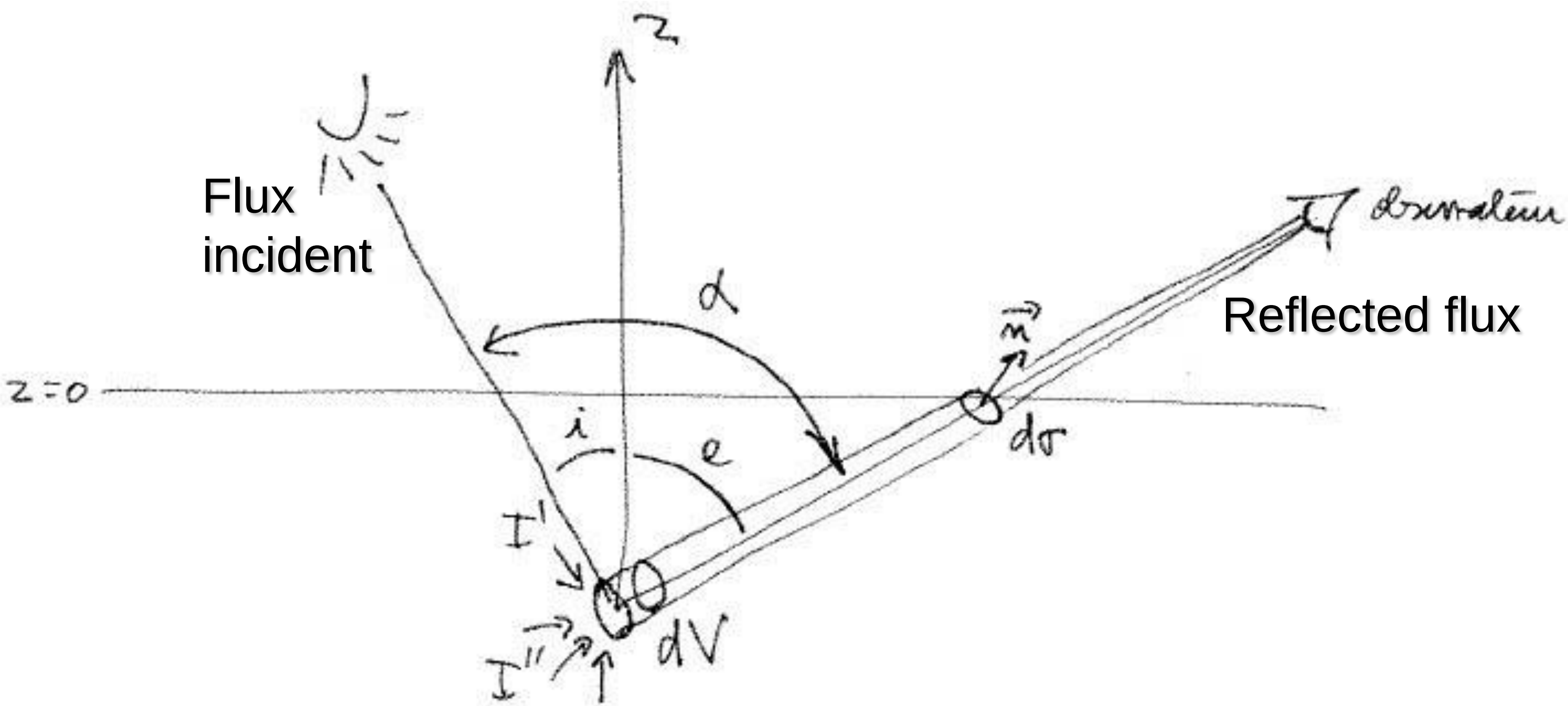
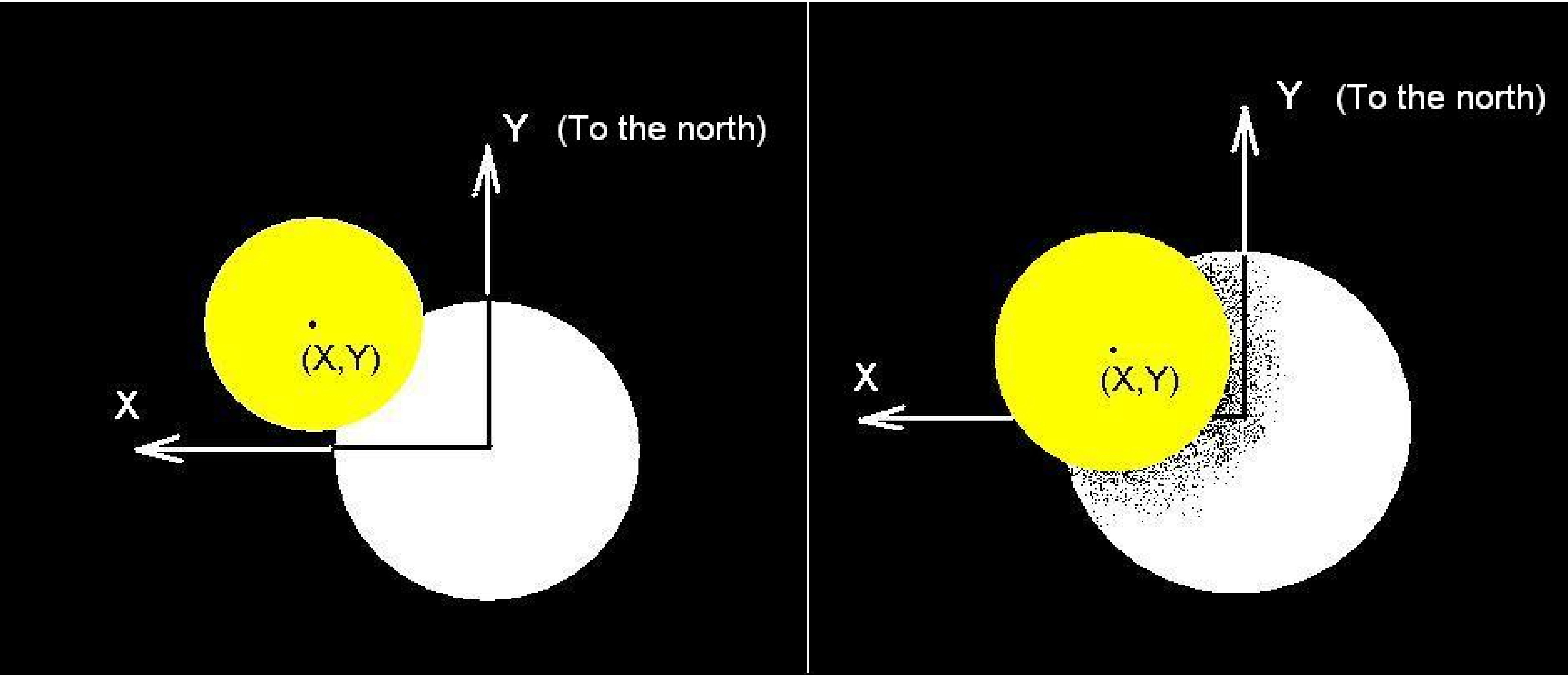


FIG. 1. Geometry of an occultation. Occulted area = $\alpha_1 a_1^2 + \alpha_2 a_2^2 - hd$.

The law of reflection-diffusion



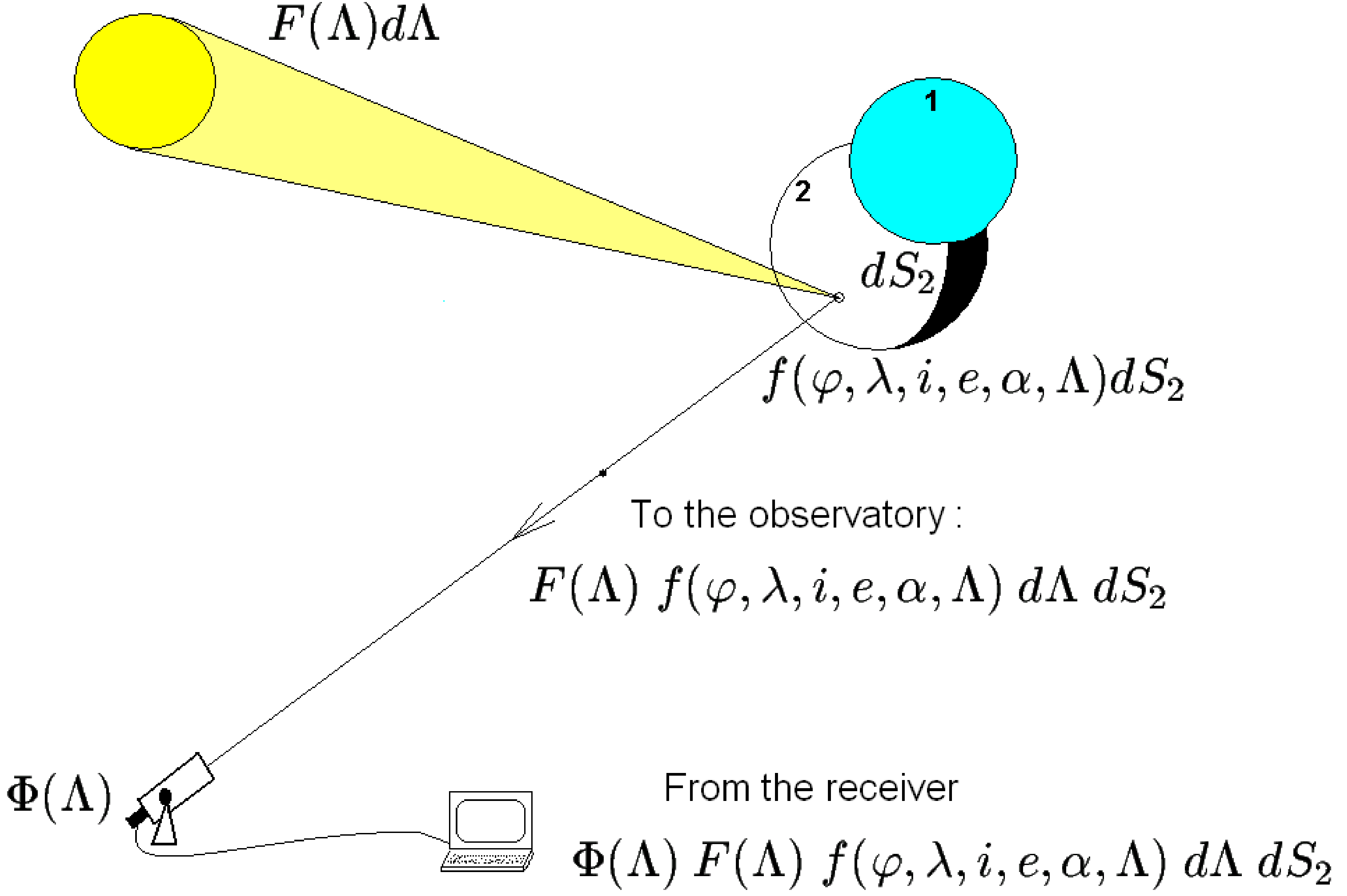
Relative coordinate system (X, Y)



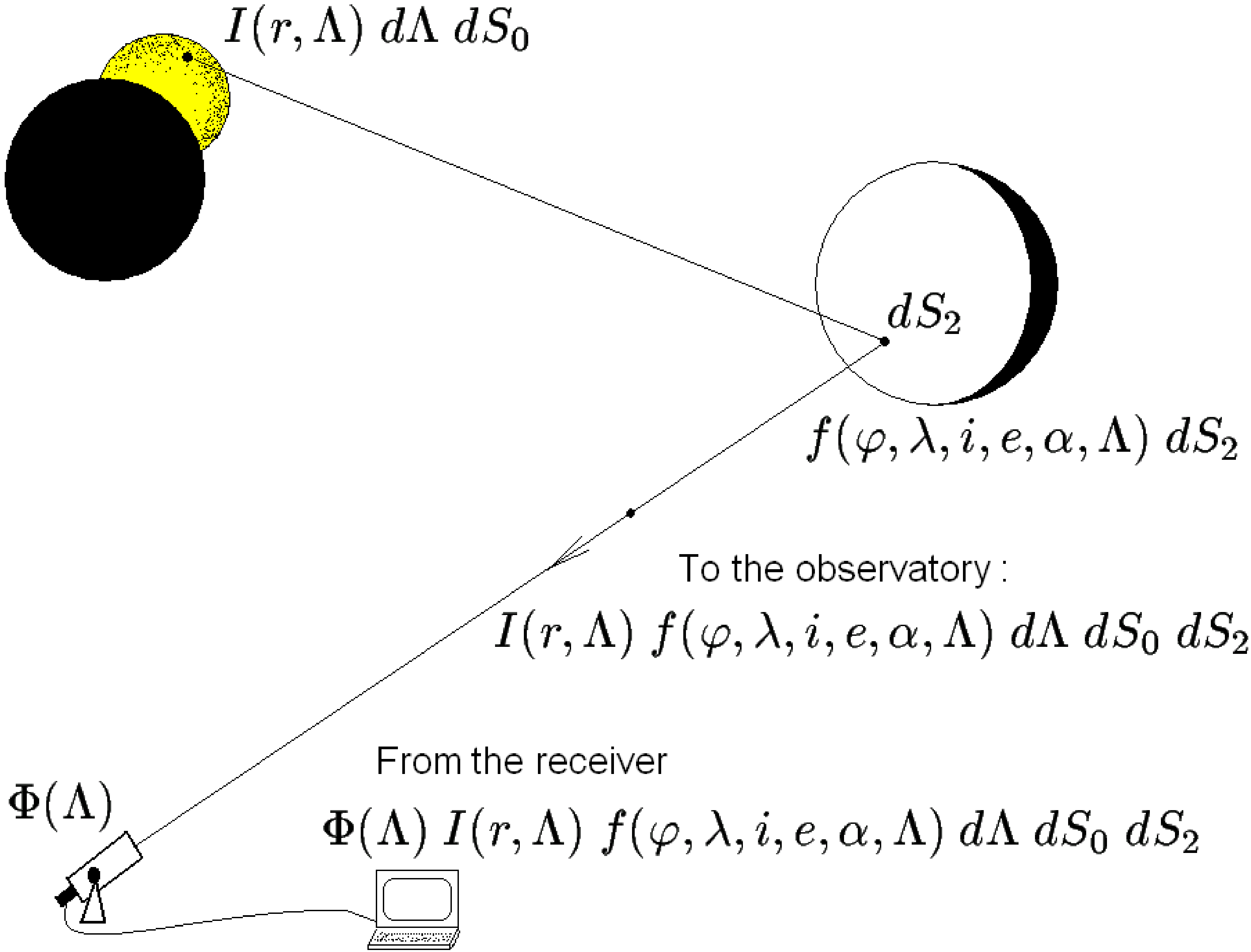
View from the Earth (mutual occultation)

View from the Sun (mutual eclipse)

$$X = \Delta\alpha \cos(\delta), \quad Y = \Delta\delta$$



$F(\Lambda) d\Lambda$
1
2
dS_2
$f(\varphi, \lambda, i, e, \alpha, \Lambda) dS_2$
To the observatory :
$F(\Lambda)\ f(\varphi, \lambda, i, e, \alpha, \Lambda)\ d\Lambda\ dS_2$
$\Phi(\Lambda)$
From the receiver
$\Phi(\Lambda)\ F(\Lambda)\ f(\varphi, \lambda, i, e, \alpha, \Lambda)\ d\Lambda\ dS_2$



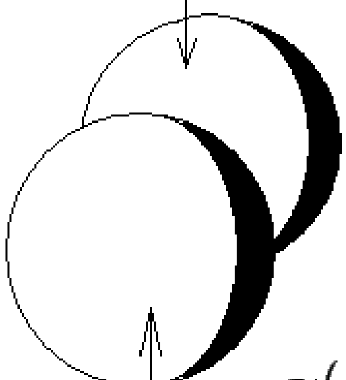
$I(r,\Lambda)\,d\Lambda\,dS_0$
dS_2
$f(\varphi,\lambda,i,e,\alpha,\Lambda)\,dS_2$
To the observatory :
$I(r,\Lambda)\,f(\varphi,\lambda,i,e,\alpha,\Lambda)\,d\Lambda\,dS_0\,dS_2$
From the receiver
$\Phi(\Lambda)$
$\Phi(\Lambda)\,I(r,\Lambda)\,f(\varphi,\lambda,i,e,\alpha,\Lambda)\,d\Lambda\,dS_0\,dS_2$

Mutual occultation

$G_{\underline{\underline{b}}}^{(p)}$ outside of the event

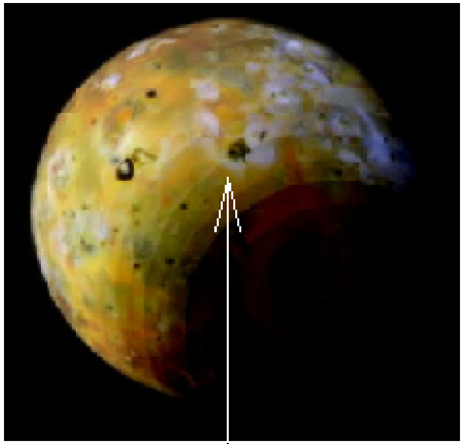
$$S = \frac{G_b^{(a)} + G^{(p)}}{G_b^{(a)} + G_b^{(p)}} = \frac{1 + \frac{G^{(p)}}{G_b^{(a)}}}{1 + \frac{G_b^{(p)}}{G_b^{(a)}}}$$

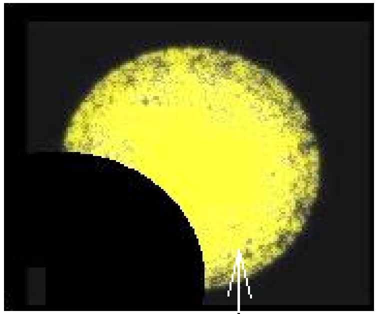
$$G^{(p)} = \int_{S_2} \int_{\Lambda_1}^{\Lambda_2} \Phi(\Lambda)\, F(\Lambda)\, f_2(\varphi, \lambda, i, e, \alpha, \Lambda)\, d\Lambda\, dS_2$$



$$G^{(a)} = \int_{S_1} \int_{\Lambda_1}^{\Lambda_2} \Phi(\Lambda)\, F(\Lambda)\, f_1(\varphi, \lambda, i, e, \alpha, \Lambda)\, d\Lambda\, dS_1$$

Mutual eclipse





$$G^{(p)} = \int_{S_2} \int_{\Lambda_1}^{\Lambda_2} \Phi(\Lambda)\ f(\varphi, \lambda, i, e, \alpha, \Lambda) \int_{S_0} I(r, \Lambda)\ dS_0\ d\Lambda\ dS_2$$

$G_{\underline{\underline{b}}}^{(p)}$ outside of the event $\Rightarrow$

$$S = \frac{G^{(p)}}{G_b^{(p)}}$$

Photometric function

$$f(\varphi,\lambda,i,e,\alpha,\Lambda) = R(\alpha,i\ ,e\ ,\Lambda)\ A(\theta,\Lambda)$$

θ - rotation angle

Groundbased photometry

Morrison, D., Morrison, N. D., 1977.

Photometric function:

1. Lommel-Seeliger's law + albedo(α,Λ)
2. Hapke's reflectance function
   + Hapke's parameters → McEven et al. (1988) for Io
   Domingue and Verbicer (1997)
   (V and B bands only)
   for another satellites

α - phase angle
i - incidence angle
e - reflectance angle
φ,λ - cartographic coordinates
Λ - wavelength

Two methods

Vasundhara (2003): $\cdot A(\varphi, \lambda, \Lambda)$

$\Downarrow$

satellite surface mapping

http://jupiter.berkeley.edu/maps/

Emelianov (2008): $A(\theta, \Lambda)$

$\downarrow$

θ - rotation angle

Groundbased photometry

Morrison, D., Morrison, N. D., 1977.

Photometric function

$$f(\varphi, \lambda, i, e, \alpha, \Lambda) = R(\alpha, i, e, \Lambda) \cdot A(\varphi, \lambda, \Lambda)$$

satellite surface mapping
http://jupiter.berkeley.edu/maps/

Photometric function:

1. Lommel-Seeliger's law + albedo(α, Λ)
2. Hapke's reflectance function
   + Hapke's parameters → McEven et al. (1988) for Io
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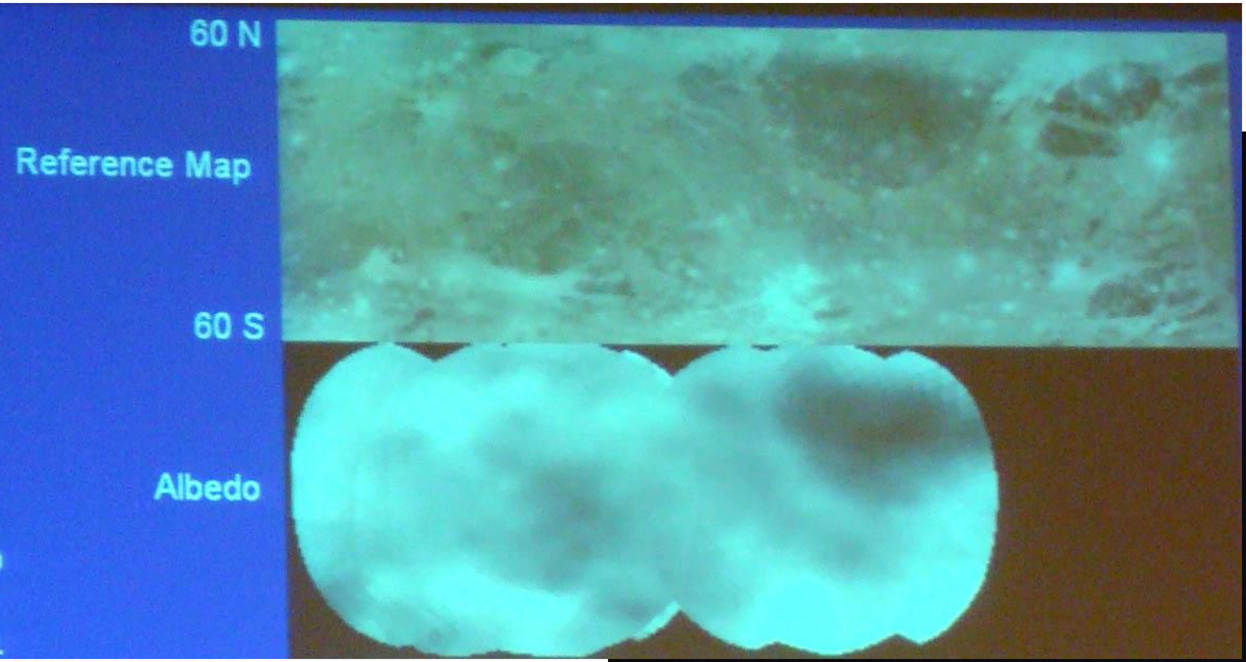
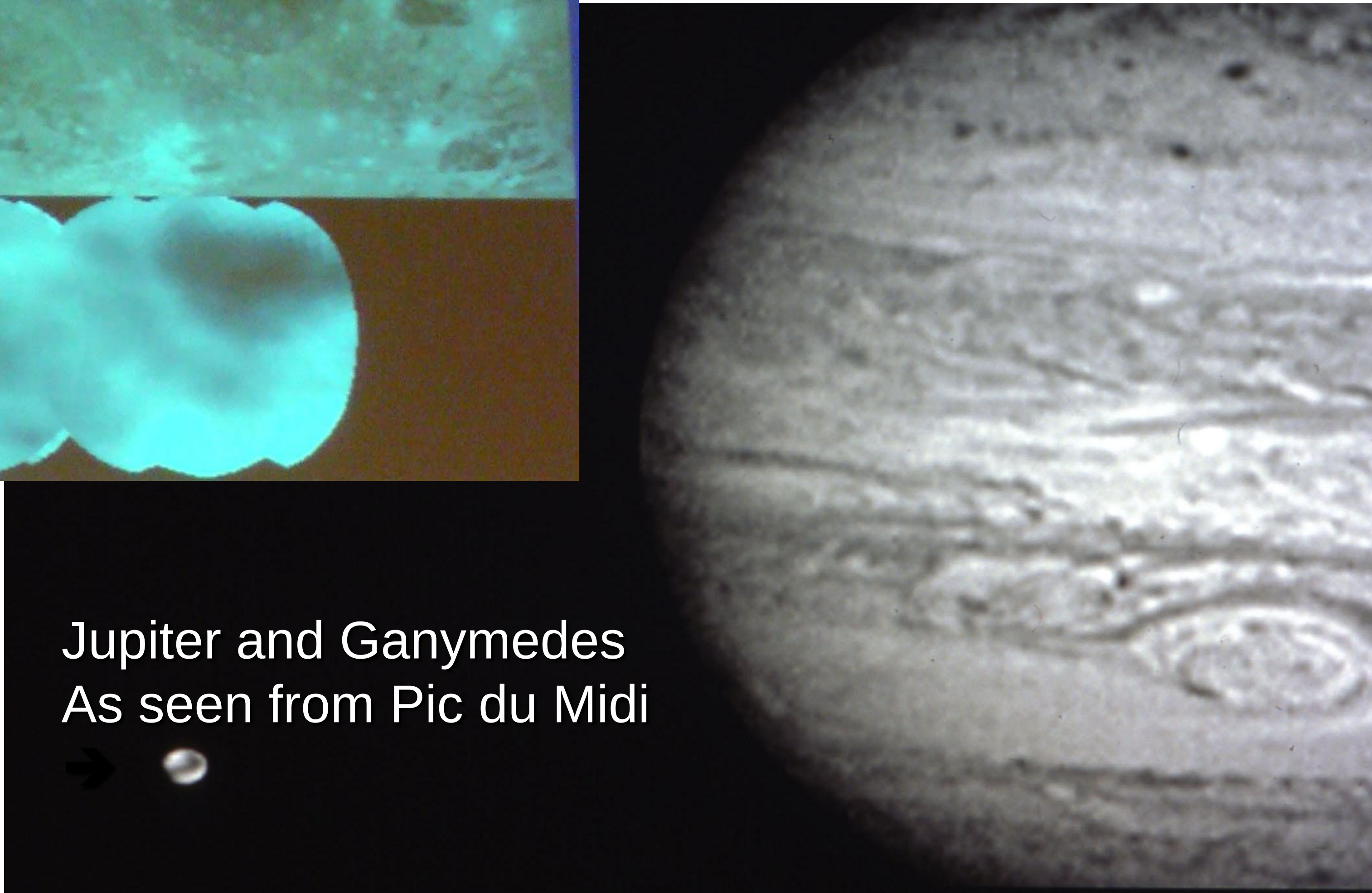
   for another satellites

α - phase angle
i - incidence angle
e - reflectance angle
φ, λ - cartographic coordinates
Λ - wavelength

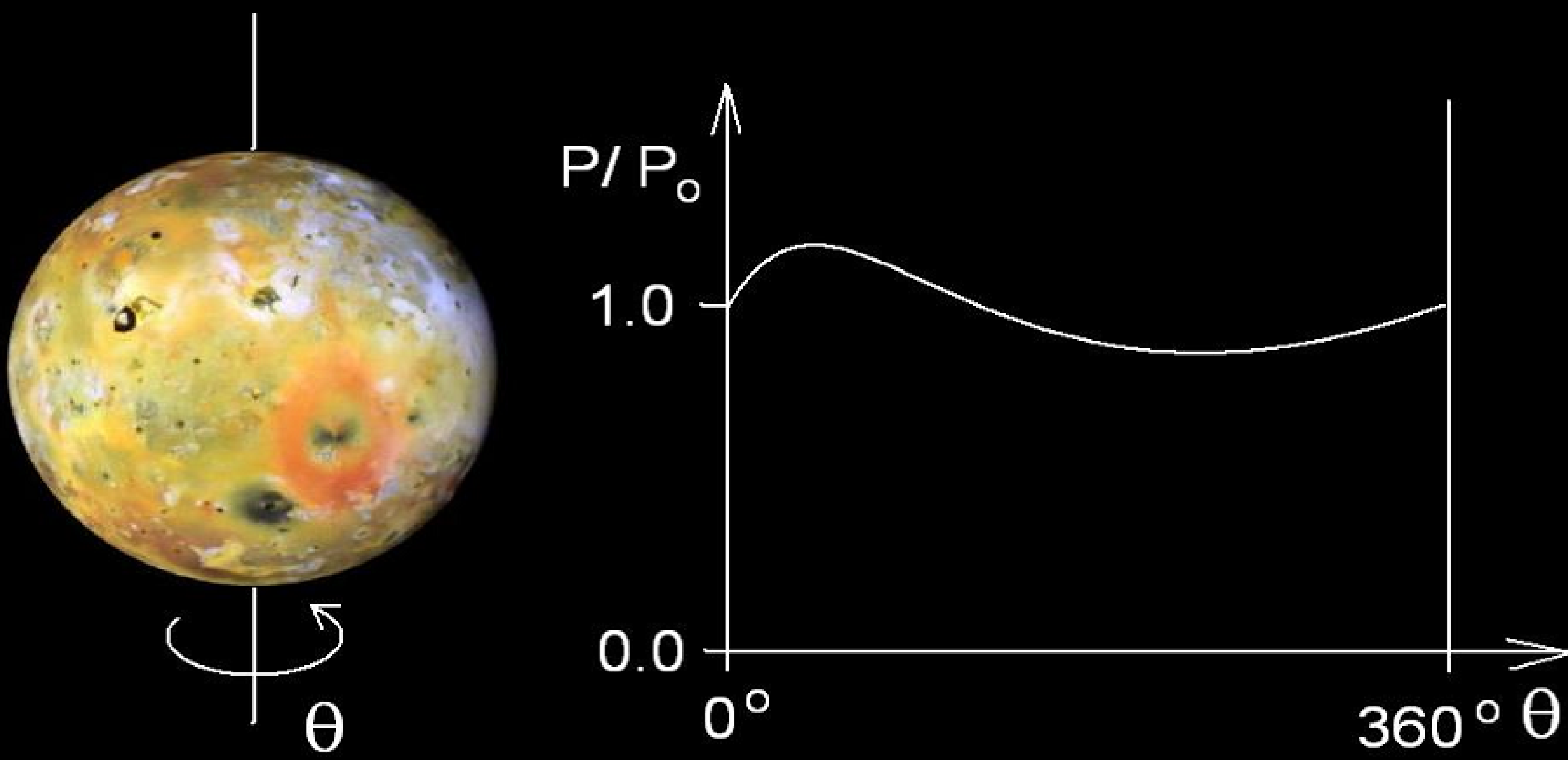
Increasing the precision: the surface of the satellites is not uniform

- For « large » objects (the apparent diameter being larger than 0.5 arcsec), it is possible to improve the correction photocentre-centre of mass thanks to maps of albedos and to modeling the phase (60 mas maximum for Ganymedes)

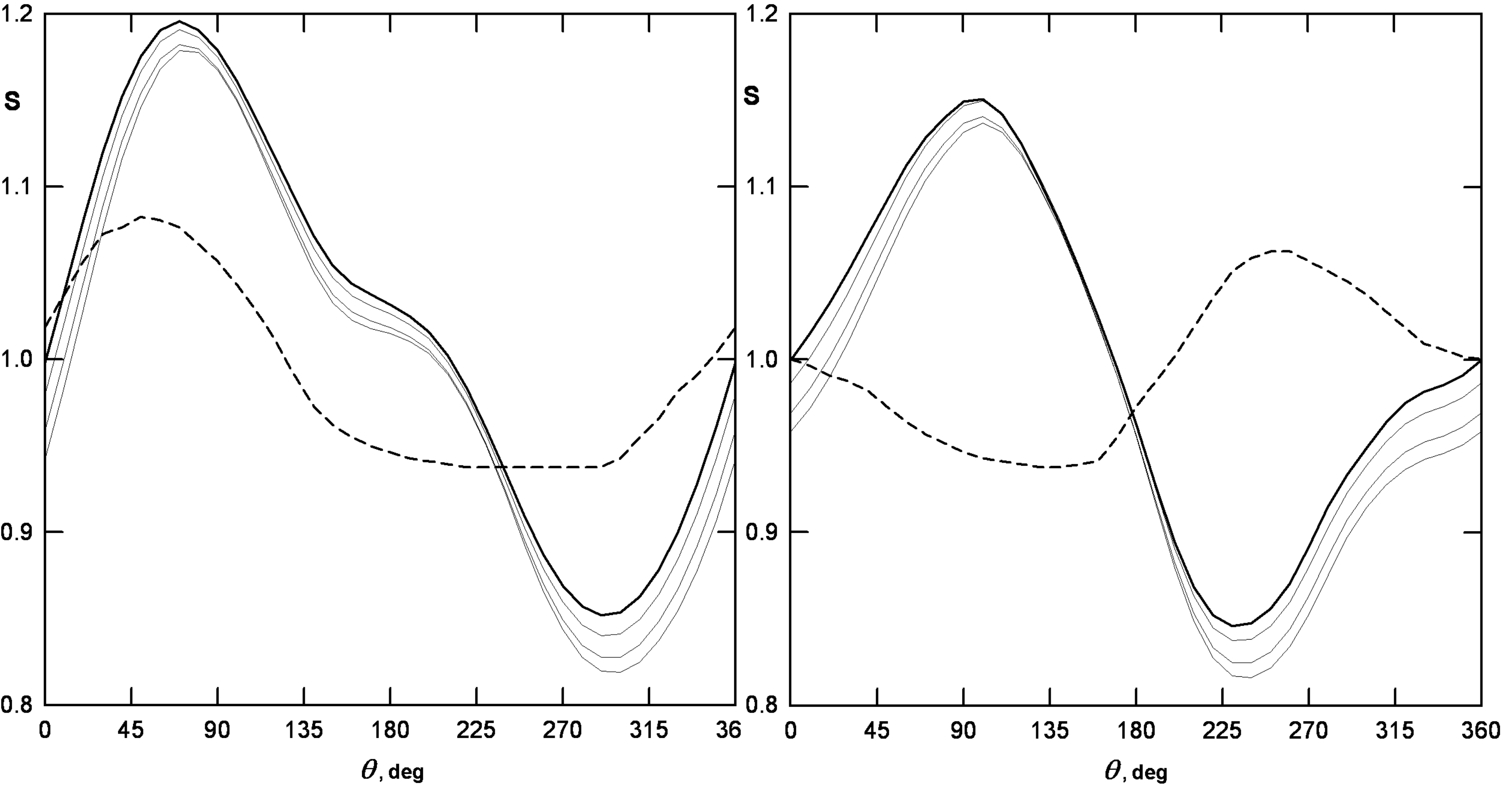




The photometric function depending on the central meridian

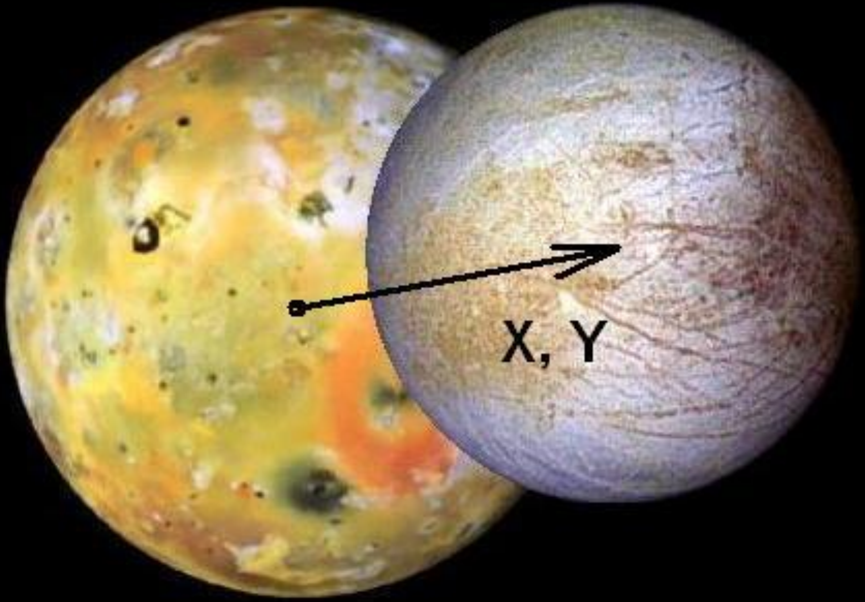


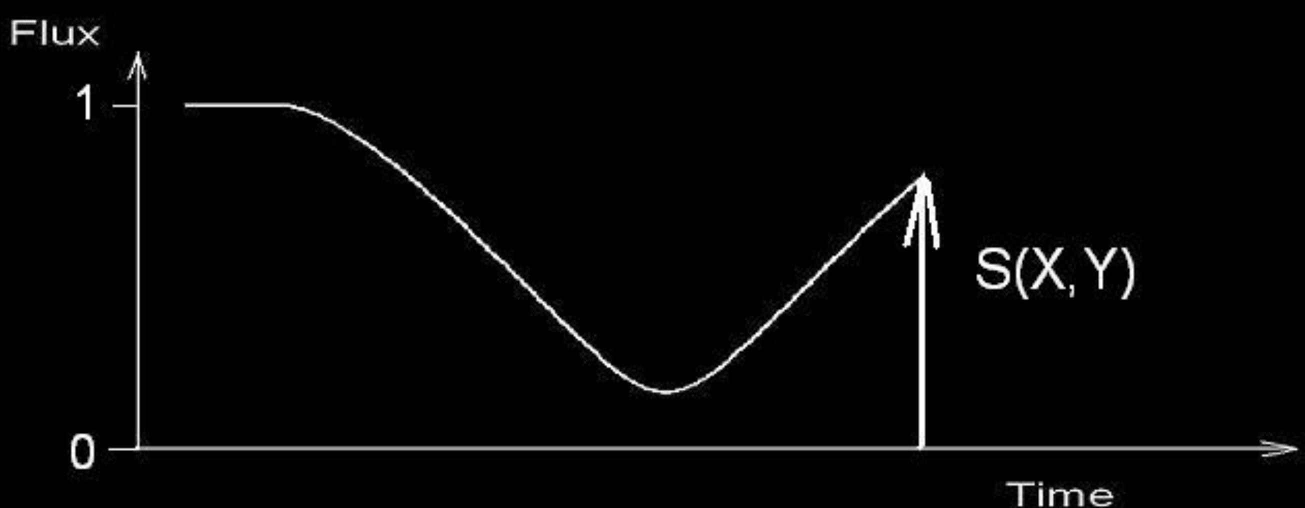
P(θ) - the integrated albedo of the satellite



The integrated brightness of the satellite Ganymede (at left) and Callisto (at right) as a function of the angle of rotation based on the surface maps (lines for different phase angles) and the results of ground-based photometry (dashed line).

Morrison, D., Morrison, N. D., 1977. Photometry of the Gallilean satellites, in Planetary satellites. Tucson, University of Arizona Press. 363.


X, Y


Flux
1
0
S(X,Y)
Time

Reduction method

reacting of the receiver

$$E(t) = K \cdot S(X(t), Y(t))$$

Intensity of light:

- of the two satellites (occultation)
- of the eclipsed satellite (eclipse)

$S = 1$ before and after the event

Option: $$E(t) = K \cdot S(X(t), Y(t)) + P$$

Reduction method

$$X(t) = X^{th}(t) + D_x(t)\ ,$$

$$Y(t) = Y^{th}(t) + D_y(t)\ .$$

$$X(t) = X^{th}(t) + \overline{D}_x\ ,$$

$$Y(t) = Y^{th}(t) + \overline{D}_y\ .$$

$$E(t) = K \cdot S(X^{th}(t) + \overline{D}_x,\ Y^{th}(t) + \overline{D}_y) + P$$

Conditional equations: (unknowns: $K, P, \overline{D}_x, \overline{D}_y$):

$$E(t_i) = K \cdot S(X^{th}(t_i) + \overline{D}_x,\ Y^{th}(t_i) + \overline{D}_y) + P$$

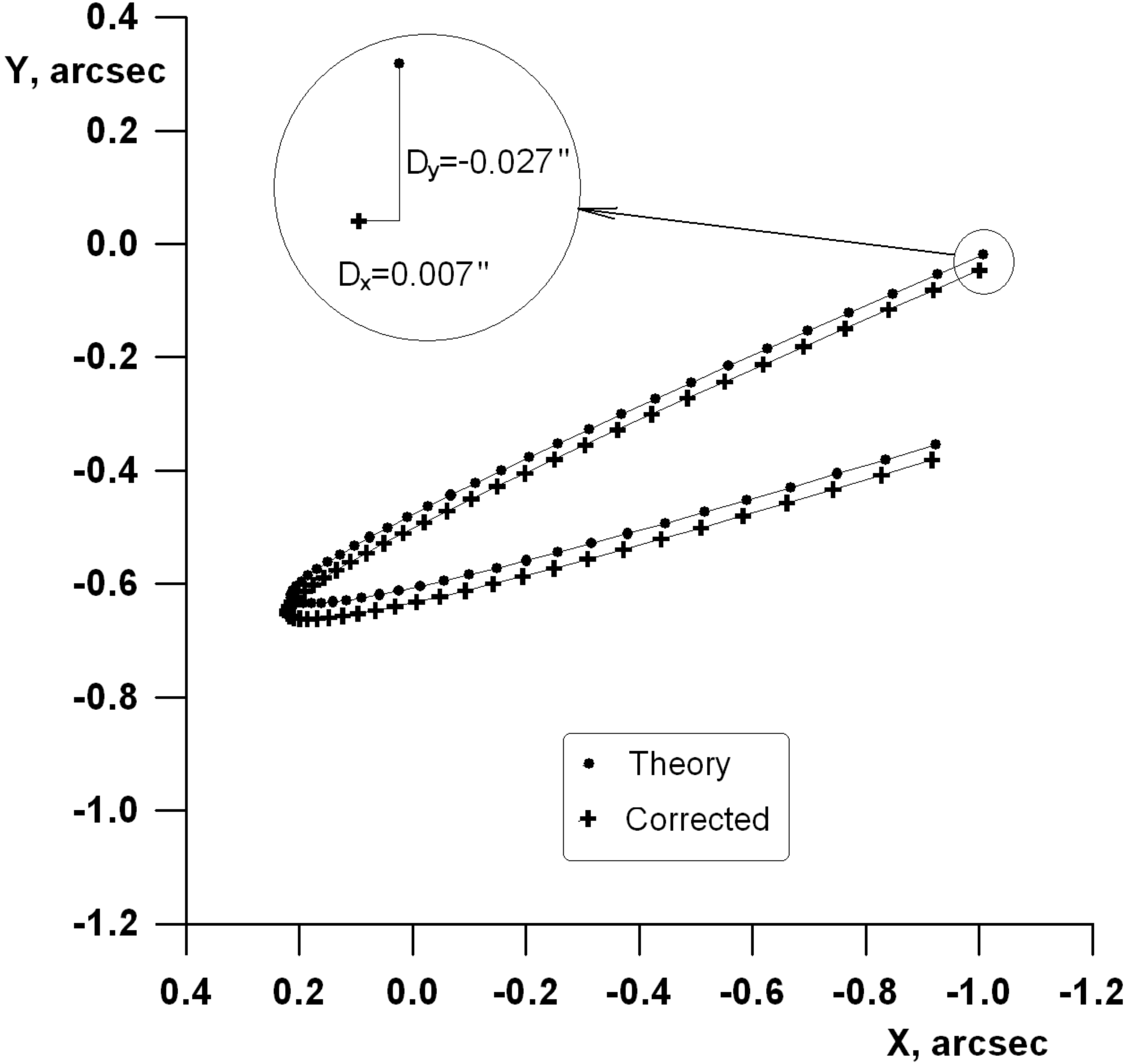
$$(i = 1, 2, ..., m)$$

After solving the system, we get the astrometric results:

$$X(t^*) = X^{th}(t^*) + \overline{D}_x, \quad Y(t^*) = Y^{th}(t^*) + \overline{D}_y$$

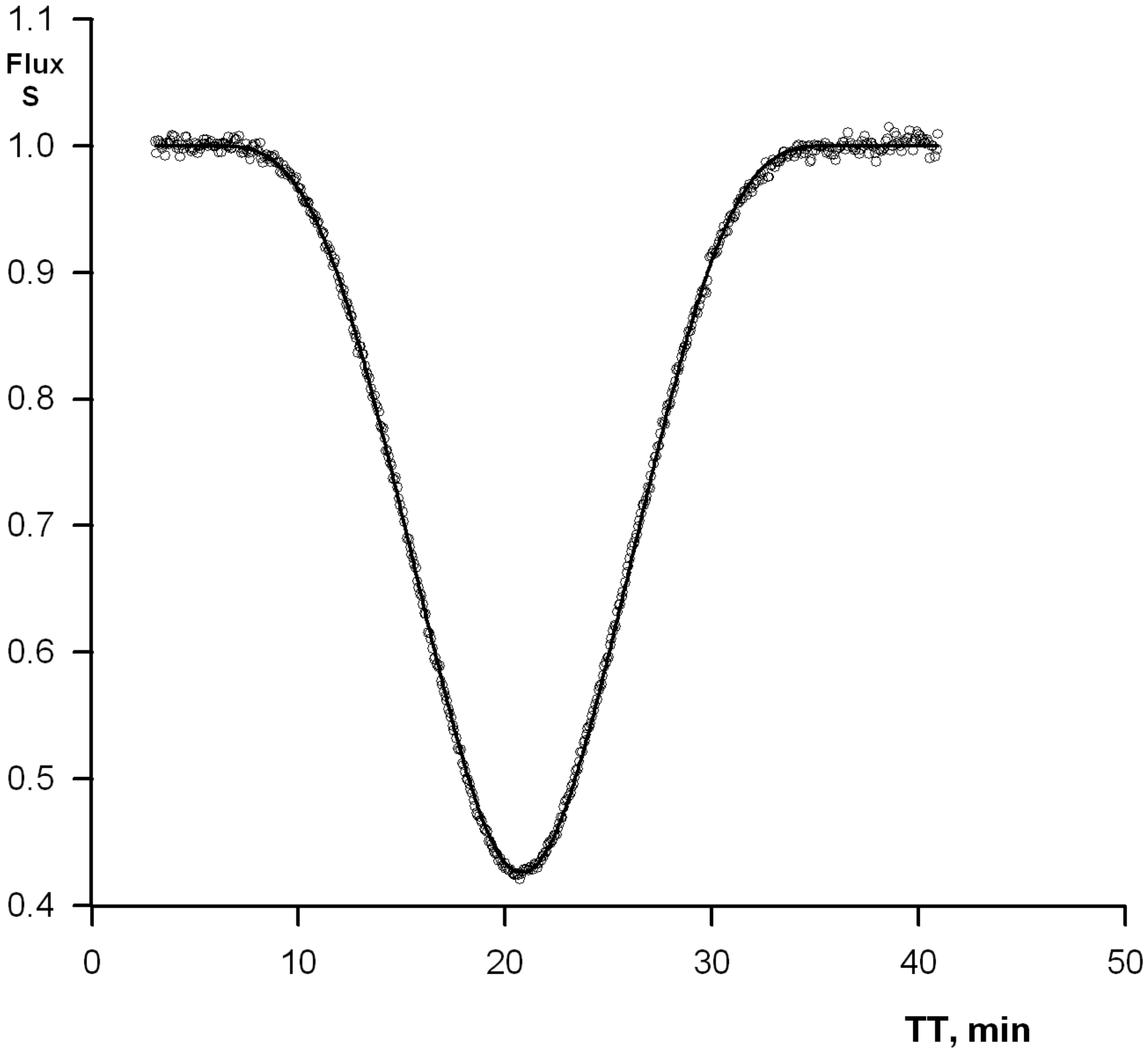
t^* : arbitrary

$$\sigma_x = \sigma[D_x] = \sigma[X(t^*)] \quad \sigma_y = \sigma[D_y] = \sigma[Y(t^*)]$$



Corrected apparent motion of Europa relative to Io

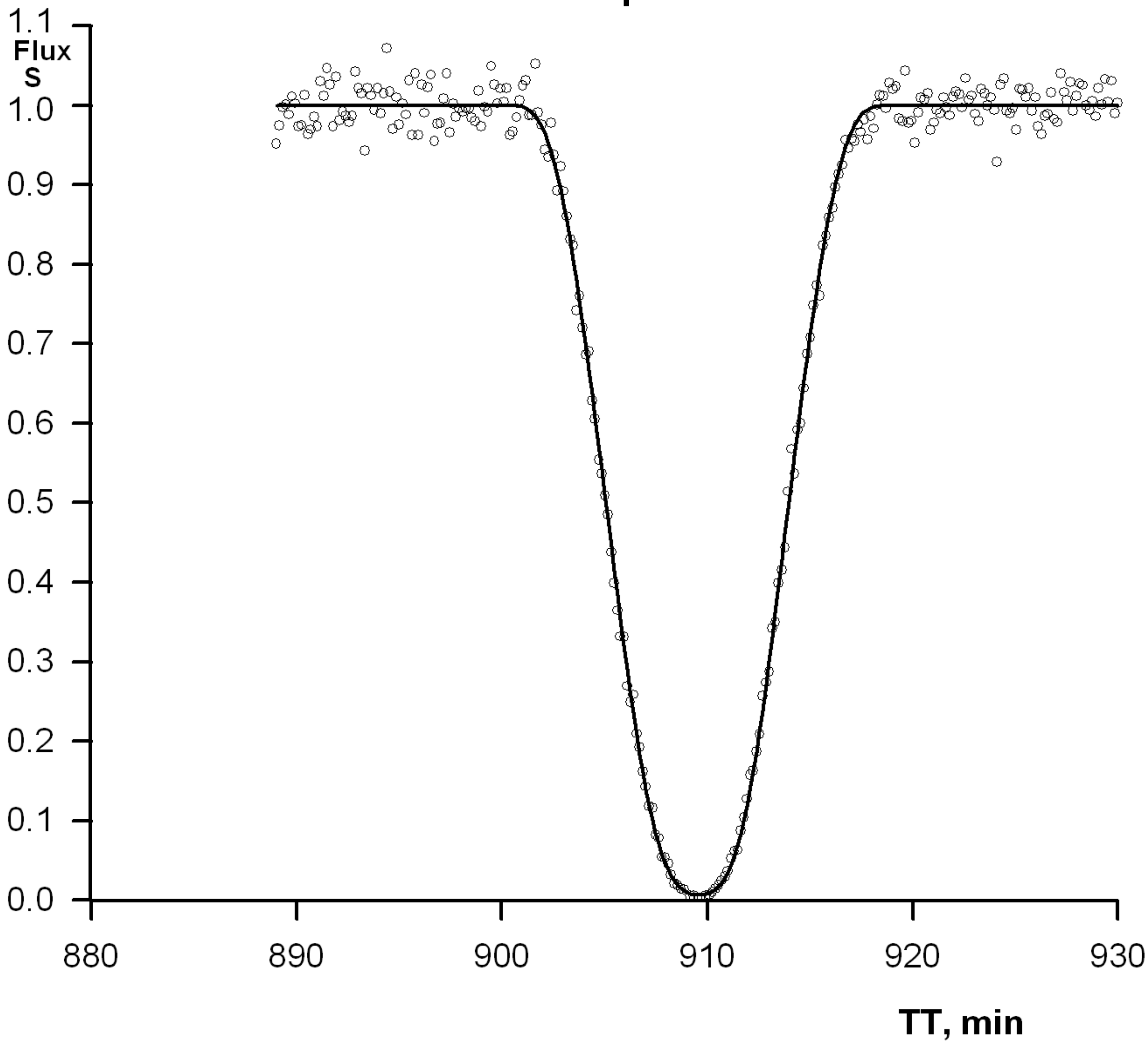
Examples



1997.08.01 4e3 Tenerife σ_x = 0.0005" σ_y = 0.0006"

O-C_x = 0.0380" O-C_y= -0.0260"

Examples

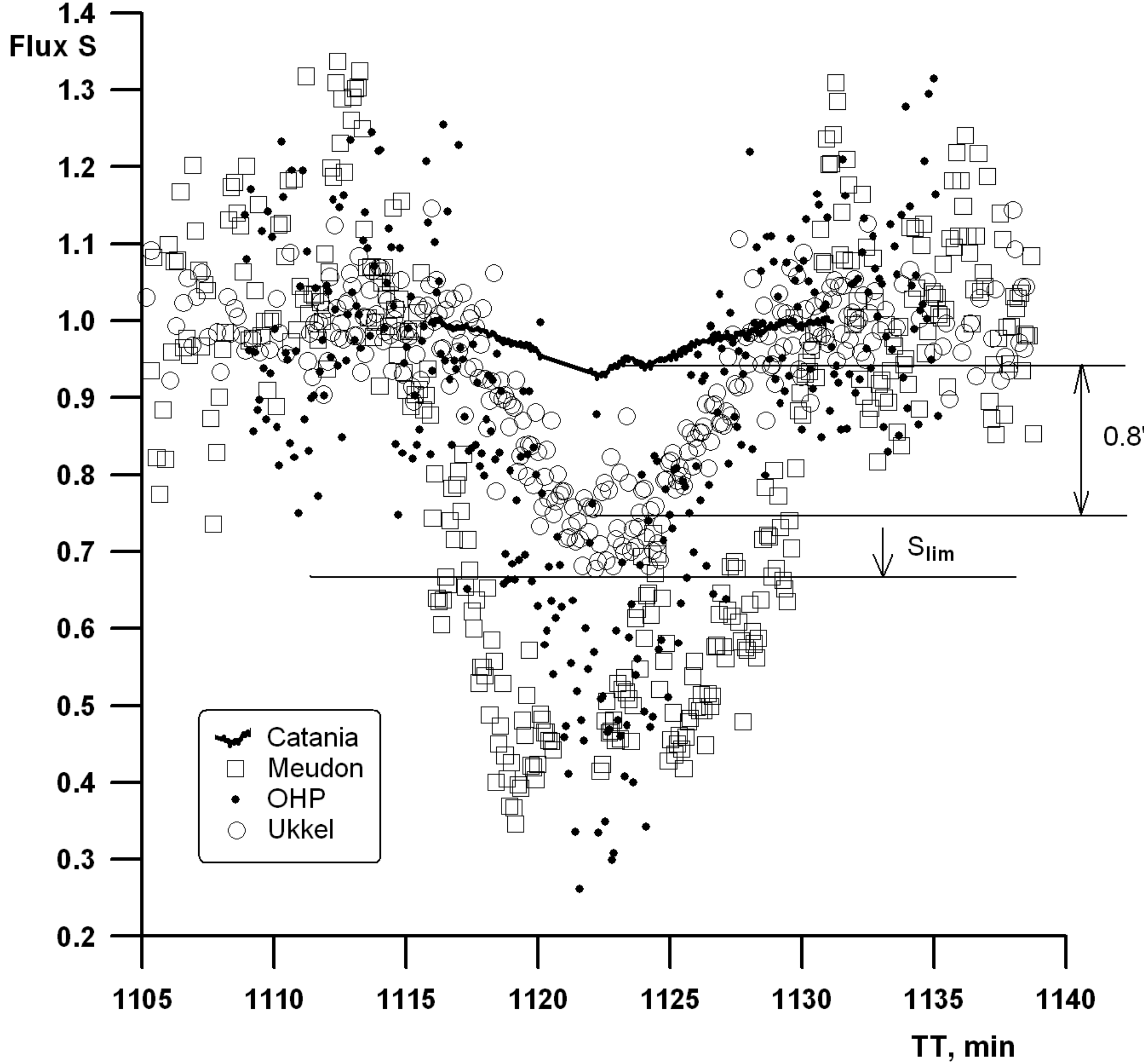


1997.09.15 3e2 Alma-Ata σ_x = 0.0029" σ_y = 0.0054"

O-C_x =-0.0059" O-C_y= 0.0497"

Examples:

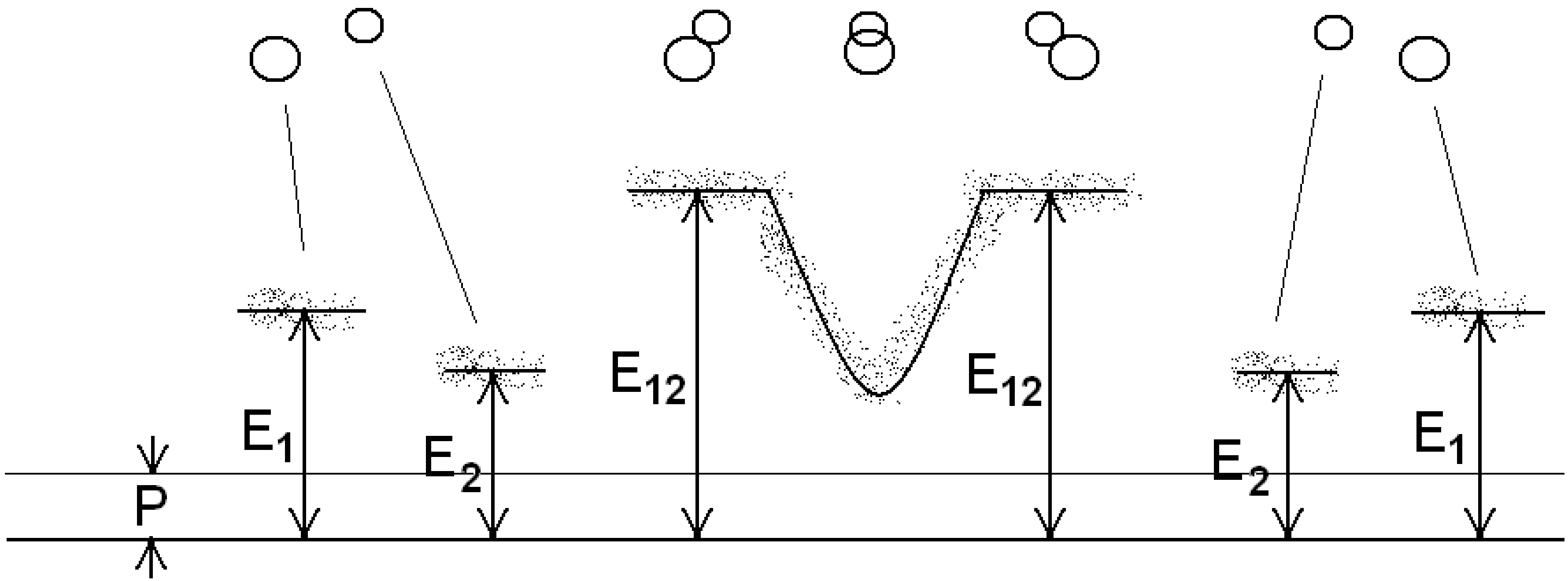
several observations of the same event not in agreement



1997.09.29 3o2

Precautions when observing

Avoiding biases: individual measurements before and after the event



$$E_1 = Rp_1 r_1^2 + P, \quad E_2 = Rp_2 r_2^2 + P, \quad E_{12} = R(p_1 r_1^2 + p_2 r_2^2) + P$$

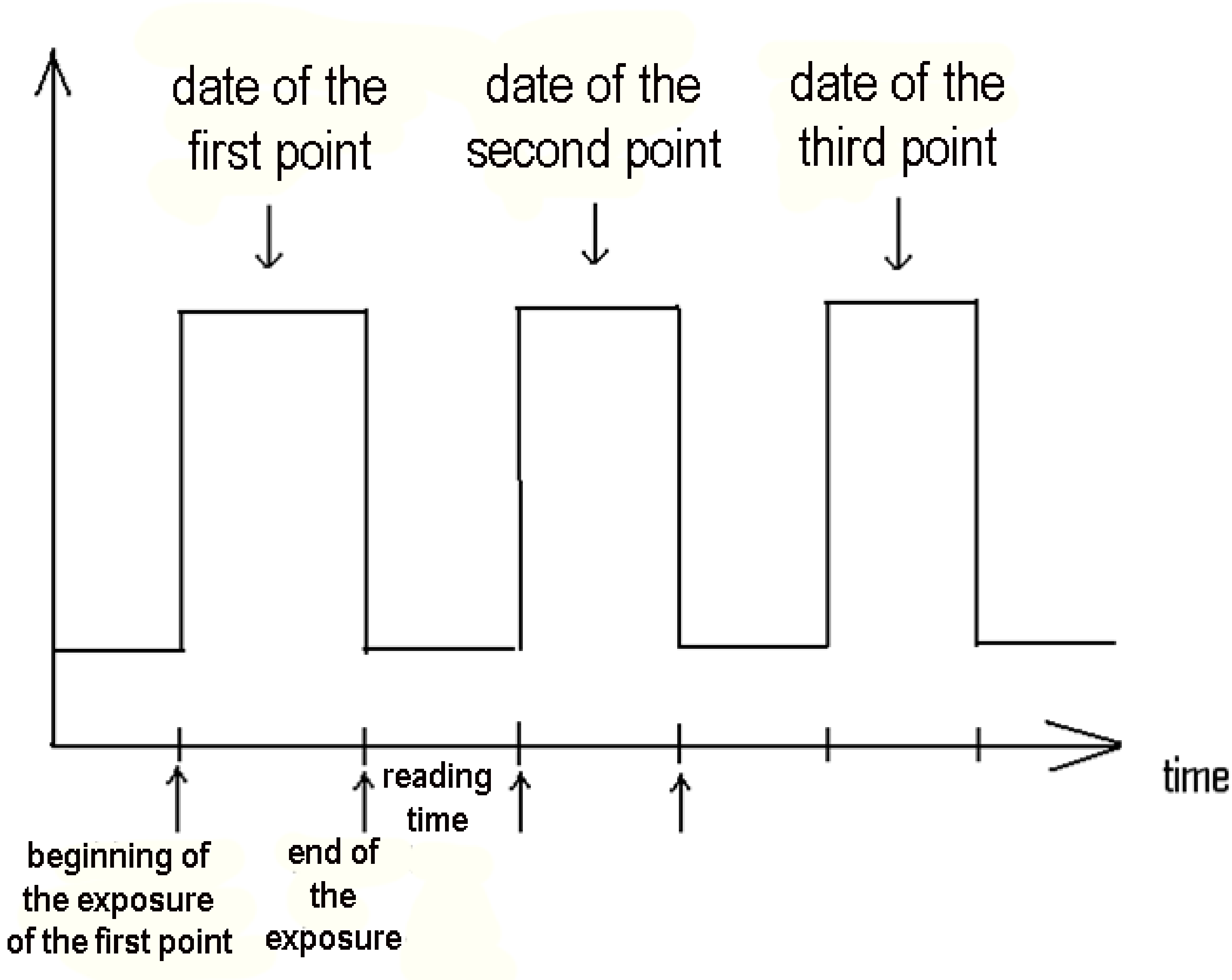
$$P = E_1 + E_2 - E_{12} \qquad \frac{p_2}{p_1} = \frac{r_1^2}{r_2^2} \, \frac{E_{12} - E_1}{E_{12} - E_2}.$$

In Emelyanov (2008, Solar System Research)

Integration time and sampling of the observation

- - the intergation time should be neither too short (for a good S/N), nor too long (for a good timing of each photometric point and to get a sufficient number of point during short events).most of time, the integration time varies from 0.1 to 2 seconds of time.
- - the sampling of the light curve (the number of individual points of photometric measure) wiull depend on the integration time and on the phenomenon itself. A short event will need more points than a long event: an event of 2 minutes need more than one point per second; a long event of 30 minutes or more will need only one point every 2 or 3 seconds of time.
- - don’t forget the time necessary to read the CCD and to record the data.
- - the sampling is the result of the integration time plus the reading and recording time.

Dating the observation



Bien dater une succession rapide d'images

Saturation

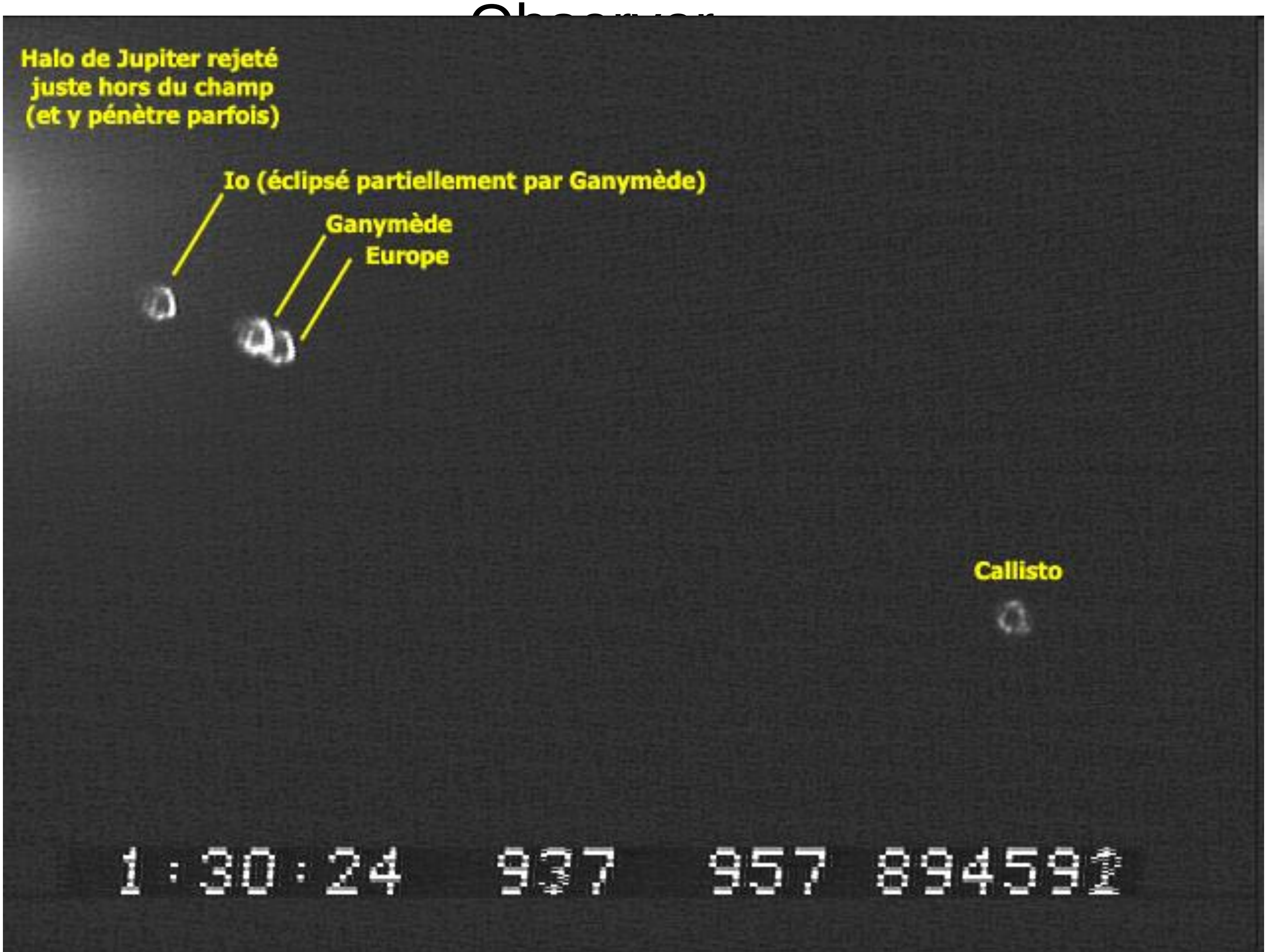
- The saturation must be avoided: photometry is not confident and the magnitude drop is wrong when the images are saturated. Then it is necessary to:
- - decrease the integration time (but it may decrease the S/N)
- - decrease the aperture of the telescope
- - use a density filter to decrease the light arriving on the receiver
- - put the images slightly out of focus in order to spread the light on the target.

The last solution is necessary in case of bad seeing which spread the light. At the time of the event when the two satellites are close together the density of light will increase because the two images will be added and the saturation will occur.

An event out of focus

-The images of the satellites have been slightly put out of focus in order to avoid saturation

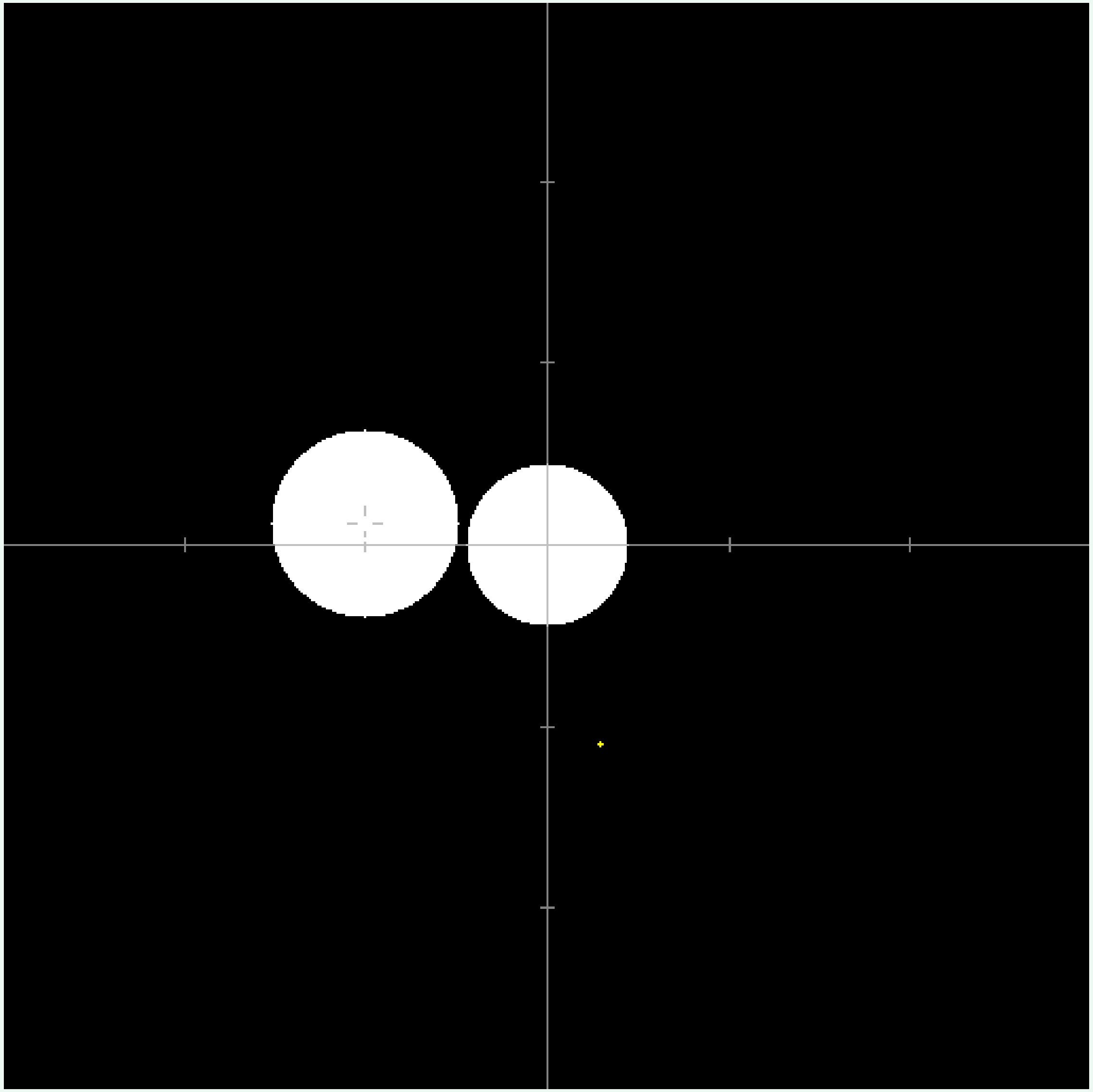
Observer


Halo de Jupiter rejeté
juste hors du champ
(et y pénètre parfois)
Io (éclipsé partiellement par Ganymède)
Ganymède
Europe
Callisto
1:30:24 937 957 894591

Mutual phenomena

- Mean duration: 5 to 10 minutes
- Some events are grazing with a small magnitude drop

- Some events are very long such as:
- on 12 December 2014 at 23h 12m 44s: J2 occults J1 during 187 minutes



Present field : **6" x 6"**
Time moment: **2014 12 12 23 12 0.00 (UTC)**
Observatory: **Geocenter**

IMCCE/SAI. Natural Satellites Ephemeride Server. MULTI-SAT.

Satellites of Jupiter

Reference body:
J2 Europe
Marked satellite:
J1 Io
Epoch of equator and equinox J2000
Differential coordinates

Refresh image
With 6" field scale
One time step of 0.2000 hours
- Back
- Non
- Forward

Marked satellite:
J1 Io

Center of the field:
α = 9^h 39^m 57.109^s
δ = 14° 47' 37.79"

N
E + W
S

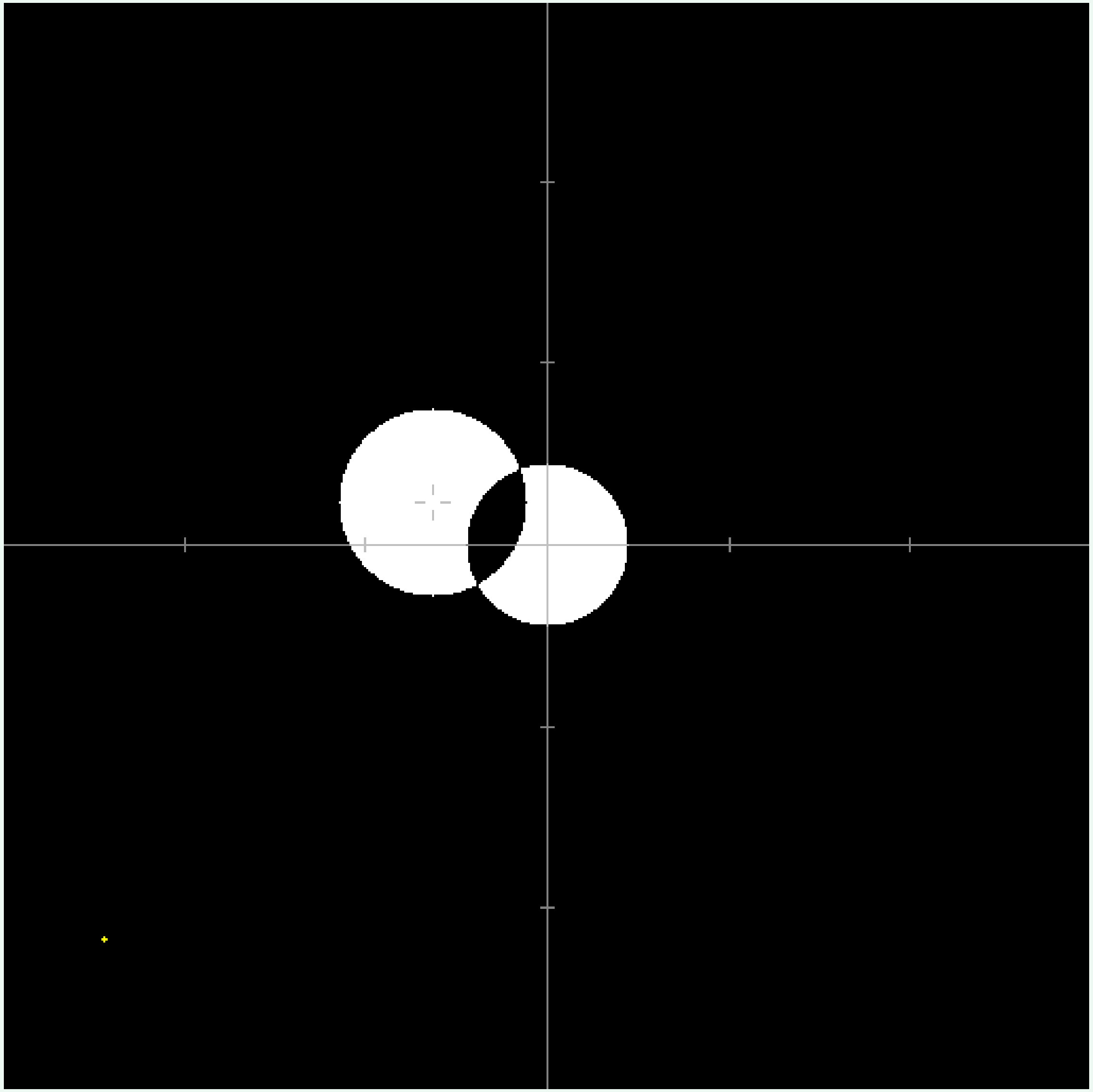
Coordinates and magnitudes

Historique Marque-pages Outils ?

IMCCE-SAI: Natural Satelli... | IMCCE-SAI: Natural Satelli... | IMCCE-SAI: Natural Satelli... | Elections municipales et co... | Club Eclipse - WETO 2014 | resta

e.fr/cgi-bin/saimirror/nss-eph3.cgi

amalthée observation CC



Present field : **6" x 6"**
Time moment: **2014 12 12 23 24 0.00 (UTC)**
Observatory: **Geocenter**

IMCCE/SAI. Natural Satellites Ephemeride Server. MULTI-SAT.

Satellites of Jupiter

Reference body:
J2 Europe
Marked satellite:
J1 Io
Epoch of equator and equinox J2000
Differential coordinates

Refresh image

With 6" field scale

One time step of 0.2000 hours

- Back
- Non
- Forward

Marked satellite:
J1 Io

Center of the field:
$\alpha = 9^h\ 39^m\ 56.914^s$
$\delta = 14^\circ\ 47'\ 39.02''$

N
E + W
S

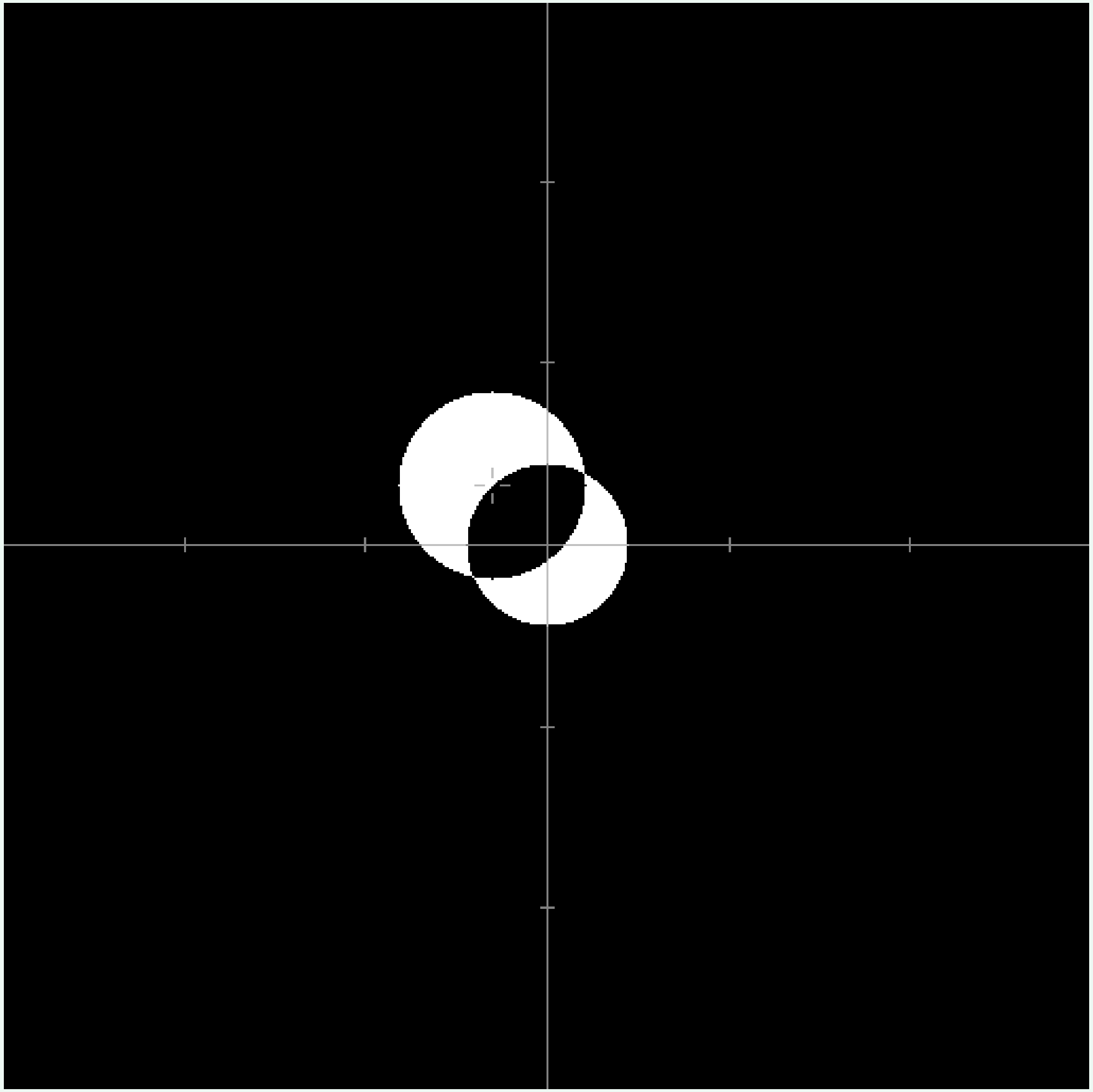
Coordinates and magnitudes

Historique Marque-pages Outils ?

IMCCE-SAI: Natural Satelli... | IMCCE-SAI: Natural Satelli... | IMCCE-SAI: Natural Satelli... | Elections municipales et co... | Club Eclipse - WETO 2014 | resta

e.fr/cgi-bin/saimirror/nss-eph3.cgi

amalthée observation CC



Present field : **6" x 6"**

Time moment: **2014 12 12 23 36 0.00 (UTC)**

Observatory: **Geocenter**

IMCCE/SAI. Natural Satellites Ephemeride Server. MULTI-SAT.

Satellites of Jupiter

Reference body:
J2 Europe
Marked satellite:
J1 Io
Epoch of equator and equinox J2000
Differential coordinates

Refresh image

With 6" field scale

One time step of 0.2000 hours

- Back
- Non
- Forward

Marked satellite:
J1 Io

Center of the field:

$\alpha = 9^h\ 39^m\ 56.720^s$

$\delta = 14^\circ\ 47'\ 40.24''$

N
E + W
S

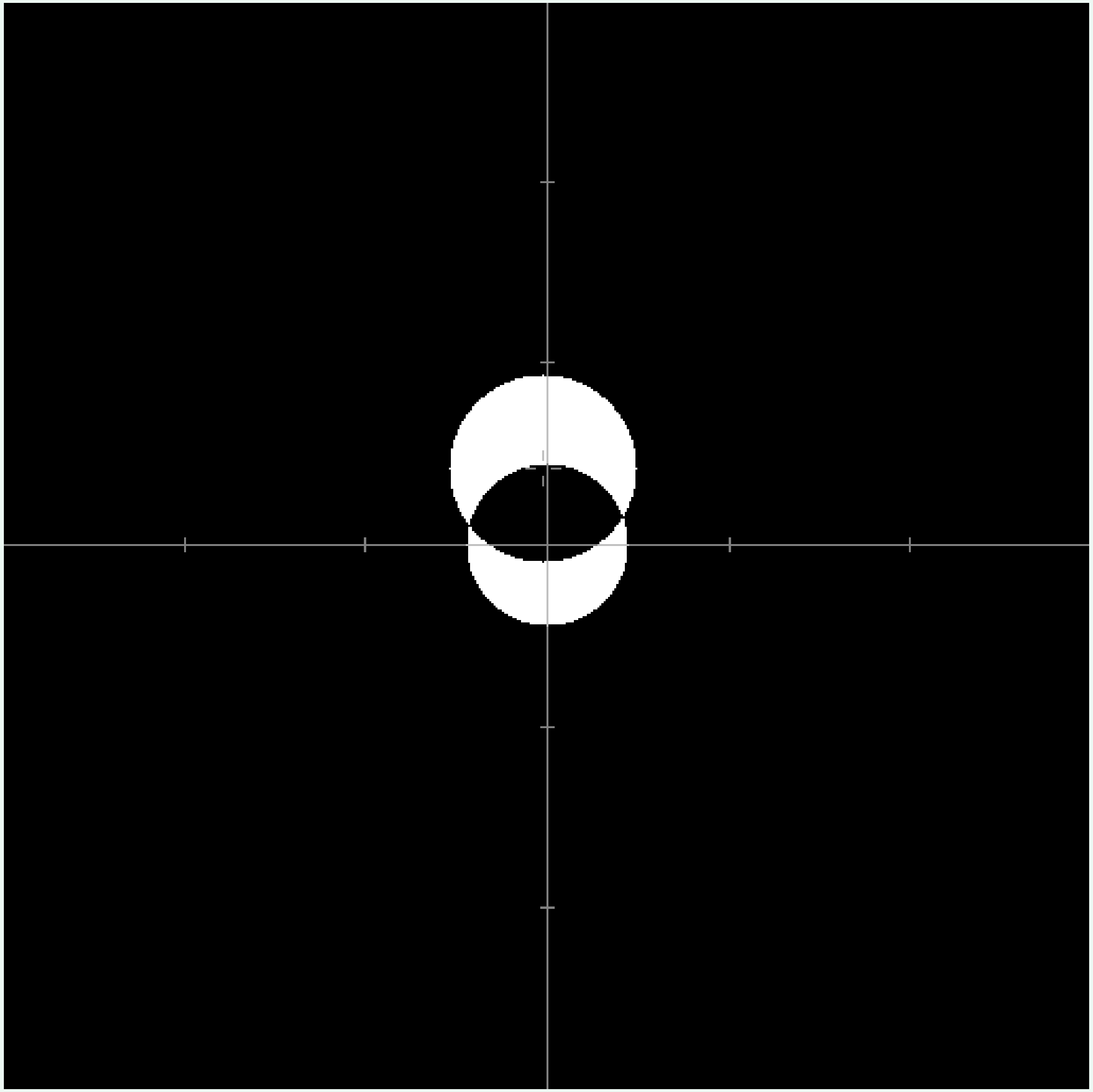
Coordinates and magnitudes

Historique Marque-pages Outils ?

IMCCE-SAI: Natural Satelli... | IMCCE-SAI: Natural Satelli... | IMCCE-SAI: Natural Satelli... | Elections municipales et co... | Club Eclipse - WETO 2014 | resta

e.fr/cgi-bin/saimirror/nss-eph3.cgi

amalthée observation CC



Present field : **6" x 6"**

Time moment: **2014 12 12 23 48 0.00 (UTC)**

Observatory: **Geocenter**

IMCCE/SAI. Natural Satellites Ephemeride Server. MULTI-SAT.

Satellites of Jupiter

Reference body:
J2 Europe
Marked satellite:
J1 Io
Epoch of equator and equinox J2000
Differential coordinates

Refresh image

With 6" field scale

One time step of 0.2000 hours

- Back
- Non
- Forward

Marked satellite:
J1 Io

Center of the field:

$\alpha = 9^h\ 39^m\ 56.527^s$

$\delta = 14^\circ\ 47'\ 41.45''$

N
E + W
S

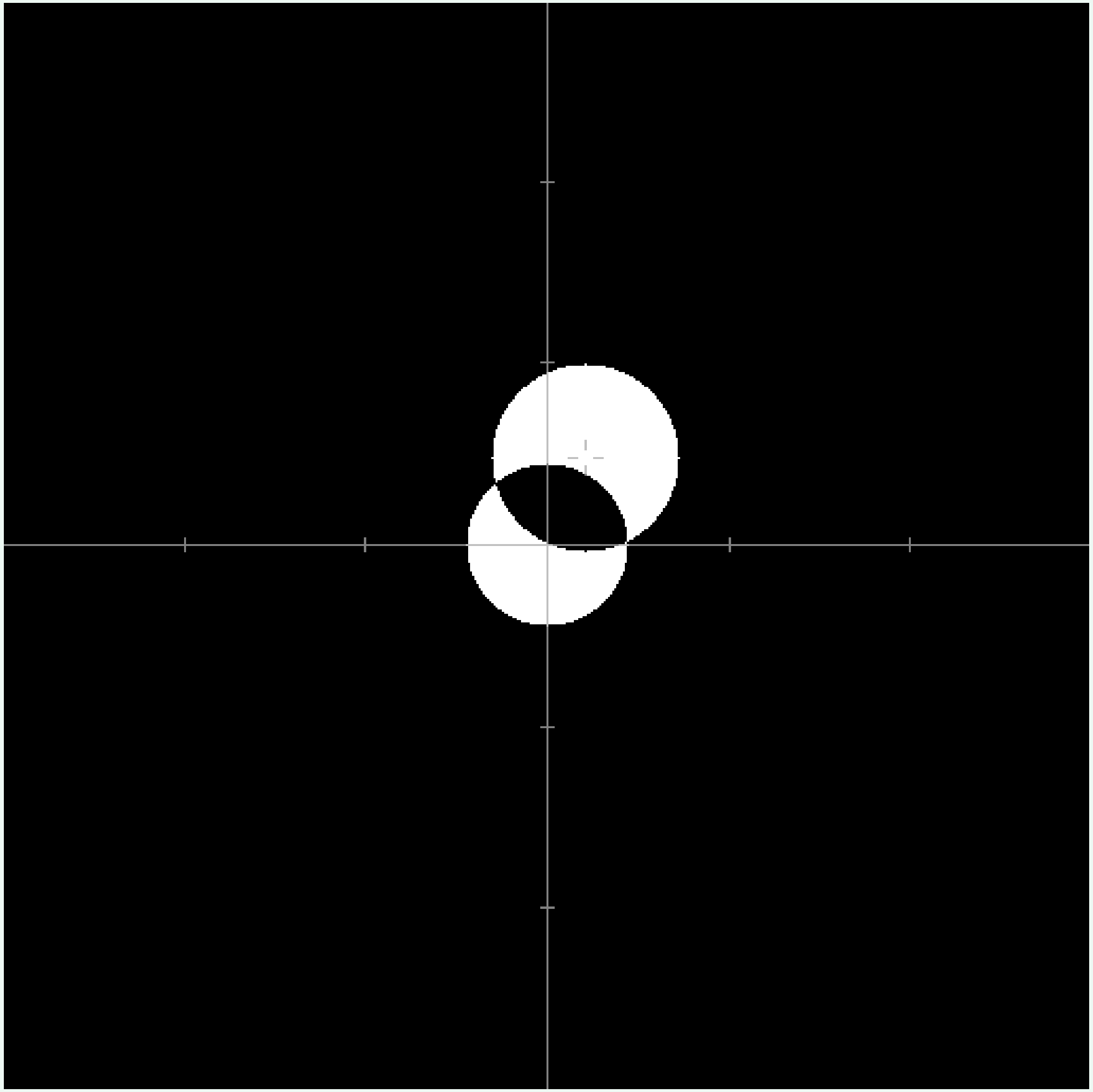
Coordinates and magnitudes

Historique Marque-pages Outils ?

IMCCE-SAI: Natural Satelli... | IMCCE-SAI: Natural Satelli... | IMCCE-SAI: Natural Satelli... | Elections municipales et co... | Club Eclipse - WETO 2014 | resta

e.fr/cgi-bin/saimirror/nss-eph3.cgi

amalthée observation CC



Present field : **6" x 6"**
Time moment: **2014 12 13 0 0 0.00 (UTC)**
Observatory: **Geocenter**

IMCCE/SAI. Natural Satellites Ephemeride Server. MULTI-SAT.

Satellites of Jupiter

Reference body:
J2 Europe
Marked satellite:
J1 Io
Epoch of equator and equinox J2000
Differential coordinates

Refresh image

With 6" field scale

One time step of 0.2000 hours

- Back
- Non
- Forward

Marked satellite:
J1 Io

Center of the field:
$\alpha = 9^h\ 39^m\ 56.334^s$
$\delta = 14^\circ\ 47'\ 42.67''$

N
E + W
S

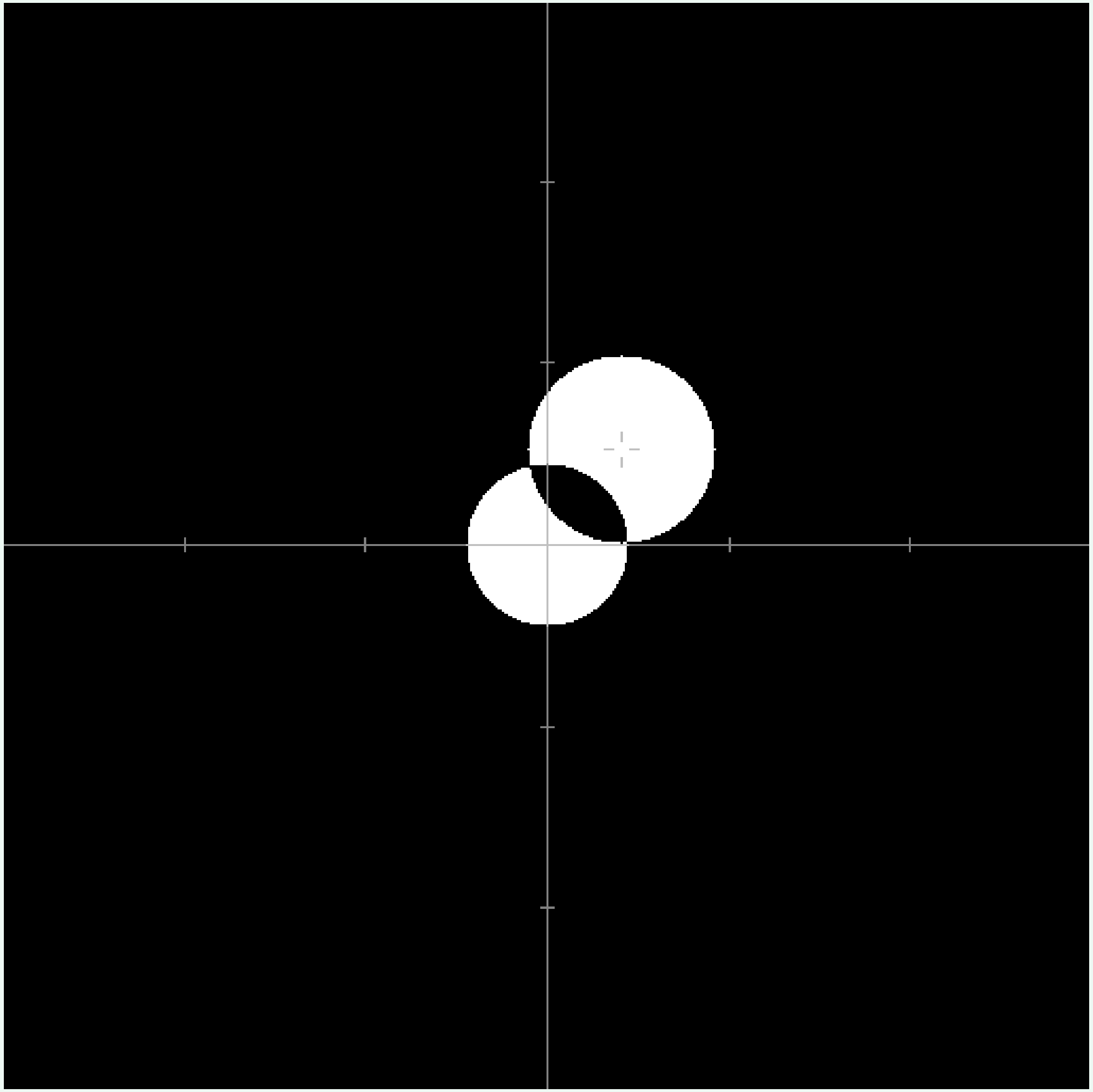
Coordinates and magnitudes

Historique Marque-pages Outils ?

IMCCE-SAI: Natural Satelli... | IMCCE-SAI: Natural Satelli... | IMCCE-SAI: Natural Satelli... | Elections municipales et co... | Club Eclipse - WETO 2014 | resta

e.fr/cgi-bin/saimirror/nss-eph3.cgi

amalthée observation CC



Present field : **6" x 6"**
Time moment: **2014 12 13 0 12 0.00 (UTC)**
Observatory: **Geocenter**

IMCCE/SAI. Natural Satellites Ephemeride Server. MULTI-SAT.

Satellites of Jupiter

Reference body:
J2 Europe
Marked satellite:
J1 Io
Epoch of equator and equinox J2000
Differential coordinates

Refresh image

With 6" field scale

One time step of 0.2000 hours

- Back
- Non
- Forward

Marked satellite:
J1 Io

Center of the field:
α = 9^h 39^m 56.143^s
δ = 14° 47' 43.87"

N
E + W
S

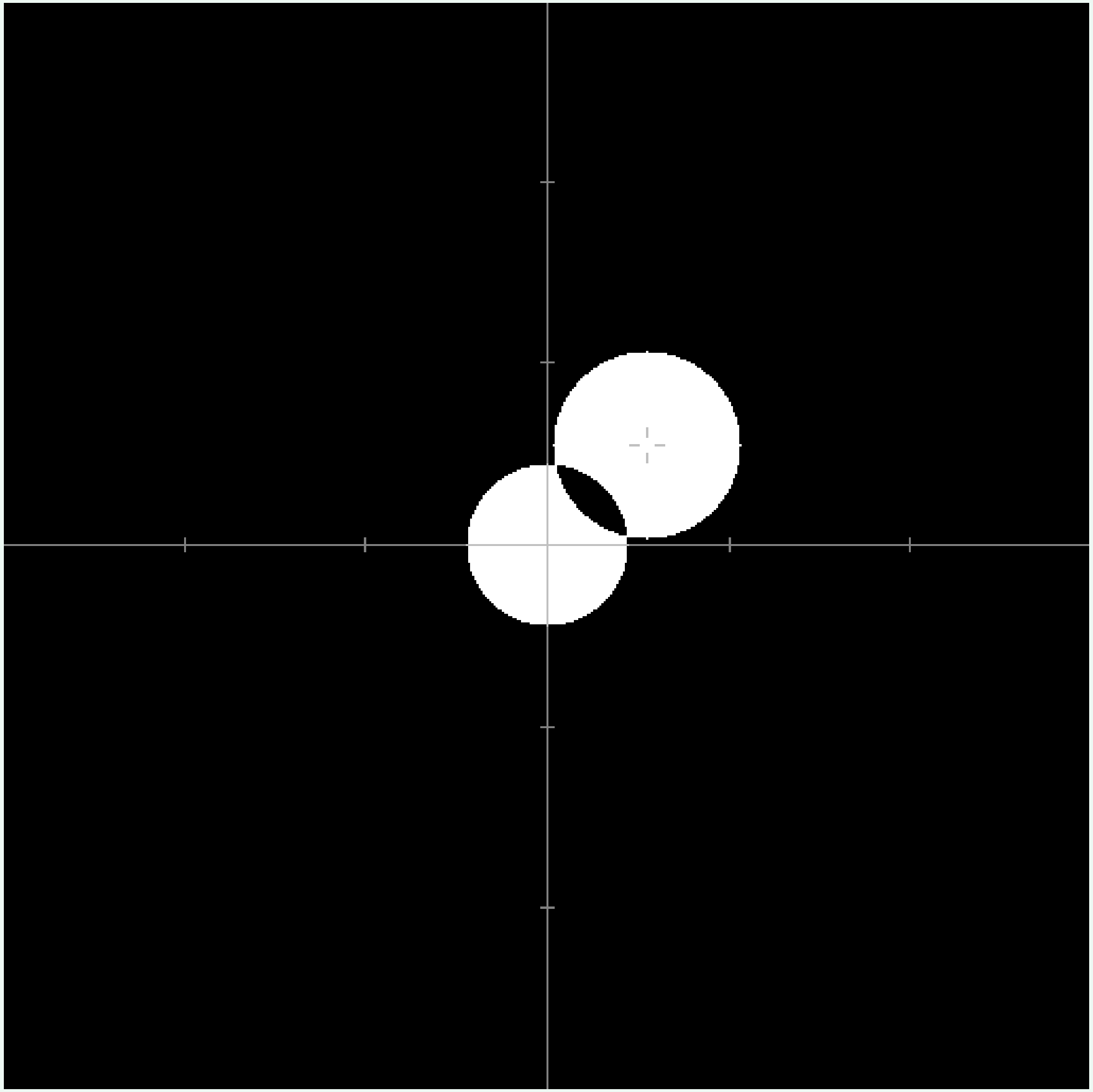
Coordinates and magnitudes

Historique Marque-pages Outils ?

IMCCE-SAI: Natural Satelli... | IMCCE-SAI: Natural Satelli... | IMCCE-SAI: Natural Satelli... | Elections municipales et co... | Club Eclipse - WETO 2014 | resta

e.fr/cgi-bin/saimirror/nss-eph3.cgi

amalthée observation CC



Present field : **6" x 6"**
Time moment: **2014 12 13 0 24 0.00 (UTC)**
Observatory: **Geocenter**

IMCCE/SAI. Natural Satellites Ephemeride Server. MULTI-SAT.

Satellites of Jupiter

Reference body:
J2 Europe
Marked satellite:
J1 Io
Epoch of equator and equinox J2000
Differential coordinates

Refresh image
With 6" field scale
One time step of 0.2000 hours
Back
Non
Forward

Marked satellite:
J1 Io

Center of the field:
$\alpha = 9^h\ 39^m\ 55.953^s$
$\delta = 14^\circ\ 47'\ 45.07''$

N
E + W
S

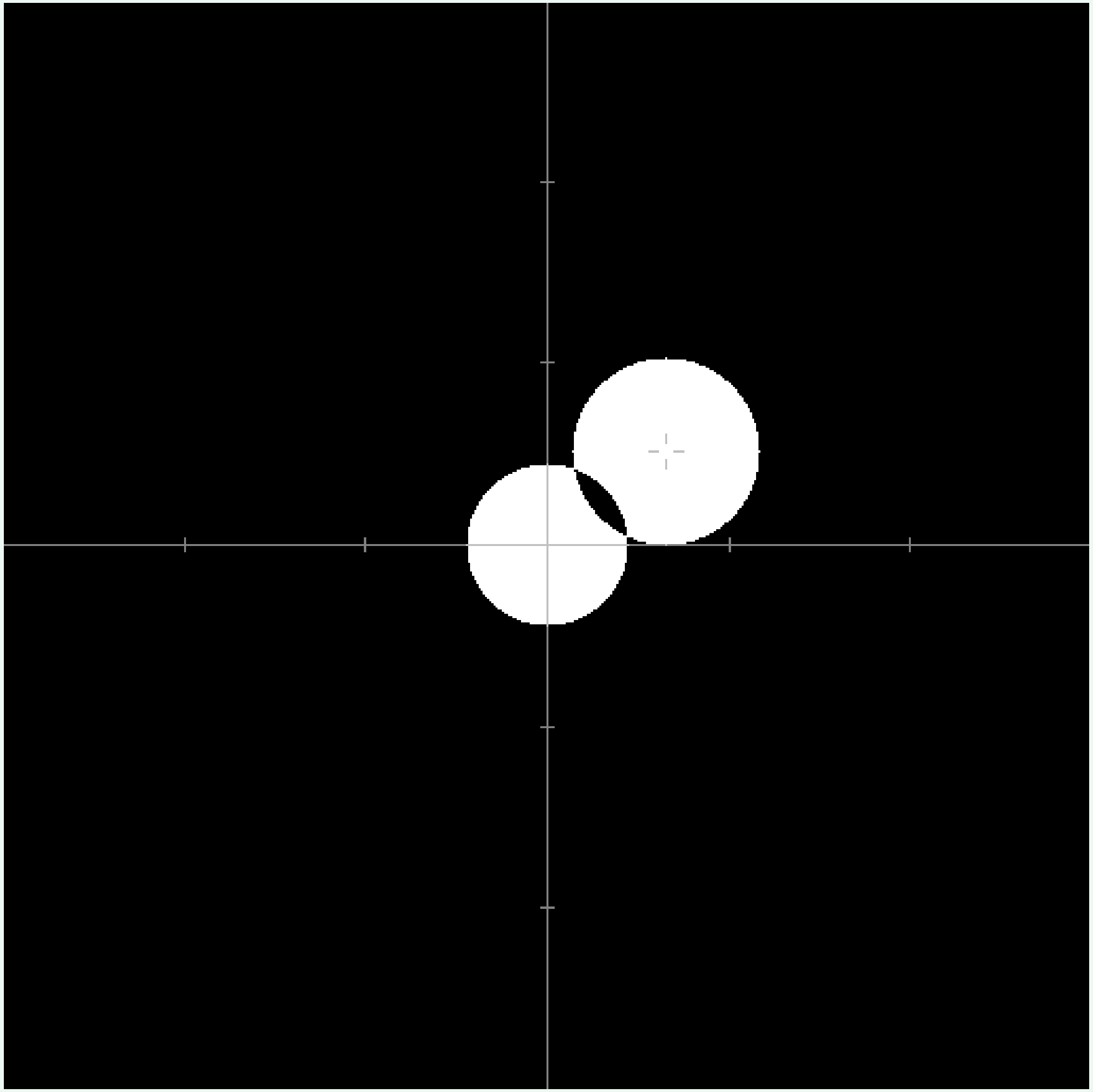
Coordinates and magnitudes

Historique Marque-pages Outils ?

IMCCE-SAI: Natural Satelli... | IMCCE-SAI: Natural Satelli... | IMCCE-SAI: Natural Satelli... | Elections municipales et co... | Club Eclipse - WETO 2014 | resta

e.fr/cgi-bin/saimirror/nss-eph3.cgi

amalthée observation CC



Present field : **6" x 6"**
Time moment: **2014 12 13 1 0 0.00 (UTC)**
Observatory: **Geocenter**

IMCCE/SAI. Natural Satellites Ephemeride Server. MULTI-SAT.

Satellites of Jupiter

Reference body:
J2 Europe
Marked satellite:
J1 Io
Epoch of equator and equinox J2000
Differential coordinates

Refresh image
With 6" field scale
One time step of 0.2000 hours
Back
Non
Forward

Marked satellite:
J1 Io

Center of the field:
α = 9^h 39^m 55.388^s
δ = 14° 47' 48.64"

N
E + W
S

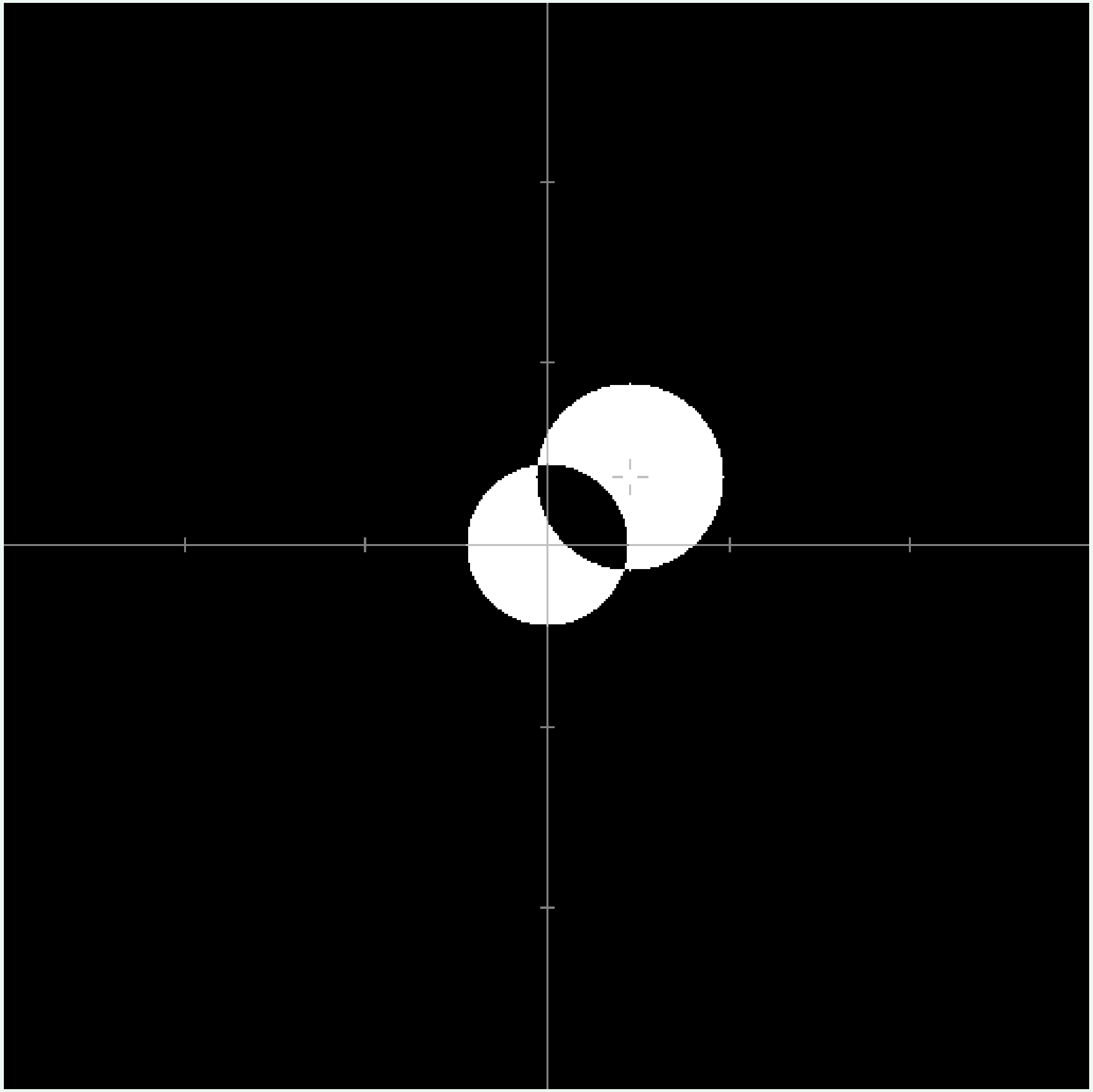
Coordinates and magnitudes

Historique Marque-pages Outils ?

IMCCE-SAI: Natural Satelli... | IMCCE-SAI: Natural Satelli... | IMCCE-SAI: Natural Satelli... | Elections municipales et co... | Club Eclipse - WETO 2014 | resta

e.fr/cgi-bin/saimirror/nss-eph3.cgi

amalthée observation CC



Present field : **6" x 6"**

Time moment: **2014 12 13 1 24 0.00 (UTC)**

Observatory: **Geocenter**

IMCCE/SAI. Natural Satellites Ephemeride Server. MULTI-SAT.

Satellites of Jupiter

Reference body:
J2 Europe
Marked satellite:
J1 Io
Epoch of equator and equinox J2000
Differential coordinates

Refresh image

With 6" field scale

One time step of 0.2000 hours

- Back
- Non
- Forward

Marked satellite:
J1 Io

Center of the field:

$\alpha = 9^h\,39^m\,55.017^s$

$\delta = 14^\circ\,47'\,50.98''$

N
E + W
S

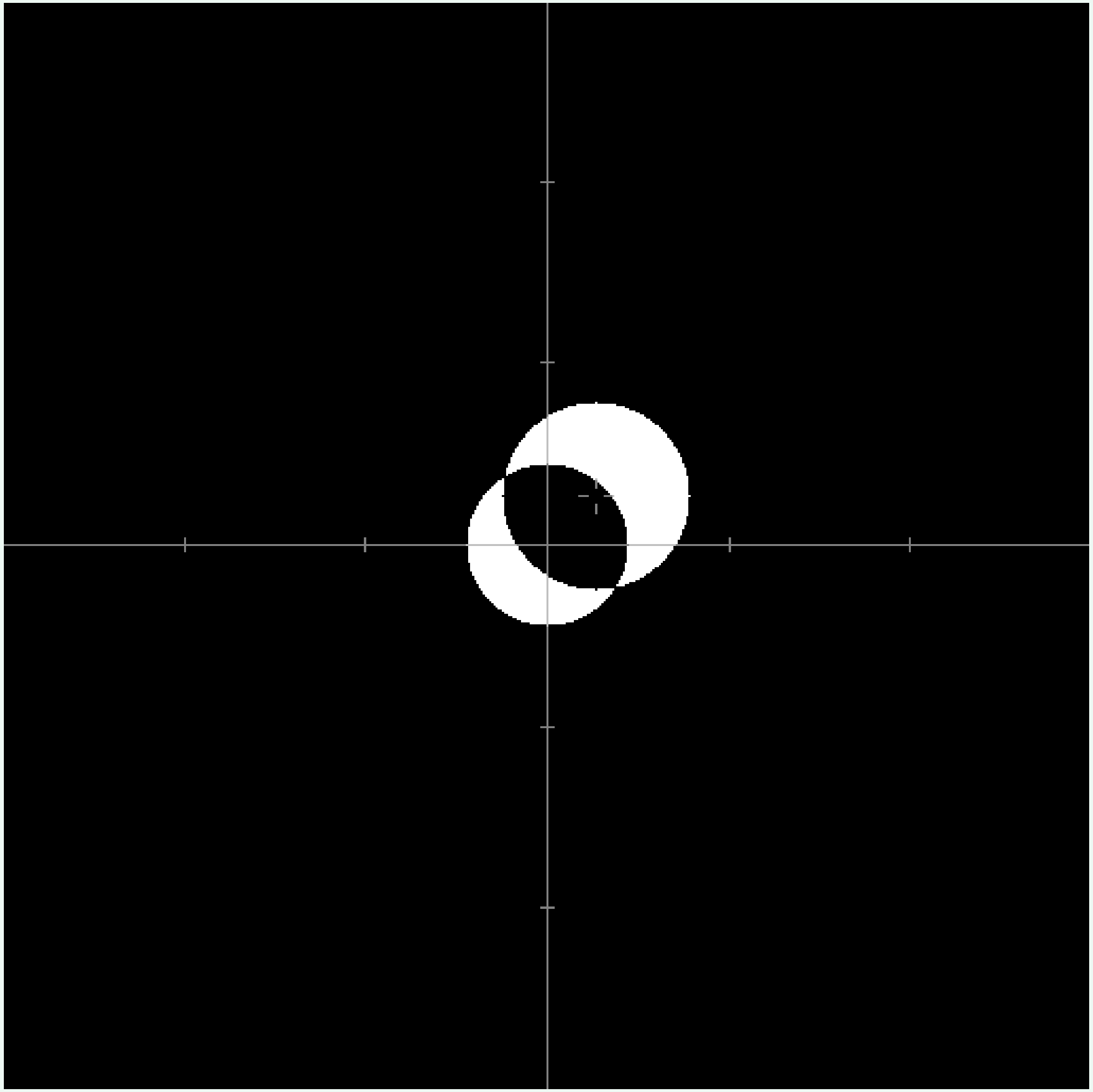
Coordinates and magnitudes

Historique Marque-pages Outils ?

IMCCE-SAI: Natural Satelli... | IMCCE-SAI: Natural Satelli... | IMCCE-SAI: Natural Satelli... | Elections municipales et co... | Club Eclipse - WETO 2014 | resta

e.fr/cgi-bin/saimirror/nss-eph3.cgi

amalthée observation CC



Present field : **6" x 6"**
Time moment: **2014 12 13 1 36 0.00 (UTC)**
Observatory: **Geocenter**

IMCCE/SAI. Natural Satellites Ephemeride Server. MULTI-SAT.

Satellites of Jupiter

Reference body:
J2 Europe
Marked satellite:
J1 Io
Epoch of equator and equinox J2000
Differential coordinates

Refresh image

With 6" field scale

One time step of 0.2000 hours

Back
Non
Forward

Marked satellite:
J1 Io

Center of the field:
$\alpha = 9^h\ 39^m\ 54.834^s$
$\delta = 14^\circ\ 47'\ 52.14''$

N
E + W
S

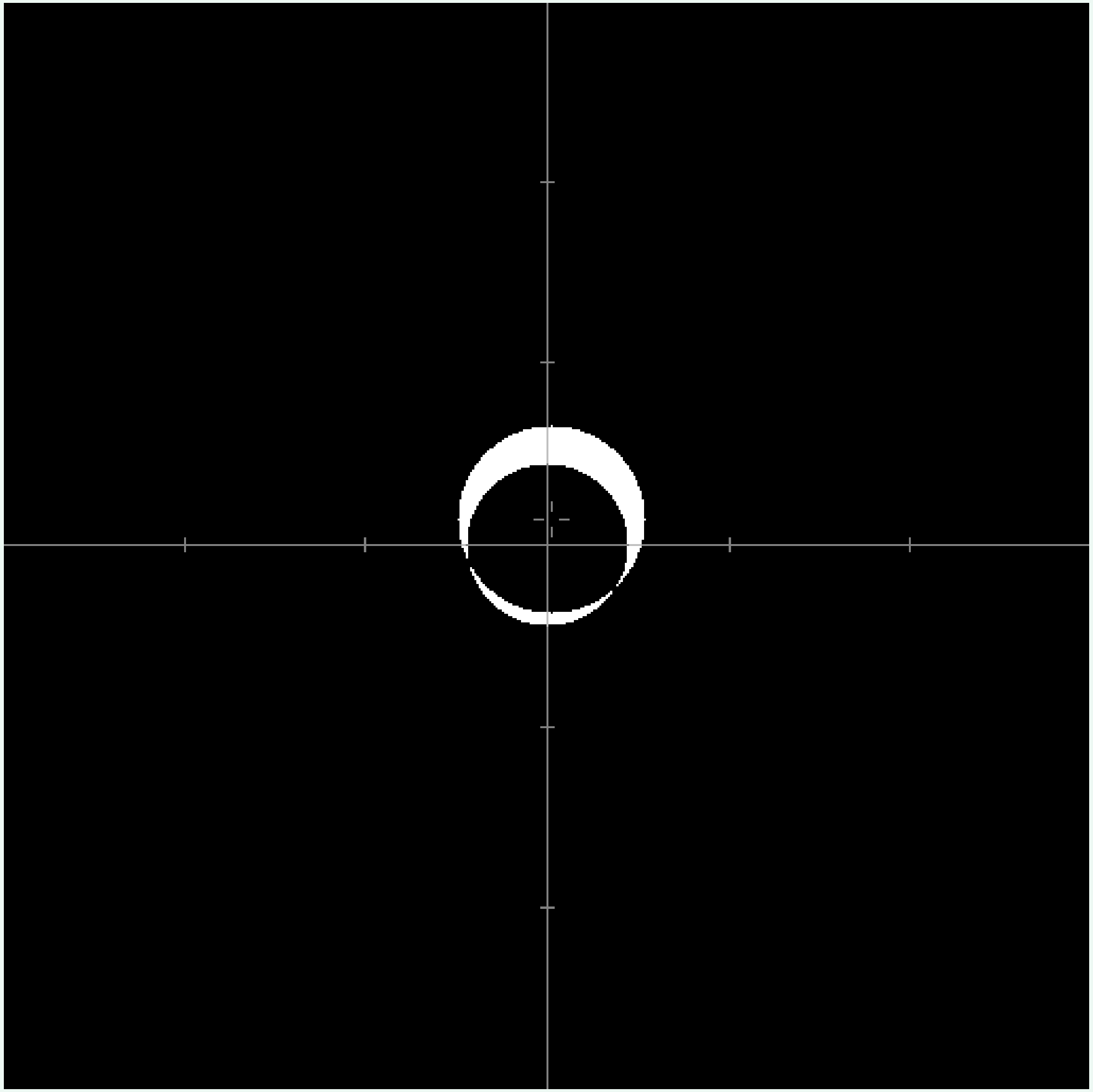
Coordinates and magnitudes

Historique Marque-pages Outils ?

IMCCE-SAI: Natural Satelli... | IMCCE-SAI: Natural Satelli... | IMCCE-SAI: Natural Satelli... | Elections municipales et co... | Club Eclipse - WETO 2014 | resta

e.fr/cgi-bin/saimirror/nss-eph3.cgi

amalthée observation CC



Present field : **6" x 6"**
Time moment: **2014 12 13 1 48 0.00 (UTC)**
Observatory: **Geocenter**

IMCCE/SAI. Natural Satellites Ephemeride Server. MULTI-SAT.

Satellites of Jupiter

Reference body:
J2 Europe
Marked satellite:
J1 Io
Epoch of equator and equinox J2000
Differential coordinates

Refresh image
With 6" field scale
One time step of 0.2000 hours
Back
Non
Forward

Marked satellite:
J1 Io

Center of the field:
$\alpha = 9^h\ 39^m\ 54.651^s$
$\delta = 14^\circ\ 47'\ 53.30''$

N
E + W
S

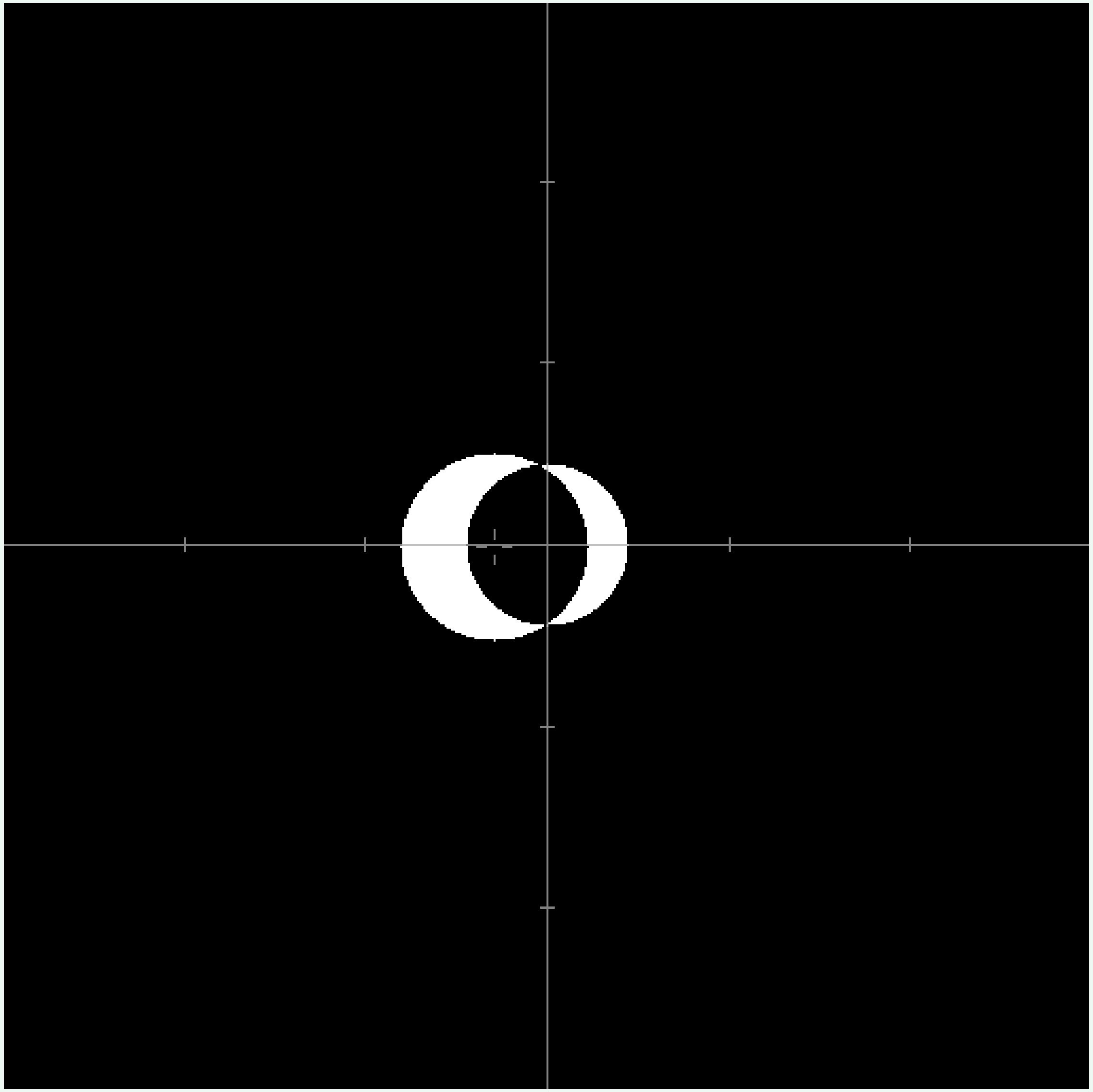
Coordinates and magnitudes

Historique Marque-pages Outils ?

IMCCE-SAI: Natural Satelli... | IMCCE-SAI: Natural Satelli... | IMCCE-SAI: Natural Satelli... | Elections municipales et co... | Club Eclipse - WETO 2014 | resta

e.fr/cgi-bin/saimirror/nss-eph3.cgi

amalthée observation CC



Present field : **6" x 6"**
Time moment: **2014 12 13 2 0 0.00 (UTC)**
Observatory: **Geocenter**

IMCCE/SAI. Natural Satellites Ephemeride Server. MULTI-SAT.

Satellites of Jupiter

Reference body:
J2 Europe
Marked satellite:
J1 Io
Epoch of equator and equinox J2000
Differential coordinates

Refresh image

With 6" field scale

One time step of 0.2000 hours

- Back
- Non
- Forward

Marked satellite:
J1 Io

Center of the field:
α = 9ʰ 39ᵐ 54.470ˢ
δ = 14° 47' 54.44"

N
E + W
S

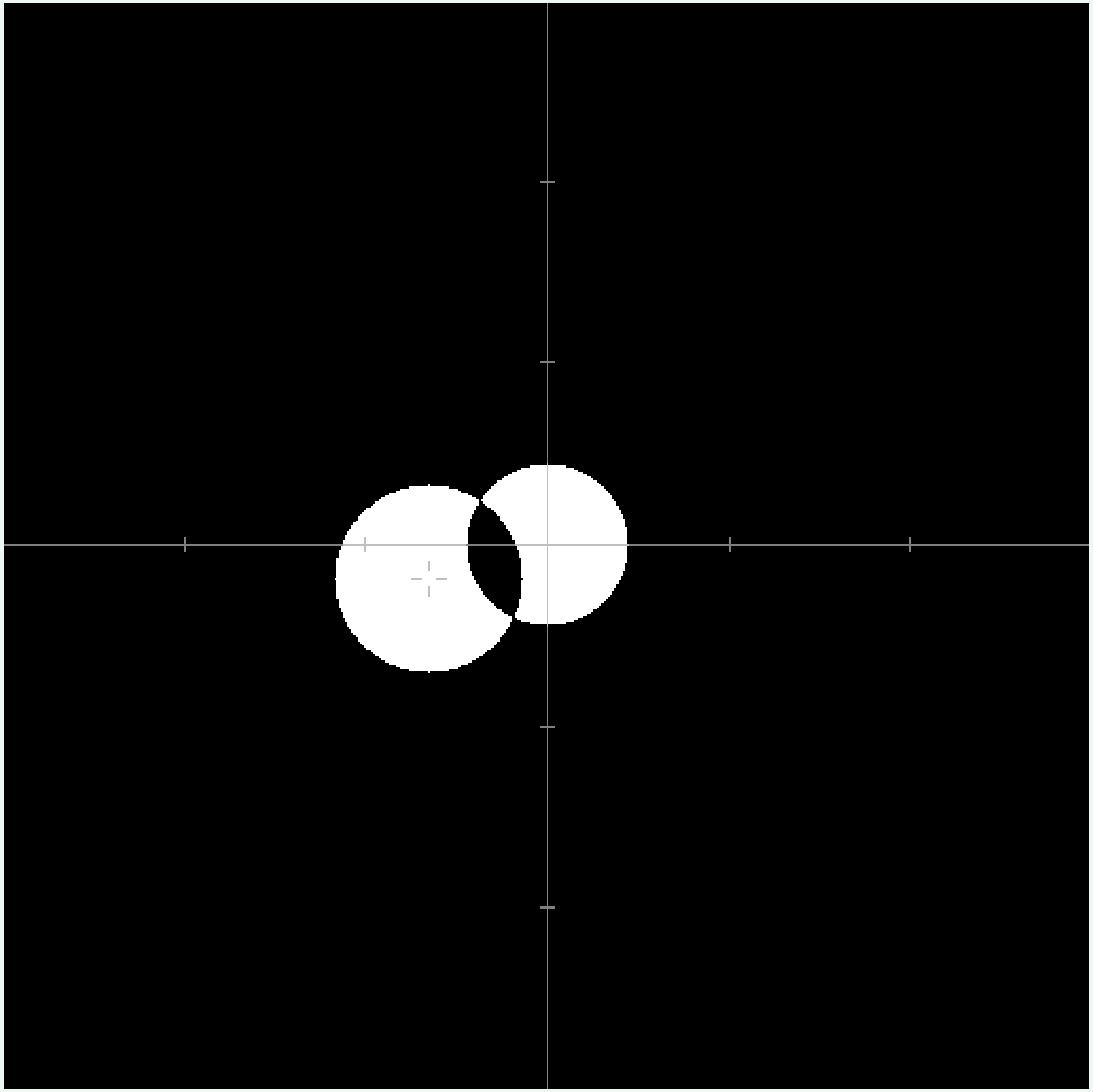
Coordinates and magnitudes

Historique Marque-pages Outils ?

IMCCE-SAI: Natural Satelli... | IMCCE-SAI: Natural Satelli... | IMCCE-SAI: Natural Satelli... | Elections municipales et co... | Club Eclipse - WETO 2014 | resta

e.fr/cgi-bin/saimirror/nss-eph3.cgi

amalthée observation CC



Present field : **6" x 6"**
Time moment: **2014 12 13 2 12 0.00 (UTC)**
Observatory: **Geocenter**

IMCCE/SAI. Natural Satellites Ephemeride Server. MULTI-SAT.

Satellites of Jupiter

Reference body:
J2 Europe
Marked satellite:
J1 Io
Epoch of equator and equinox J2000
Differential coordinates

Refresh image

With 6" field scale

One time step of 0.2000 hours

- Back
- Non
- Forward

Marked satellite:
J1 Io

Center of the field:
α = 9^h 39^m 54.291^s
δ = 14° $47'$ $55.58''$

N
E + W
S

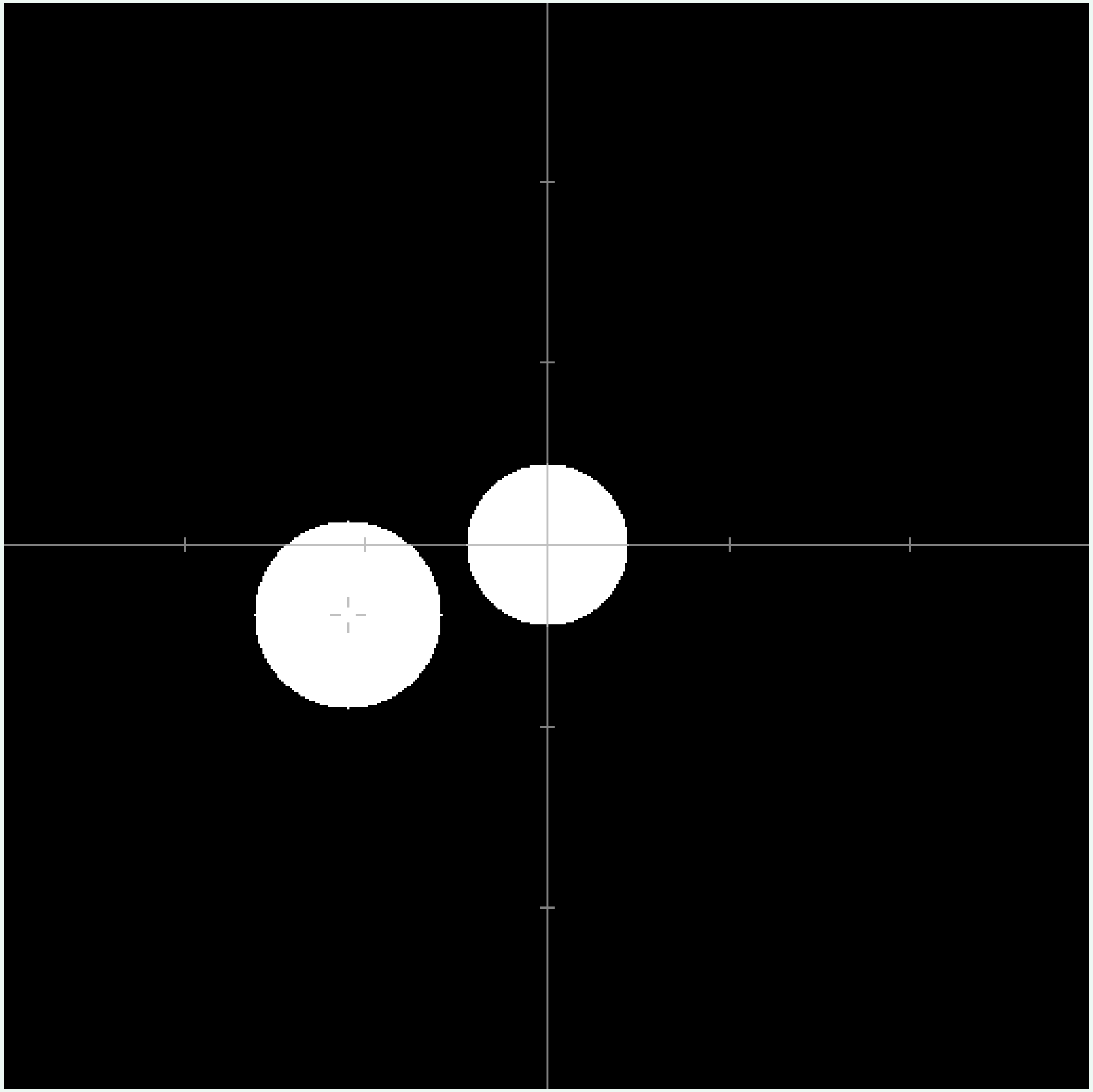
Coordinates and magnitudes

Historique Marque-pages Outils ?

IMCCE-SAI: Natural Satelli... | IMCCE-SAI: Natural Satelli... | IMCCE-SAI: Natural Satelli... | Elections municipales et co... | Club Eclipse - WETO 2014 | resta

e.fr/cgi-bin/saimirror/nss-eph3.cgi

amalthée observation CC



Present field : **6" x 6"**
Time moment: **2014 12 13 2 24 0.00 (UTC)**
Observatory: **Geocenter**

IMCCE/SAI. Natural Satellites Ephemeride Server. MULTI-SAT.

Satellites of Jupiter

Reference body:
J2 Europe
Marked satellite:
J1 Io
Epoch of equator and equinox J2000
Differential coordinates

Refresh image

With 6" field scale

One time step of 0.2000 hours

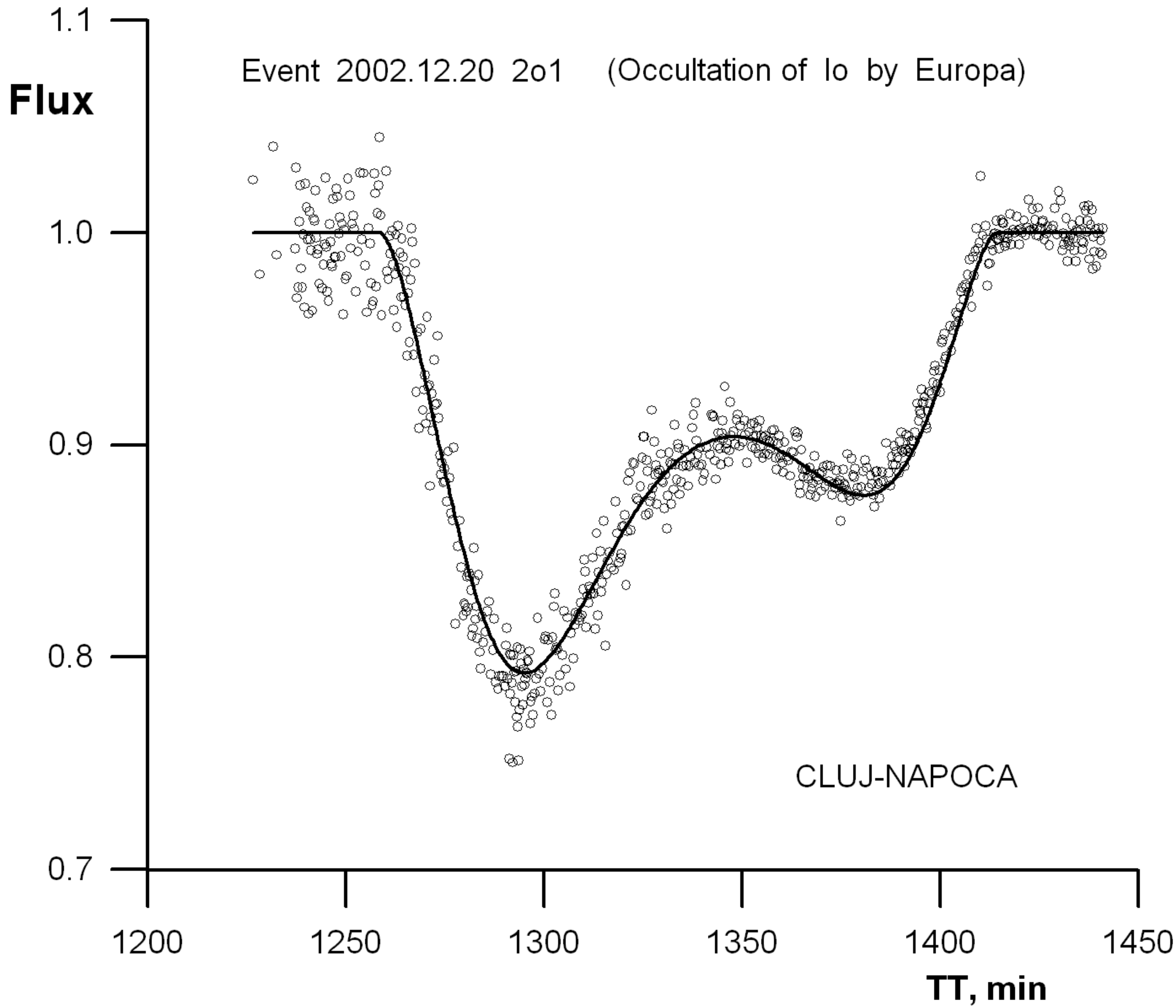
- Back
- Non
- Forward

Marked satellite:
J1 Io

Center of the field:
$\alpha = 9^h\ 39^m\ 54.112^s$
$\delta = 14^\circ\ 47'\ 56.72''$

N
E + W
S

Coordinates and magnitudes


Event 2002.12.20 2o1 (Occultation of Io by Europa)
Flux
1.1
1.0
0.9
0.8
0.7
1200
1250
1300
1350
1400
1450
TT, min
CLUJ-NAPOCA

Natural Satellites Service.

Automatic input of the photometric observations of the mutual occultations and eclipses
of the galilean satellites of Jupiter in 2014-2015.

To start entering your data, send email to Dr. Arlot
arlot@imcce.fr
to obtain an unique operator ID.

To see your previously entered observation input operator ID [ ]
and code of one observation [ ] you want to see
Then press [Show]

To delete your previously entered observation from data base input operator ID [ ]
and code of one observation [ ] you want to delete.
Then press [Delete]

To input your results of observation of **one mutual phenomenon**
enter or choose the following information and press **Submit**.
You will **receive** on a separate page and by e-mail unique identification code of this **one observation.**
Remember this identification code for subsequent operations.

Input operator ID [ ]

Event identification

- Event midtime date:
  year [2009] month [01] day [01] hour [00]
- Event: [J1 - Io] [occults] [J1 - Io]
- Type of the photometric measurement:
  (•) **occultation** ( ) **eclipsed satellite only** ( ) **eclipsed and eclipsing together**

La page de téléchargement de vos observations following➔

Site identification

- Name or identifier of the **site of observation:** conventional_site_name
- Check this box ☐ to use previously entered parameters and description of the site with the given conventional site name.

  Otherwise input new parameters and description of the site.
  Note that previously entered parameters and description of the site will be replaced by new ones.

- **Parameters and description of the site of observation.**
  Disregard this section if you are using previously entered site parameters
  Observatory IAU code: XXX (put XXX if not available)
  Site geographic coordinates:
  Longitude = W 000 deg 0 min 0 sec
  Latitude = N 00 deg 0 min 0 sec
  Elevation 0 m Type of the telescope: reflector Designation: not obligatorily
  Diameter 100 cm Focal length: 1000 cm
  Description: not obligatorily

Observation condidtions

- Filter: V or check ☐ if no filter.
- Used receptor: CCD Designation: receptor type
  Receptor description: not obligatorily
- Observation conditions: not obligatorily

Observers identification

- **Enter observers names and affiliations.**
  For each observer input: surname, first name, affiliation (observers separator = ';').
- E-mail address for contacts: @
  Name of responsible person: responsible

Results of one observation (of one event)

- Choose format of the date JD with decimals
- Choose type of the photometric value
  relative flux (given with an arbitrary unknown multiplier)

In each line enter your observations (One date with photometric value per line. Max. 2000 lines)

Submit

Observation sheet to be sent with your file of data ➔

```
REPORT  OF  ONE OBSERVATION
(to be sent with the data after each observation to:
IMCCE, PHEMU09, 77 ave. Denfert-Rochereau, F-75014 PARIS, France)
or at   phemu09@imcce.fr

OBSERVED EVENT :

DATE and HOUR:

Beginning and duration of the observation:

NAMES OF THE OBSERVERS:

INSTITUTION:
ADDRESS:

LOCATION OF THE OBSERVATION:
ADDRESS:

Geographic coordinates: (longitude: h m s; latitude: � ' "; elevation= m).
IAU code:

METEOROLOGICAL CONDITIONS (fog, haze, light clouds?):

Quality of the sky (stable, transparent, photometric?):

Seeing:

Elevation of Jupiter above the horizon at the time of the observation:

Twilight? Moon?

USED TELESCOPE:
Refractor or reflector?

Aperture:

Focal length:

USED RECEPTOR:
CCD ?

Are the images put slightly out of focus?

Size of the field of the CCD:

FILTER used (if any):

SENT DATA:
file of light flux, magnitude drop or images?

TIME SCALE for dating each point
or each image:

relation to UTC:
```

Let's remind the errors to be avoided

- - to mix satellites (confusing North/South or East/West...);
- - to start observing to late and to have not enough time for the calibrations;
- - to miss observations thinking that Jupiter is too low on the horizon: observations are possible at 10 degrees above the horizon, even less…;
- - to choose a wrong diaphragm (when chosen by hardware) and to need to change it during the event or a wrong field in case of use of CCD;;
- - to suppose that the motion of the satellites is linear and uniform;
- - to think that we know everything on the Galilean satellites (the magnitude may change from one point to another on the orbits;
- - to have a wrong time scale and to be not sure of the clock (be sure to have the UTC available);
- In brief, prepare carefully the observation and follow minute after minute a procedure written in advance with a precise timing

Summary of the most important points to be examined before the observation

1 - be sure to have a time scale in UTC accurate to 0.1 second of time ;

2 - verify that Jupiter and the satellites will be visible during all the observation ;

3 - verify that each point of the lightcurve is correctly referred to the time scale with an accuracy better than 0.1 second ;

4 - think to use the right filter : 5000-5300 A, in an urban polluted site, R or I filter during twilight or near the Moon, but, if possible use a filter designed for the receptor that you use ;

5 - if you are not familiar with the material that you use, take a little more time before the observations to know it

6 - be sure of the identification of the satellites (beware the optical mounting which reverse the field) ;

7 - determine precisely the field to be recorded (CCD) or the size of the diaphragm (photometer) and what satellites should be in the diaphragm during all the time of the observation (especially for long events) ;

8 - know precisely the motions of the satellites during the events and take into account the refraction when observing low on the horizon ;

9 - take into account the presence of the Moon or of Jupiter to prepare the observation ;

10 - make individual photometric measurements of the satellites before and after the observation;

11 - measure the sky background in different areas several times during the observation ;

12 - measure the atmospheric absorption thanks to a reference object ;

13 - be careful for the observations during twilight for which a special procedure is necessary.

14 – try to observe an eclipse by the planet Jupiter before starting the observation of the mutual events to be familiar to the material and the procedure which may be improved.

Conclusions

1. The astrometric accuracy from mutual events is better of the one from direct CCD imaging.

2. The accuracy of the astrometric results is limited by the quality of the photometry and not by the method of reduction.

3. It is necessary to follow a strict protocol of observation to avoid all problems and to get a usefum observation.