IYA - HOU-SalsaJ

L'Allée des étoiles, **Alley of the stars**

tutorial with Hands-On-Universe group (www.eu-hou.net)

Lying on the vacoas cloth, wrapped with Ouma up in (a military) blanket, I look up at the stars…,I speak out their names, as I used to do with my dad, walking down (our garden Alley, that we called) Alley of the stars: Arcturus, Denebola, Bellatrix, Bételgeuse, Acomar, Antarès, Shaula, Altaïr, Andromède, Fomalhaut.

J-M.G. Le Clézio, 1985, in *The gold digger* . Literature Nobel Prize 2008.

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SalsaJ european free software on www.eu-hou.net

HOU =

Hands-On-Universe

www.handsonuniverse.org

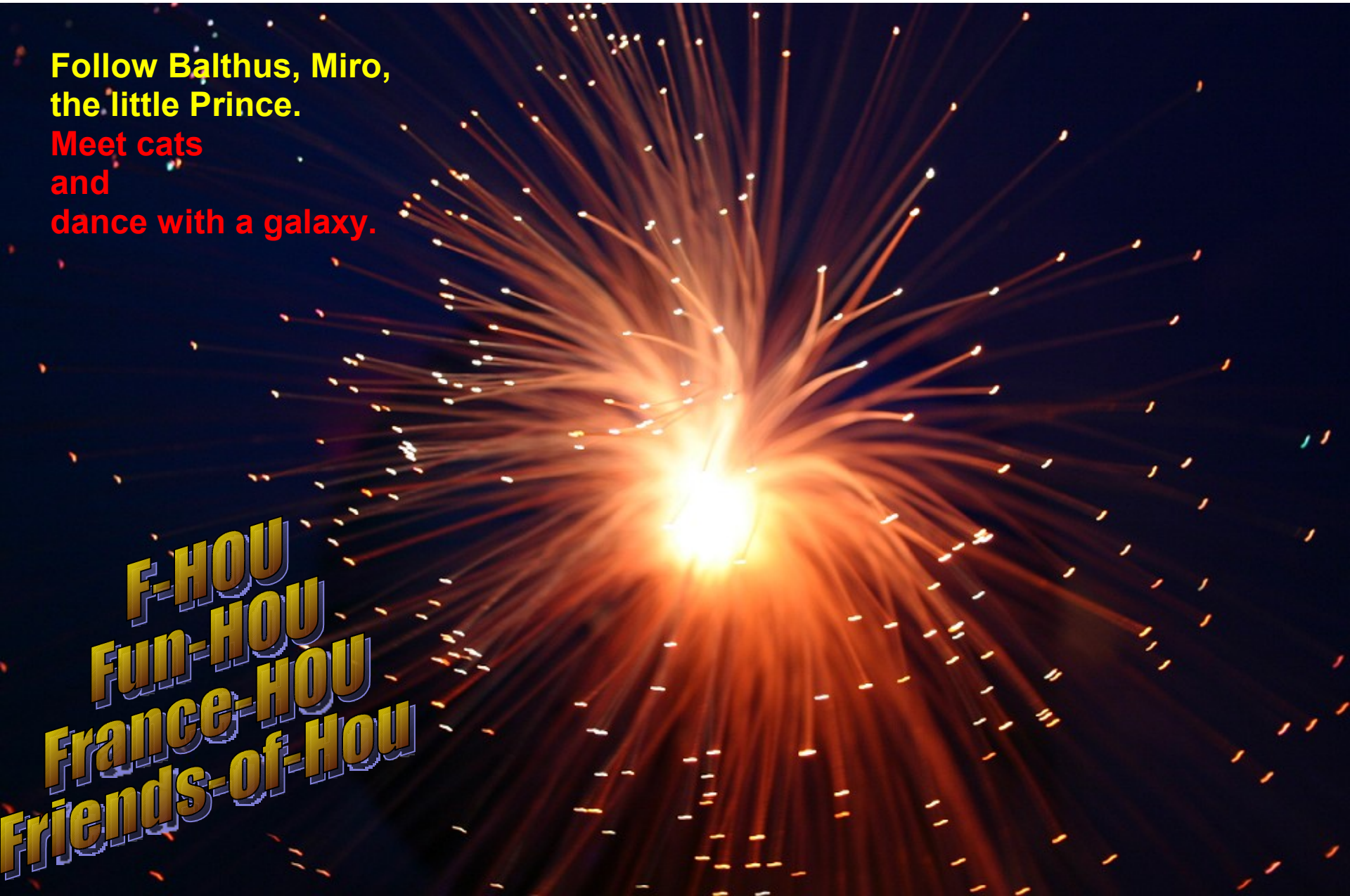
F-HOU,

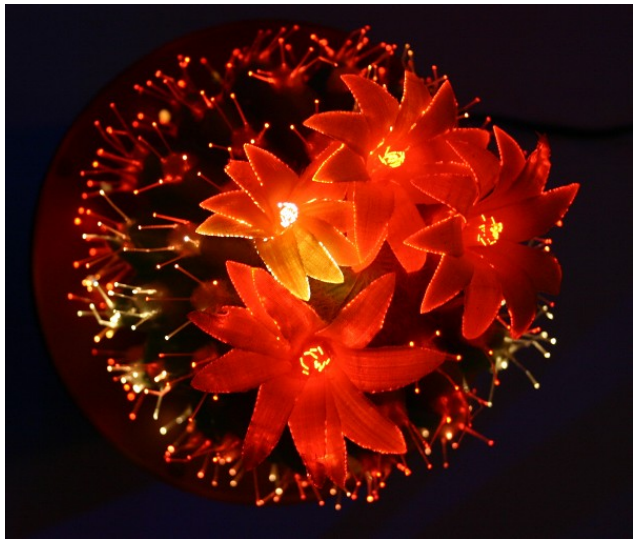
France Hands-On-Universe
www.eu-hou.net

EU-HOU,

Europe Hands-On-Universe
www.eu-hou.net

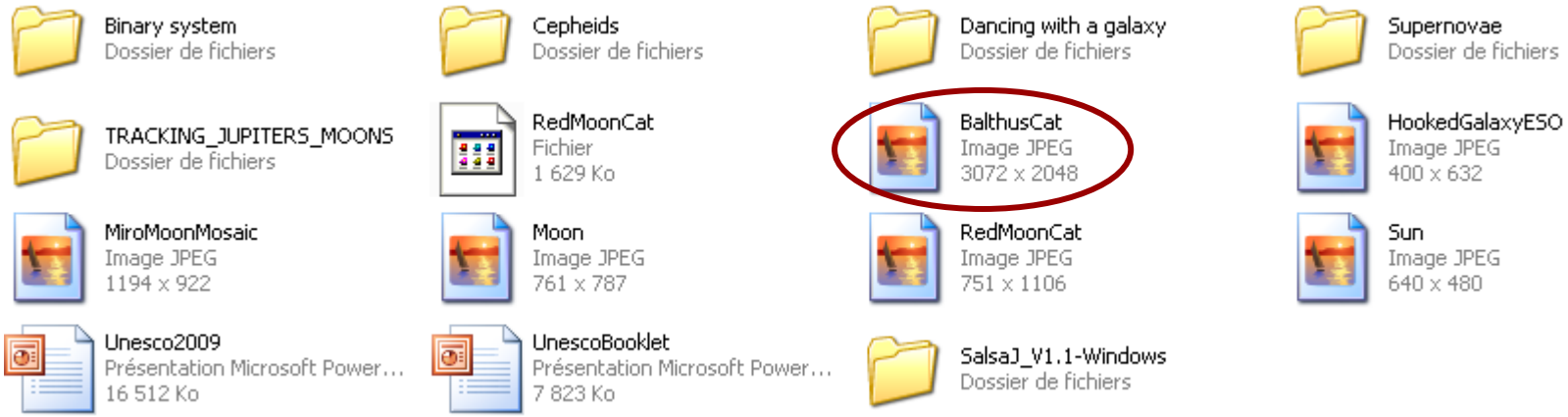
Happy Hands-On-Universe





Happy Hands-On-Universe

What you find on the CD:



All the texts are in English, except the french text inside cepheids file

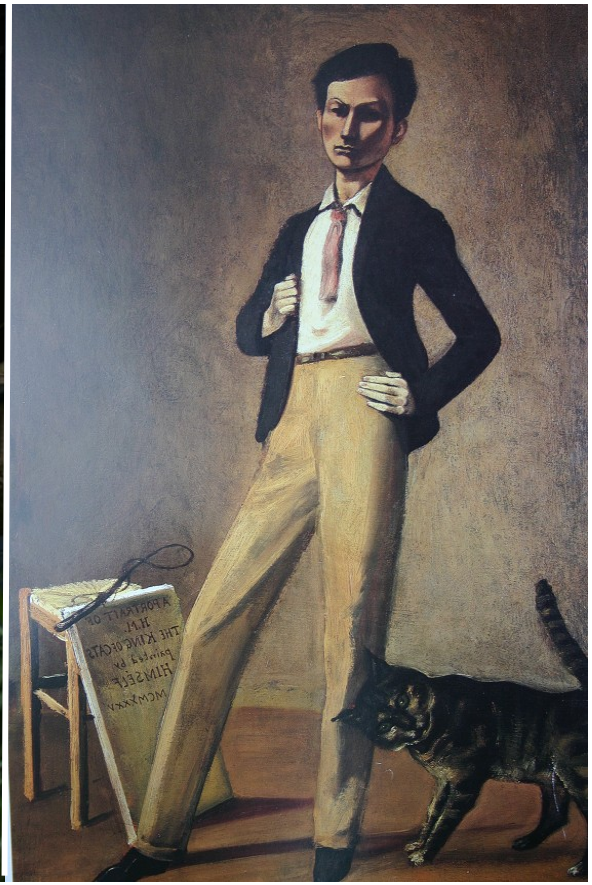
Open (or set up) SalsaJ, then Balthus'Cat

First step : Paris, Balthus, cats and SalsaJ (free software on www.eu-hou.net)

In the garden of
Champs-Elysées

painted by Balthus

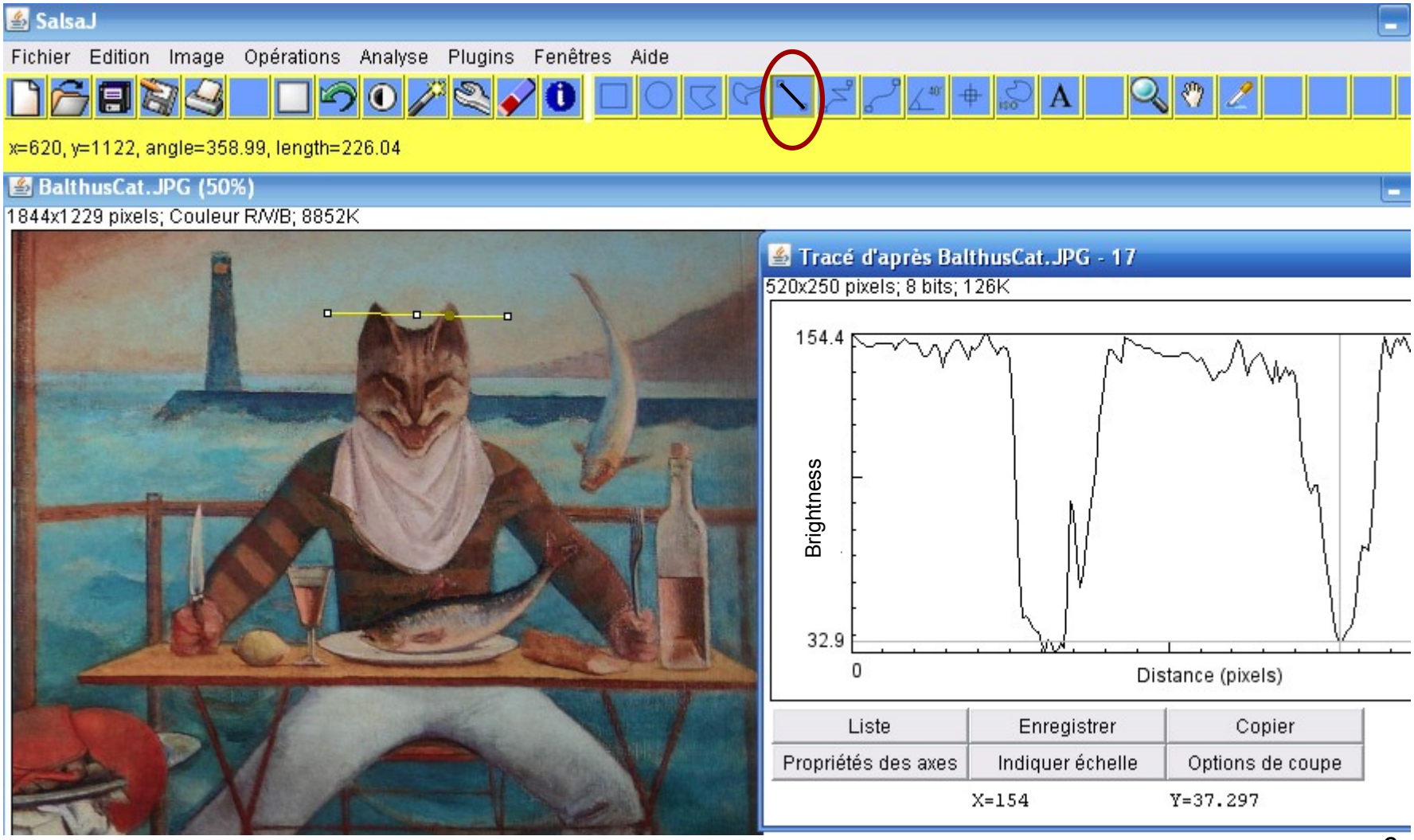
Odeon Theater and
french restaurant
Mediterranean Sea



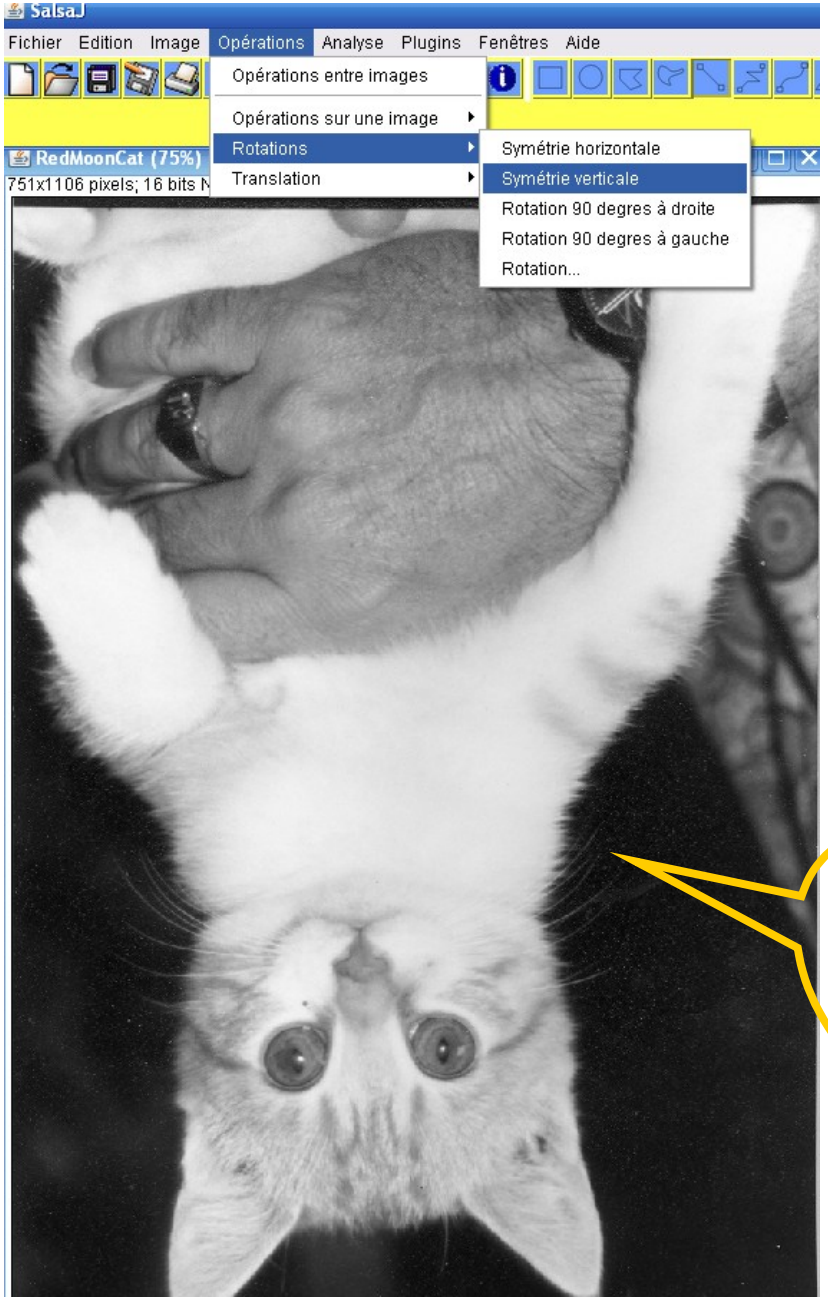
Balthus, french painter,
the King of cats

self-portrait

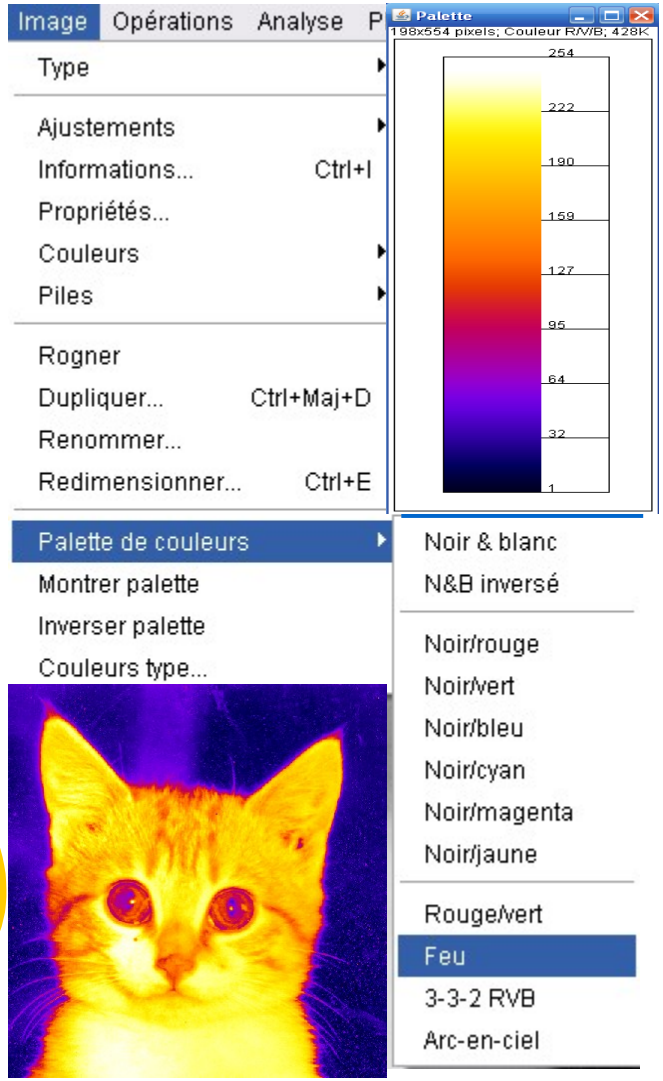
File/Open image /Balthus'Cat *(sign of Odeon restaurant)*	Draw a line through the ears of the cat	Go to Analyse/ Plot Profile



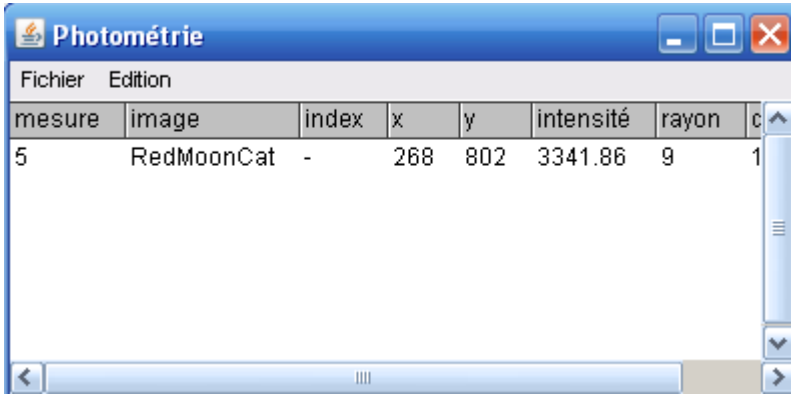
Play with the image of Red Moon Cat

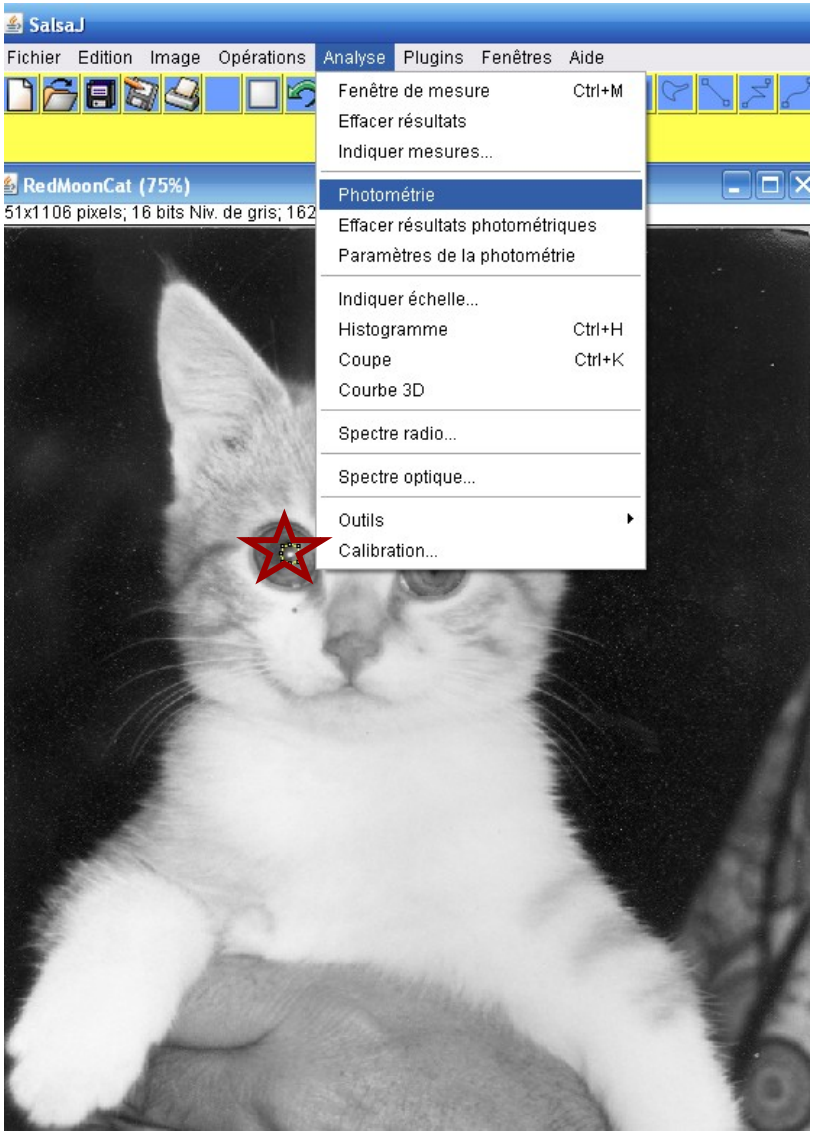


Hey, downhead, like a star in telescopes

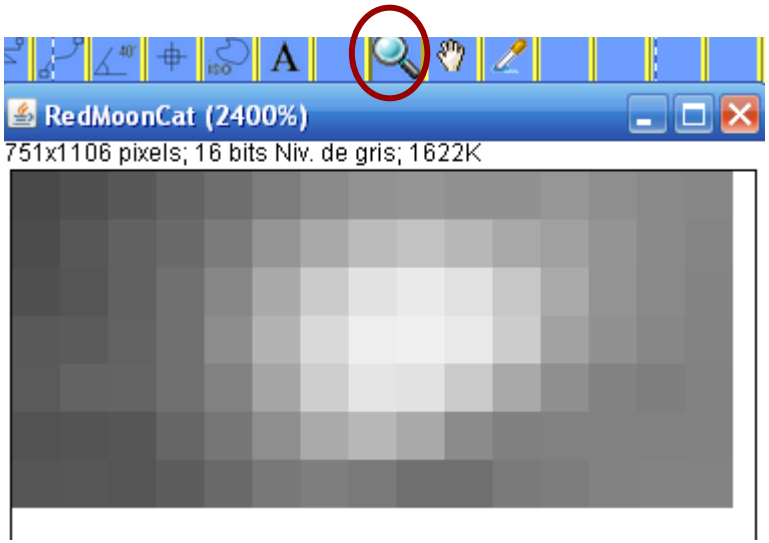


File/Open image /RedMoonCat.fts	Photometry needs a grey levels image.fts	Go to Analyse/Photometry



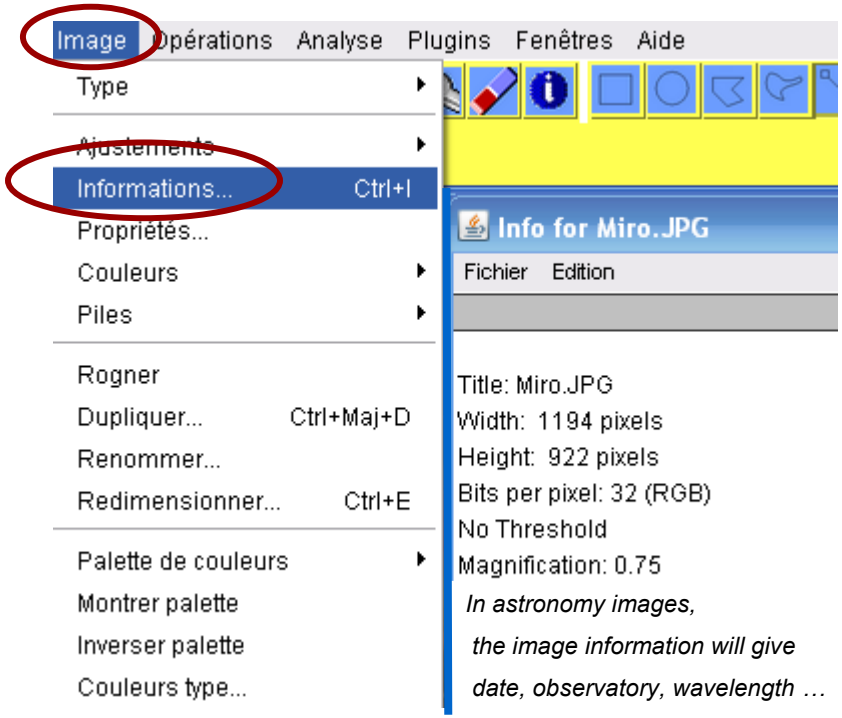


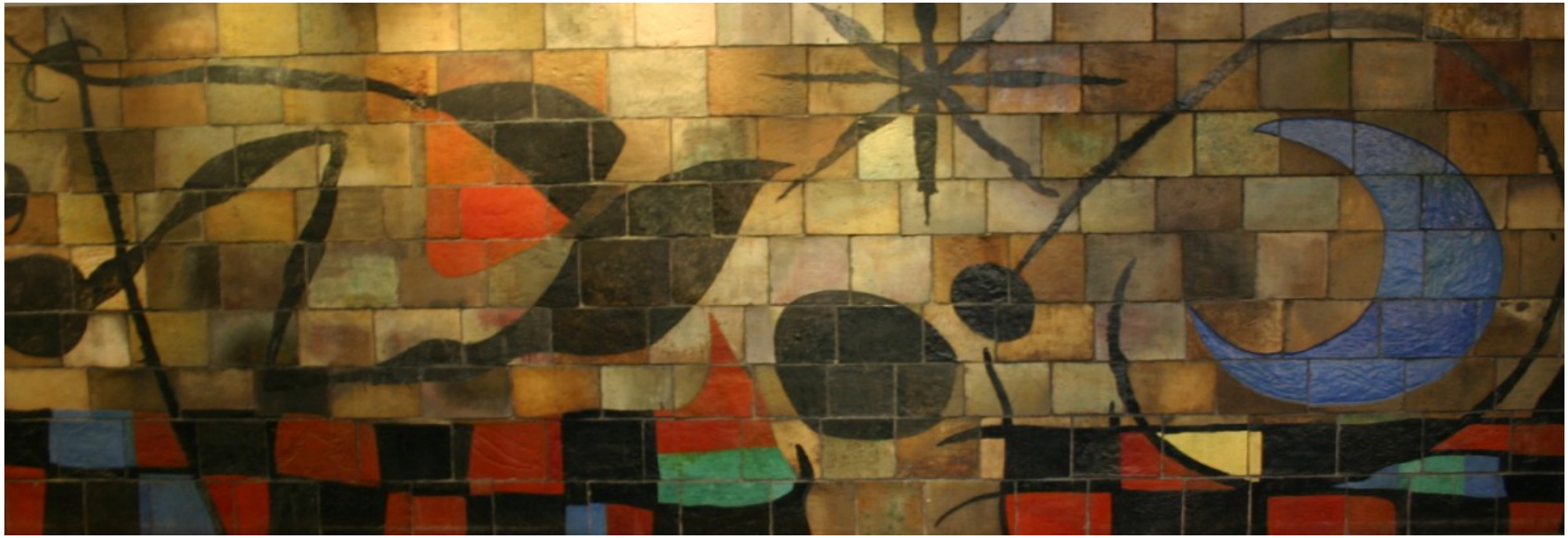
Use SalsaJ magnifying glass to see pixels:



Second step: Paris, Unesco;

see Miro's sun and moon mosaics





To compare stars and planets – SalsaJ Plot Profile

Our moon

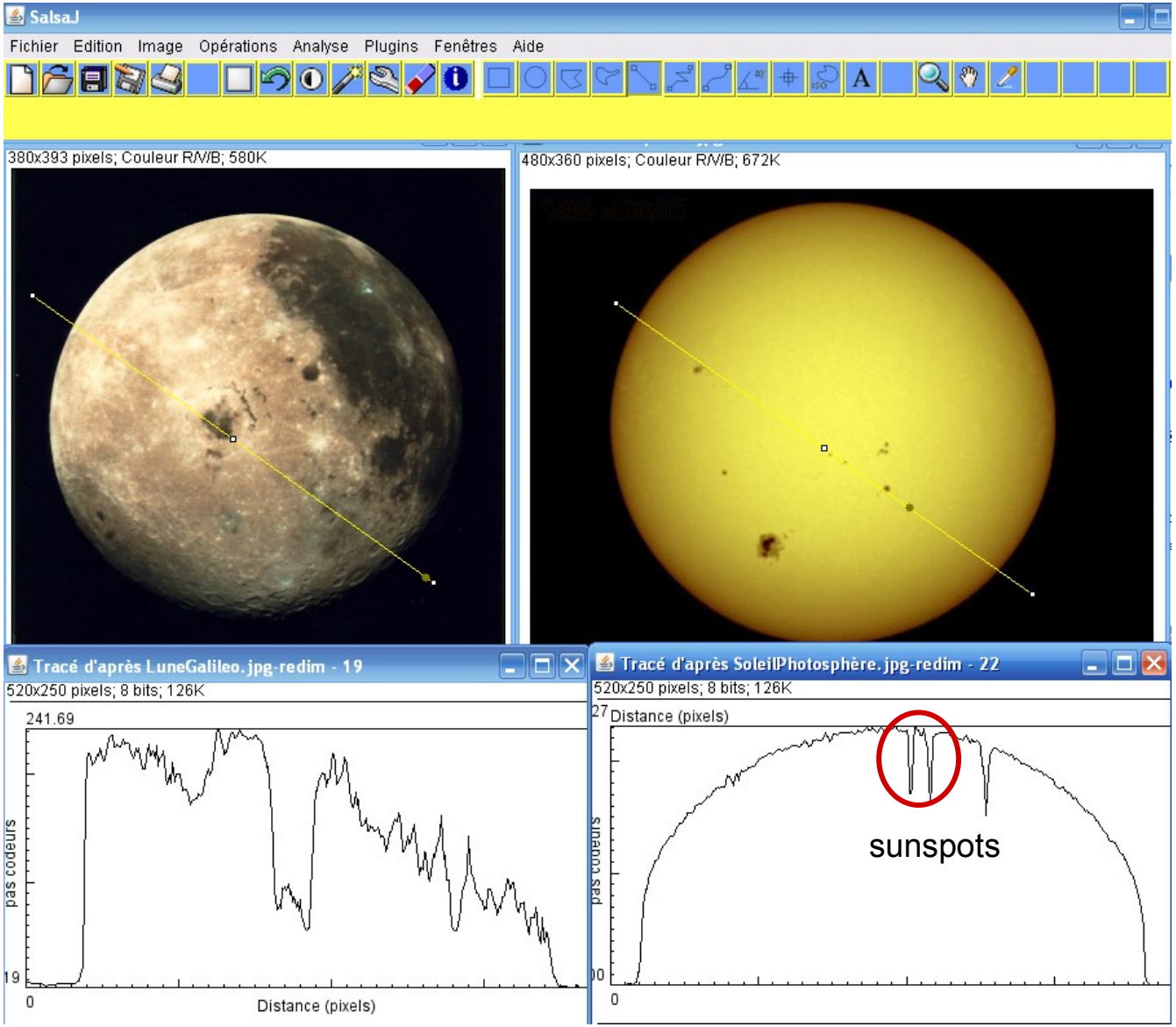
No atmosphere

Mounts and valleys

Our Sun:

Gaz(plasma) atmosphere

Sunspots

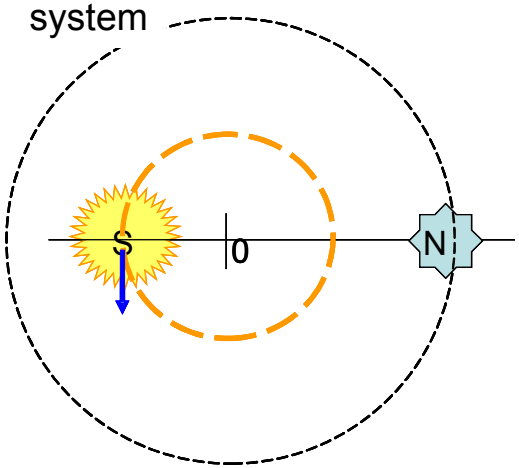


3rd step: In 2009, the Little Prince comes from an exoplanet

1943, Saint-Exupéry, french writer and aviator wrote:

I have serious reason to believe that the planet from which the little prince came is the ***asteroid B 612.***

Binary system



S= Star

N = Non identified companion

O= barycentre

2009 : Does the little prince lives on an exoplanet?

Seven steps for a dwarf star : from Doppler to exoplanets

Education and Culture

Socrates
Minerva

Seven steps for a dwarf star

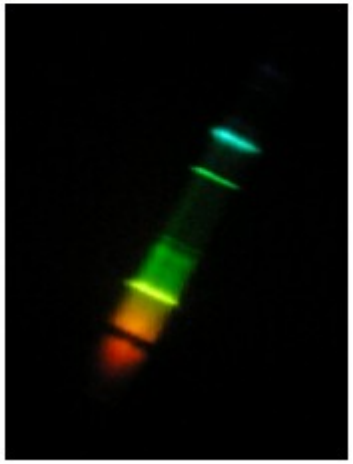
From Doppler to exoplanets

Exercice proposed by :
Roger FERLET, Institut d'Astrophysique de Paris, France
Michel FAYE, lycée Louis Le Grand , Paris , France
Suzanne FAYE, Lycée Chaptal , Paris , France

Summary :

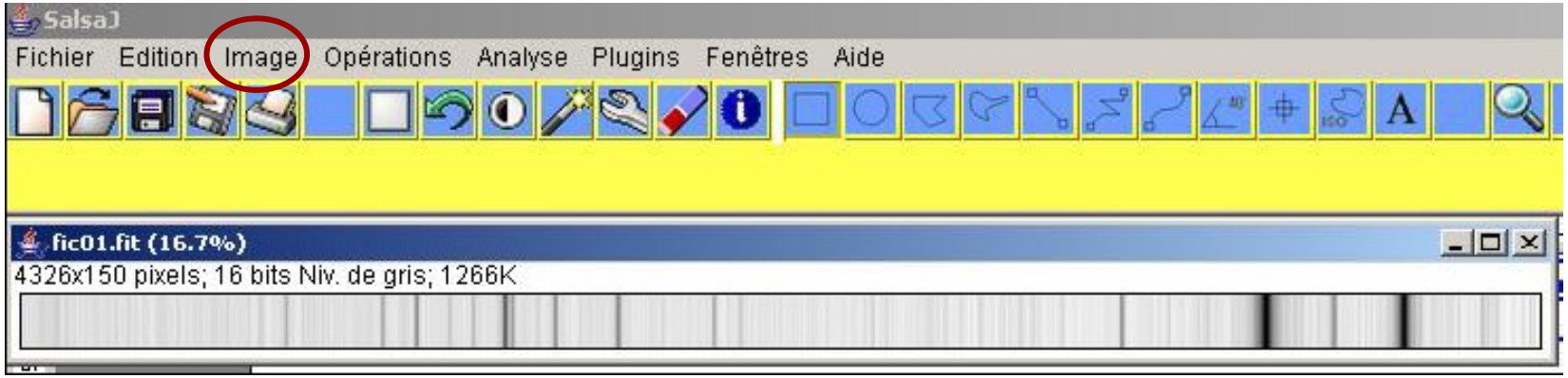
- SPECTROSCOPY
- ANIMATED MOTION OF SPECTRUM LINES
- MEASURE WAVELENGTH λ AND FLUX, OPTICAL SPECTRUM
- CALCULATING RADIAL VELOCITY OF THE STAR WITH DOPPLER SHIFT
- RADIAL VELOCITY OF THE STAR , AS A FUNCTION OF DATE
- DETERMINING THE MASS OF THE COMPANION IN BINARY SYSTEM
- DISCOVERING AN EXOPLANET WITH DOPPLER SHIFT OF A STAR

Download the exercise : pdf 317.75 Kb

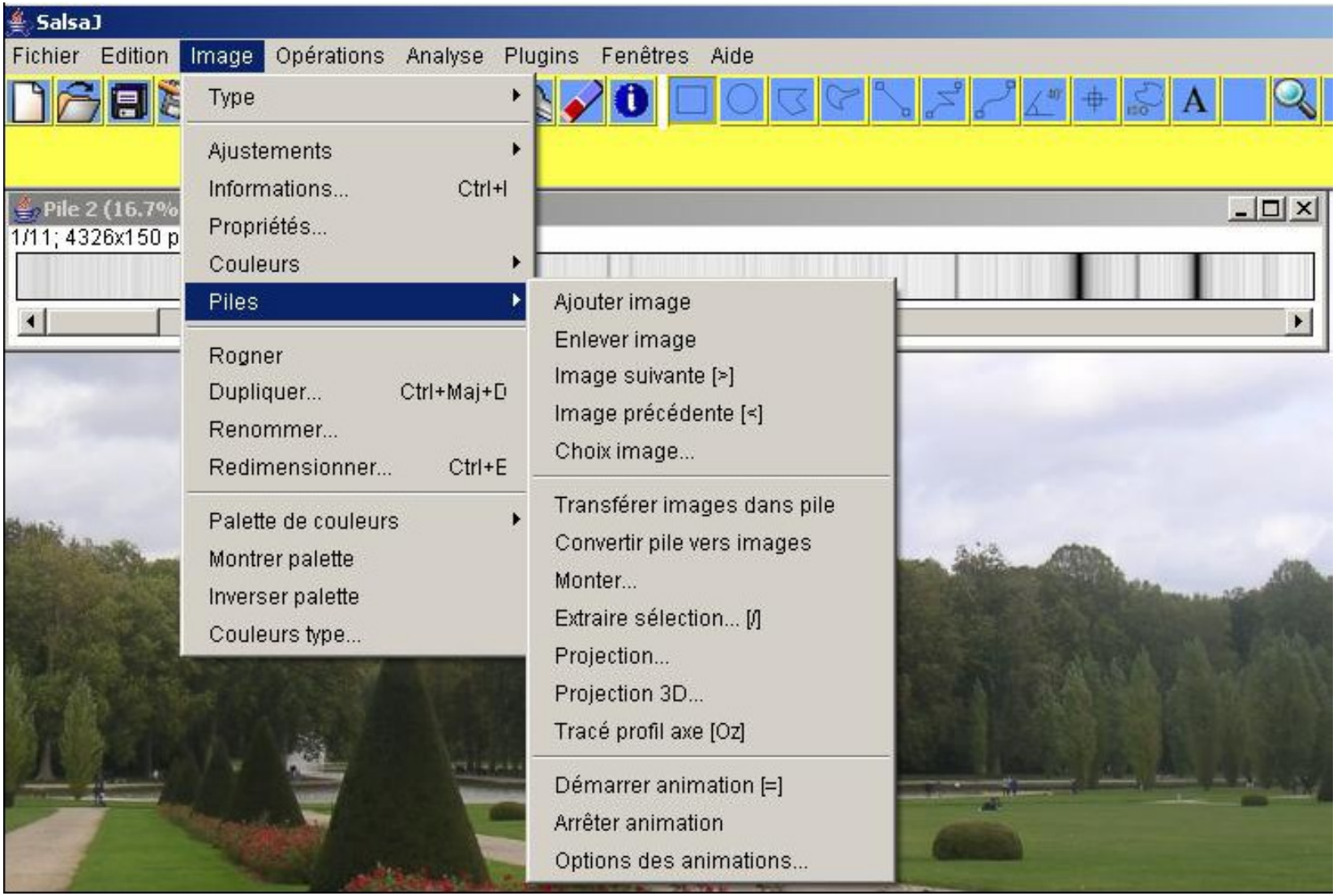


ANIMATED MOTION OF SPECTRUM LINES
USE images.fit

Note : images.fit (fit =fits = fts) are available for animation
images.dat are available for optical spectra

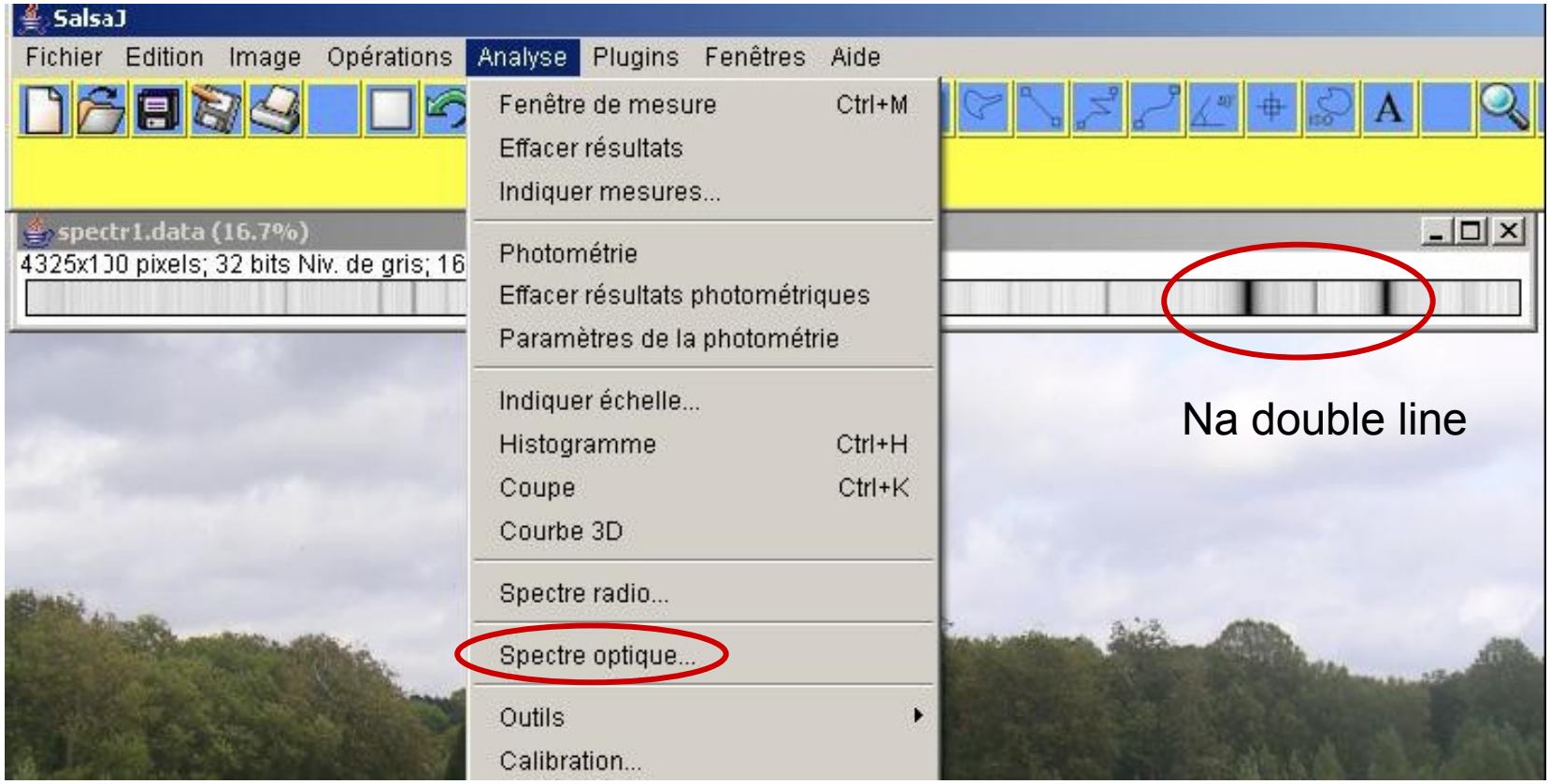


To have a global view of Doppler shift when the star moves around barycenter:
With Salsa J, **Open** (**Ouvrir)** folder (dossier) **: *binary system***
Select the 11 spectra images.fit from fic01.fit to fic11.fit : press Shift to select the 11images.fit at once.
Open (Ouvrir) these 11 images, then click on **Images** : you get a roll-down menu ; click on **Stacks (=Pile)** : you get a new menu ; click on **Transfer Images to Stacks** (=**Transférer images dans Pile)**
Click again on **Images / Stacks (=Piles) ; then Images/Start animation (=Démarrer animation)**


SalsaJ
Fichier
Edition
Image
Opérations
Analyse
Plugins
Fenêtres
Aide
Type
Ajustements
Informations... Ctrl+I
Propriétés...
Couleurs
Piles
Rogner
Dupliquer... Ctrl+Maj+D
Renommer...
Redimensionner... Ctrl+E
Palette de couleurs
Montrer palette
Inverser palette
Couleurs type...
Pile 2 (16.7%
1/11; 4326x150 p
Ajouter image
Enlever image
Image suivante [>]
Image précédente [<]
Choix image...
Transférer images dans pile
Convertir pile vers images
Monter...
Extraire sélection... [/]
Projection...
Projection 3D...
Tracé profil axe [Oz]
Démarrer animation [=]
Arrêter animation
Options des animations...

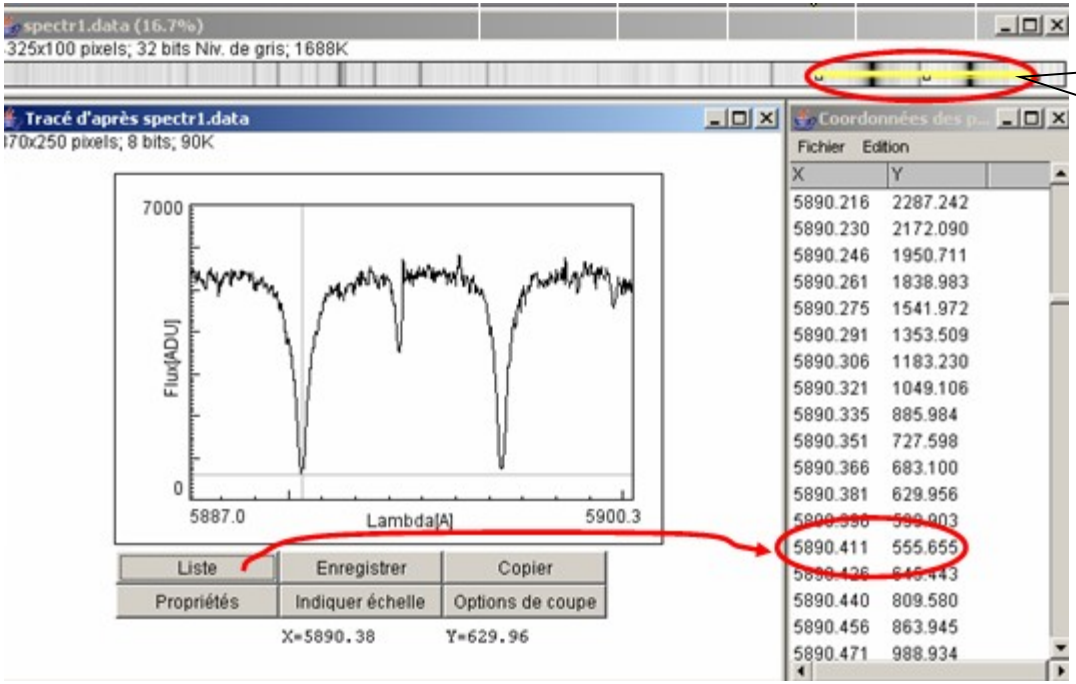
MEASURE WAVELENGTH λ AND FLUX, OPTICAL SPECTRUM
Use images.dat

Investigation of spectrum 1 : spectr 1.data
Click on **Analysis / Optical Spectrum**/ binary system / spectr1.data

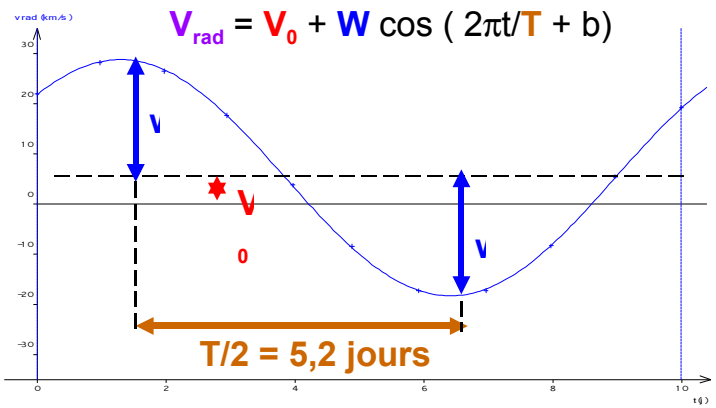


Flux according to wavelength : Φ= f(λ)

Spect1.dat image / Click on the **Straight line selection (Sélection rectiligne)** icon**,** then draw a straight line **across the Na doublet** (to have an horizontal line, press Shift during thedrawing)
Click on **Analysis / Plot Profile** (=Coupe) : you get Φ= f(λ)



On suit les raies du doublet jaune du sodium pendant plusieurs jours



4th step : SalsaJ with Galileo spectacles

Christmas 1604 : the new star was a supernova

1604 :

A young teacher discovers a new star in the sky (Galileo, october 1604)

Shakespeare begins to write « Hamlet », inspired by Tycho Brahe (the man with a golden nose)

1608: Lippershey, a spectacles vendor, introduces the first « optical pipe» as spyglasses

1582 : *The Spectacle Vendor* by Johannes Stradanus, engraved by Johannes Collaert

1609: Galileo is the first one to use it as a refractor telescope ☺

1610: Galileo publishes « The Sidereal Messenger » ::☺::::::☺

1610:

Galilean Moons

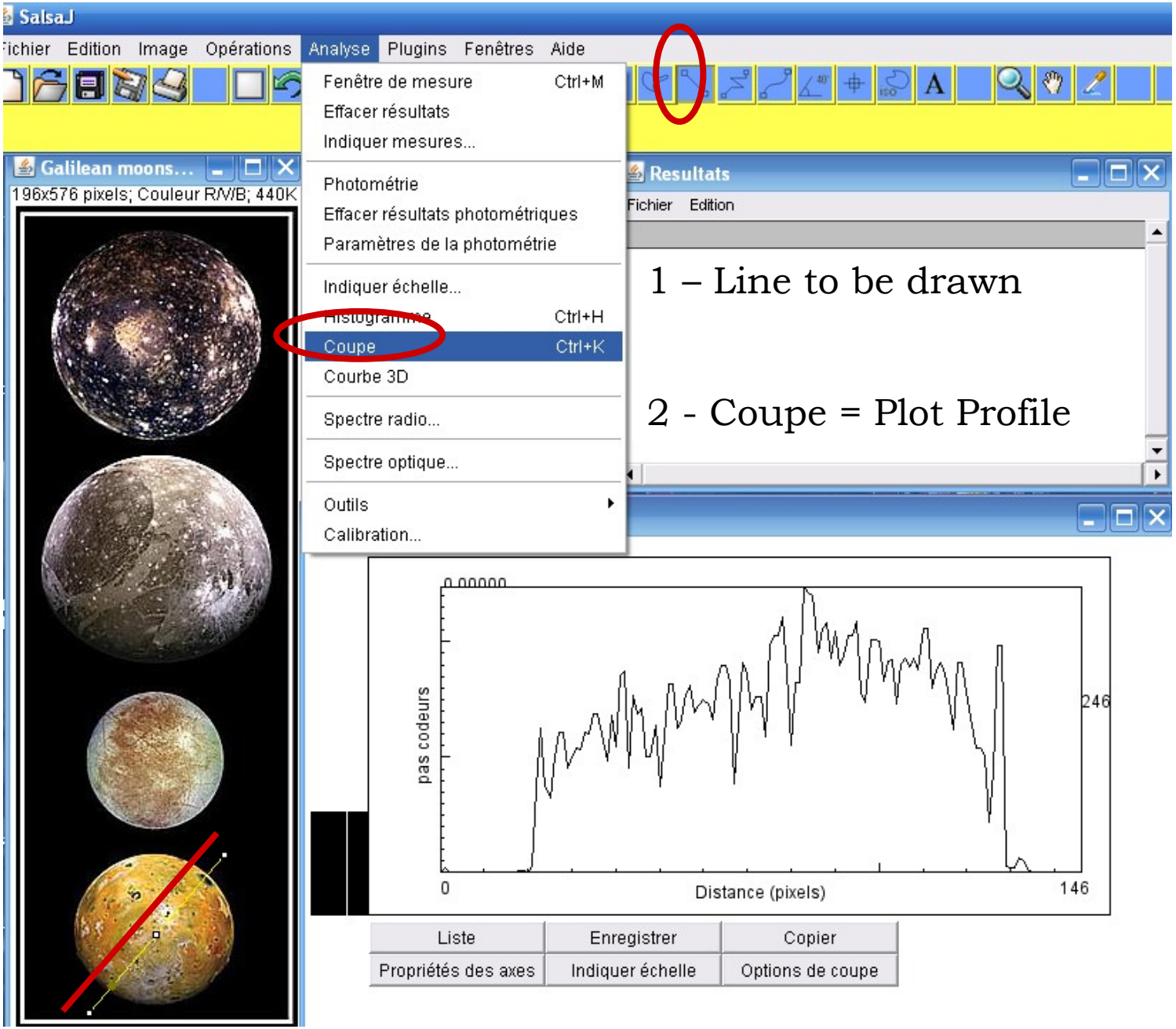
Callisto

Ganymède

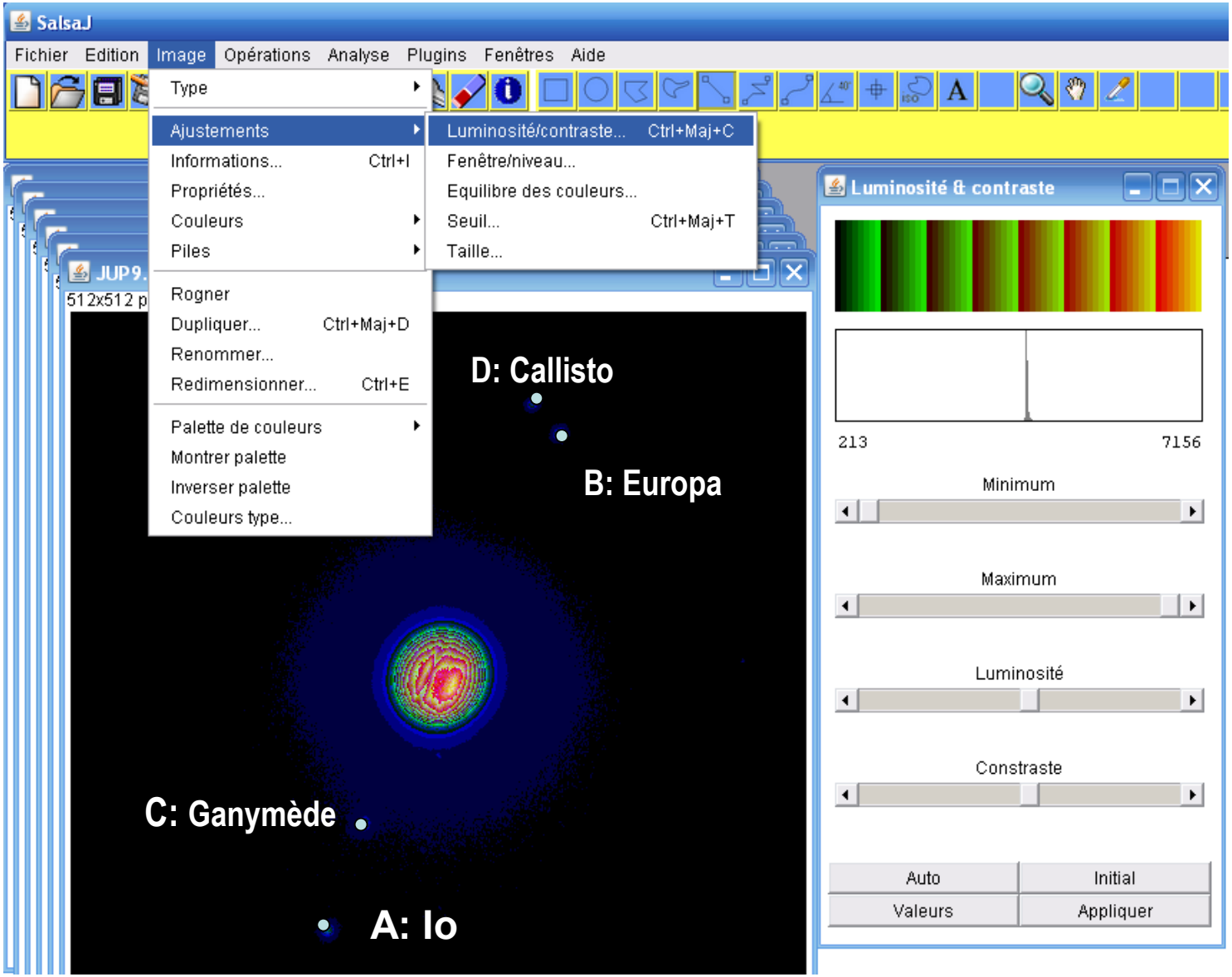
Europe

Io

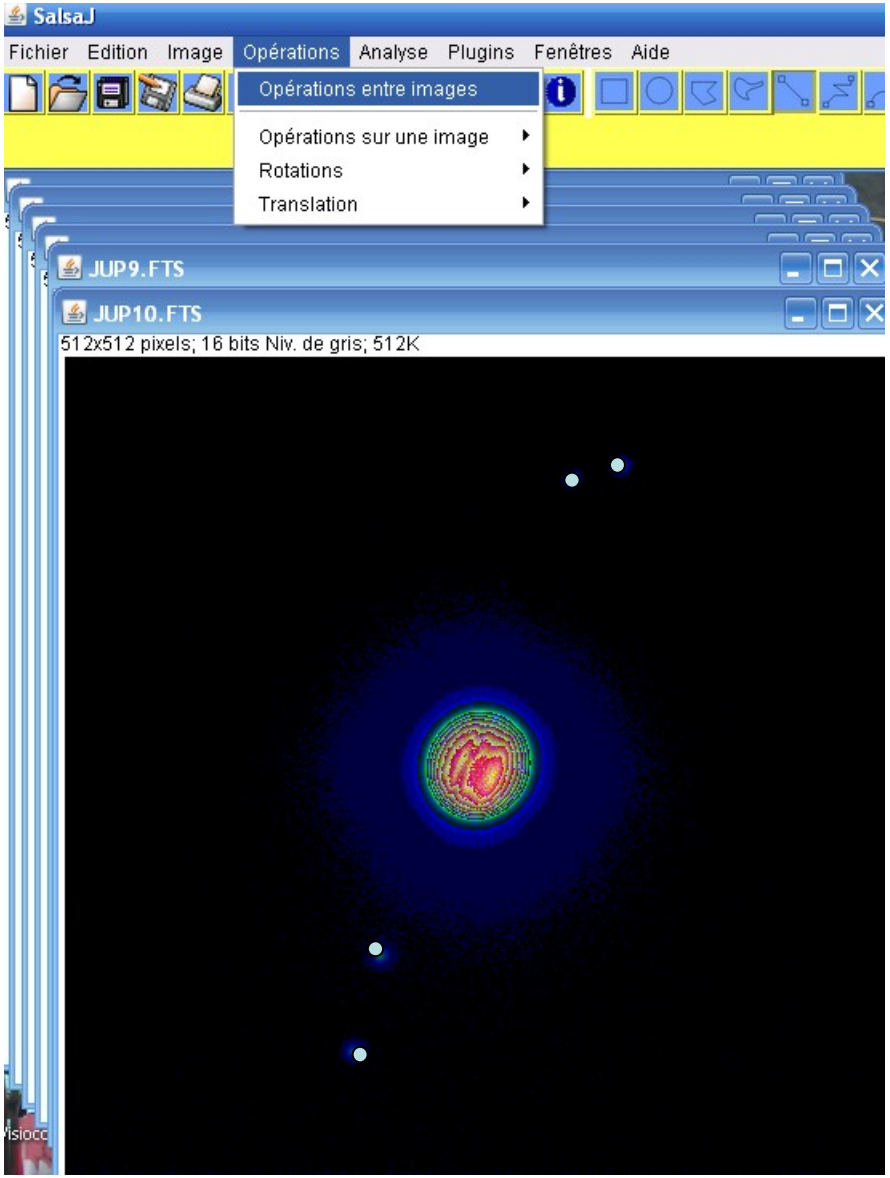
Credit NASA

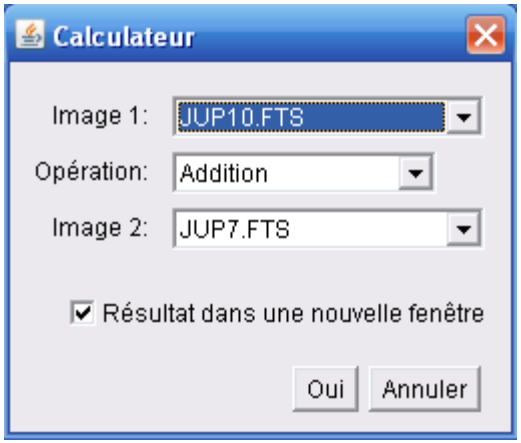


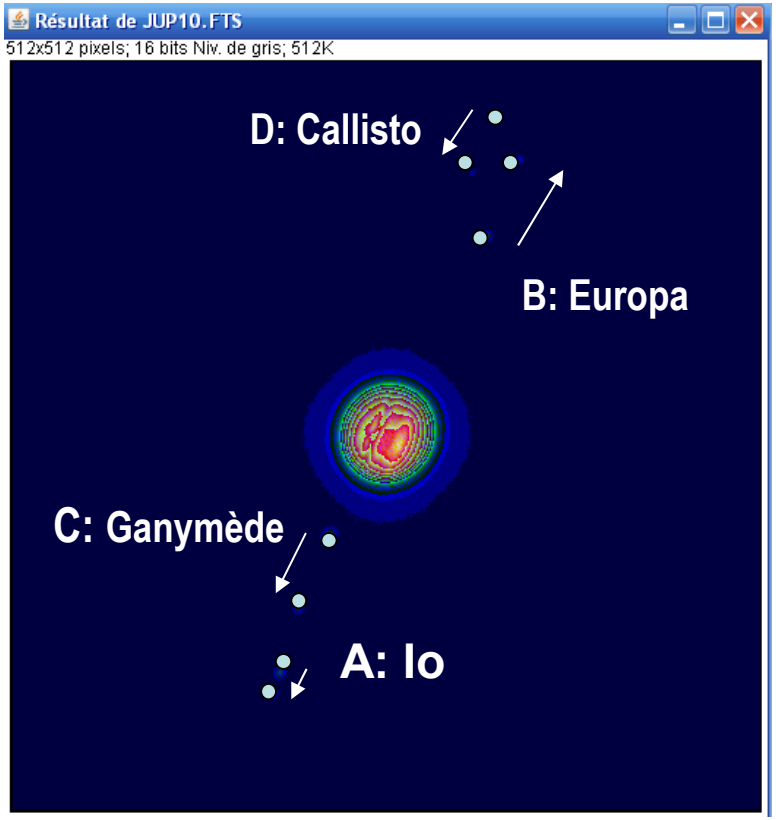
III – SalsaJ Operations: Jupiter's Galilean Moons

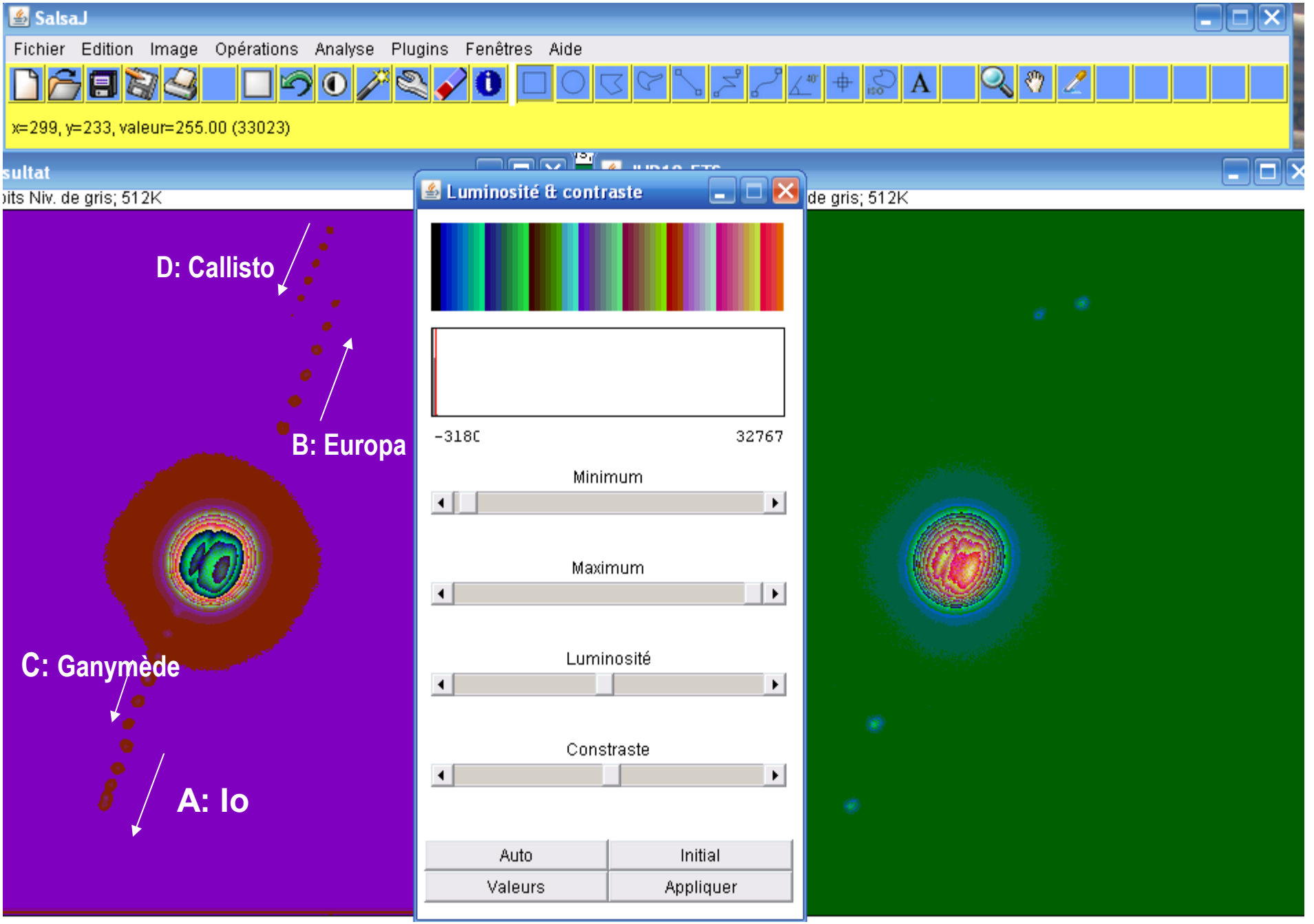


Add images (or substract ...)








SalsaJ
Fichier Edition Image Opérations Analyse Plugins Fenêtres Aide
x=299, y=233, valeur=255.00 (33023)
sultat
its Niv. de gris; 512K
D: Callisto
B: Europa
C: Ganymède
A: Io
Luminosité & contraste
-318C
32767
Minimum
Maximum
Luminosité
Constraste
Auto
Initial
Valeurs
Appliquer
de gris; 512K

With SalsaJ and Galilean Moons:

1 – You have 5 calibrated images (date 23/4/92, one hour exactly between each image, see image information)

2 – Jupiter is at center coordinates (216; 216)

3 – On picture number 10, the moon Io is at distance R from center of Jupiter

So, you can measure and calculate :

1 – Orbital period of Io : T = 1,8 day

2 – Orbital radius of Io : $R = 4{,}2 \,.\, 10^8$ m

3 – Jupiter Mass: $M_J = 4\pi^2 r^3 / G T^2 = 2.\ 10^{27}$ kg

Name	Discovery Date	Discoverer	Distance from Jupiter (10^3 km)	Orbital Period (days)	Mass (10^{20} kg)	Radius (km)
Io (A)	1610	Galileo Galilei	421.6	1.769138	893.2	1821.6
Europa (B)			670.9	3.551181	480.0	1560.8
Ganymede (C)			1070.4	7.154553	1481.9	2631.2
Callisto (D)			1882.7	16.689018	1075.9	2410.3

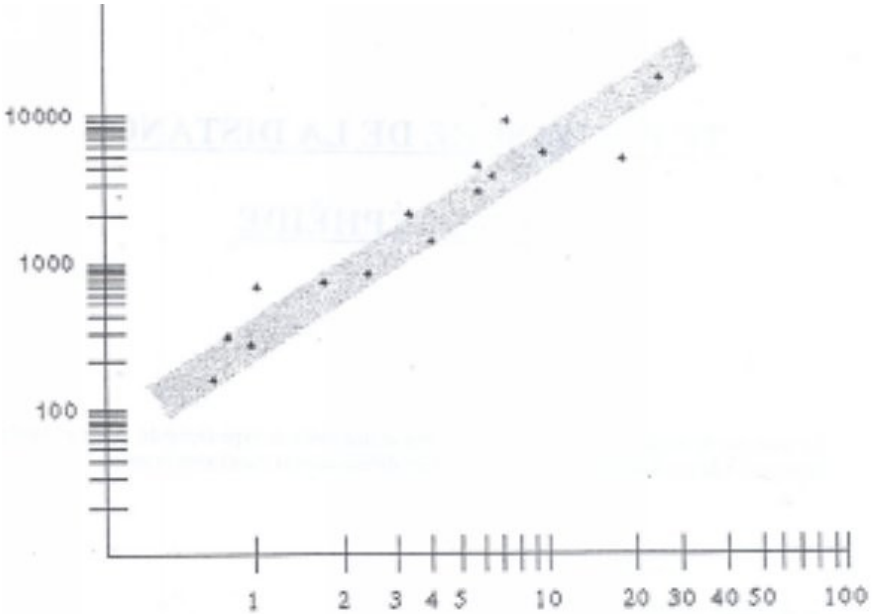
Cepheids and photometry

Analyse/ Photometry

Calculate the rate of brightness:
Variable star/steady star

Photometry of cepheids, relation *Brightness - period*

Variation périodique de l'éclat apparent de la céphéide:



Luminosité – Période: courbe établie par Henrietta Lewitt (1912)
échelle logarithmique

d=(Lmoy / 4.π. Emoy)$^{1/2}$ = [Puissance émise par l'étoile/ (4 π Puissance reçue par unité de surface, obtenue par comparaison avec étoile de référence, voir TP)]$^{1/2}$

Today deep sky: Captain Hooked, Hooked galaxy and a supernova

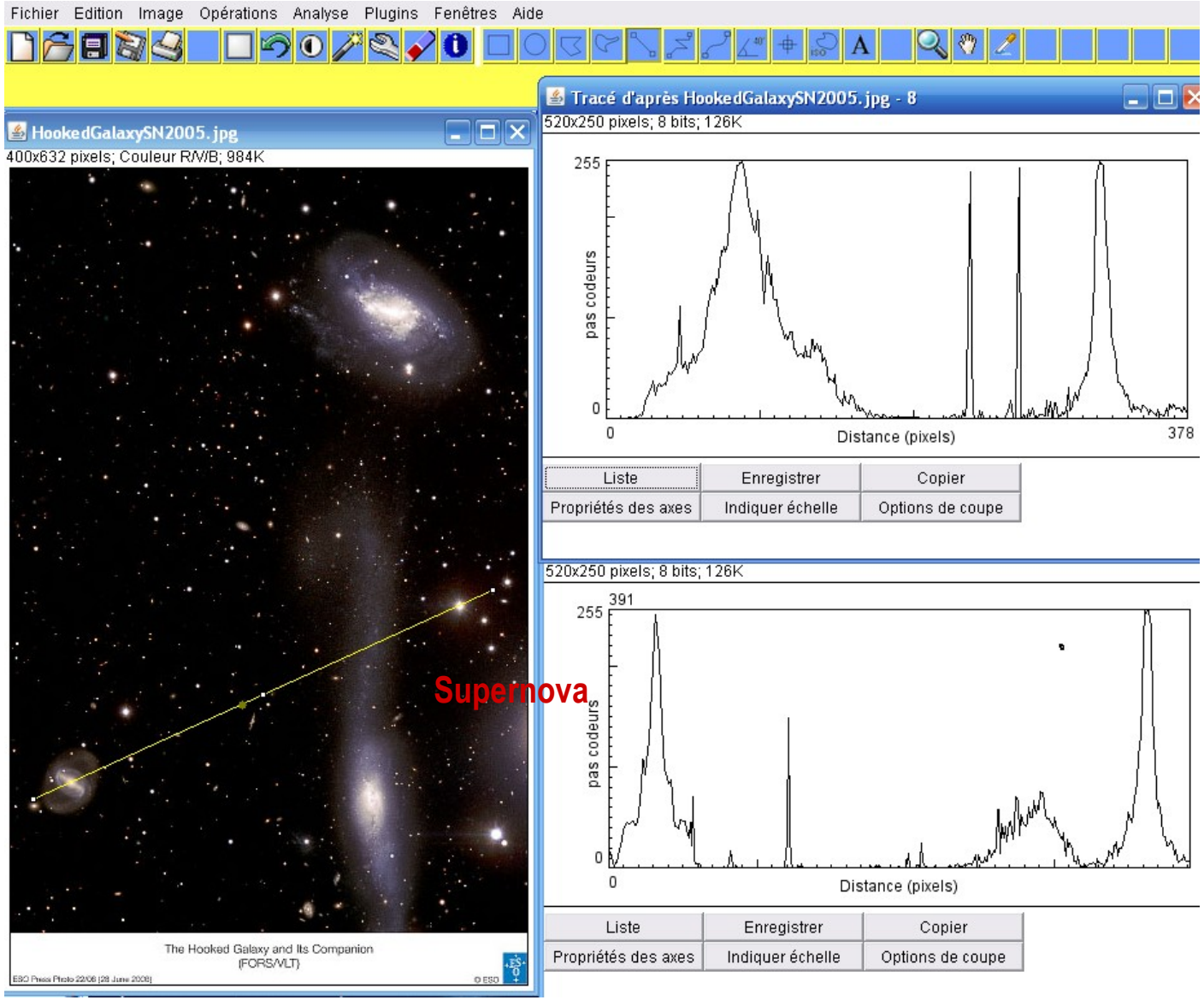
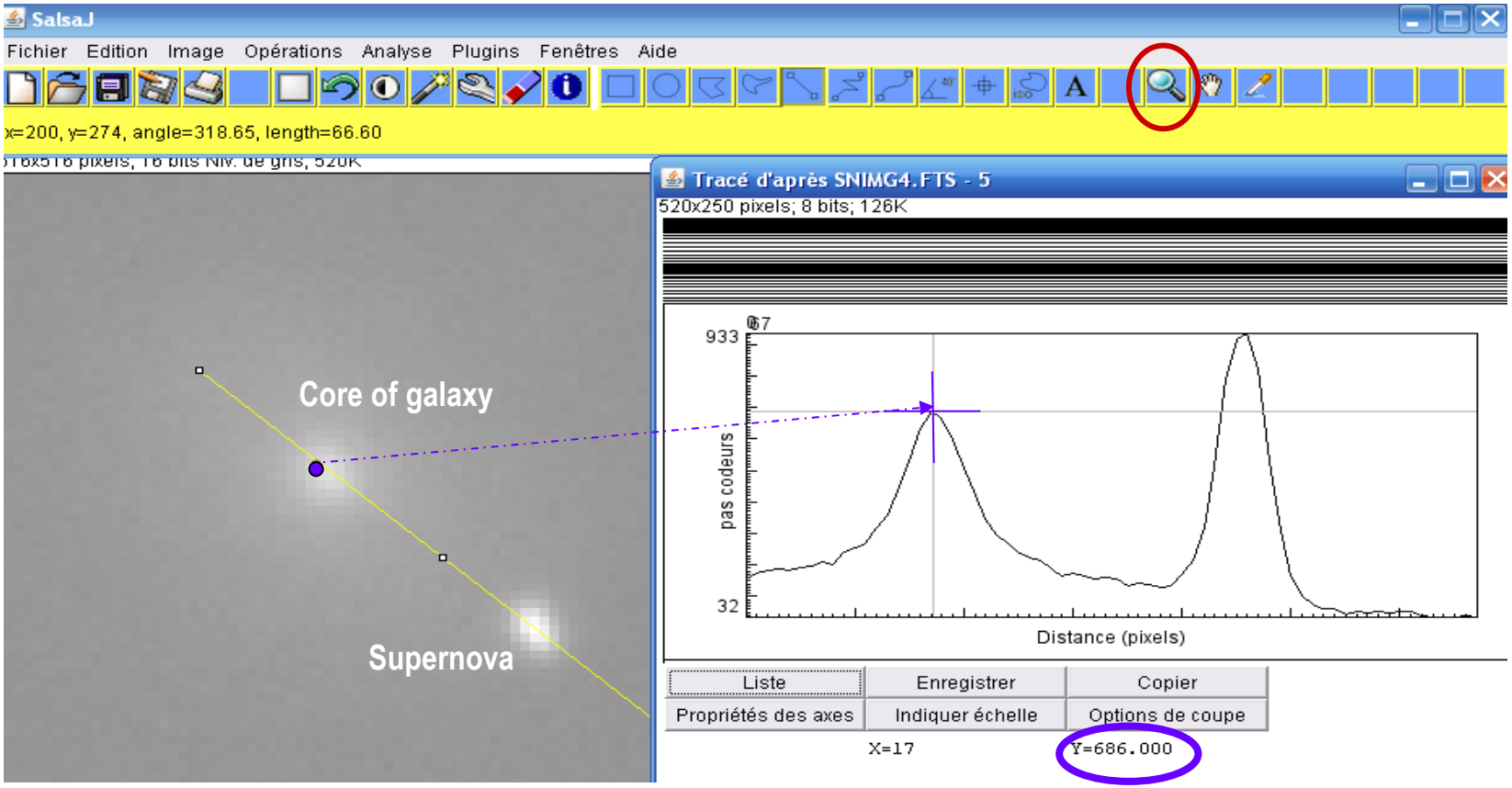


Image available on http://www.eso.org/public/outreach/press-rel/pr-2006/images/phot-22-06-preview.jpg

1-Open images SUPERNOVA_LIGHT_CURVES (12 images/ Read dates in Image Info)
2-Automatic photometry is not very precise; **open image one by one, enlarge (zoom)**
3-Use **Analyse /Plot Profile**, follow curve with cursor, then read **peaks ordinates** on each image:

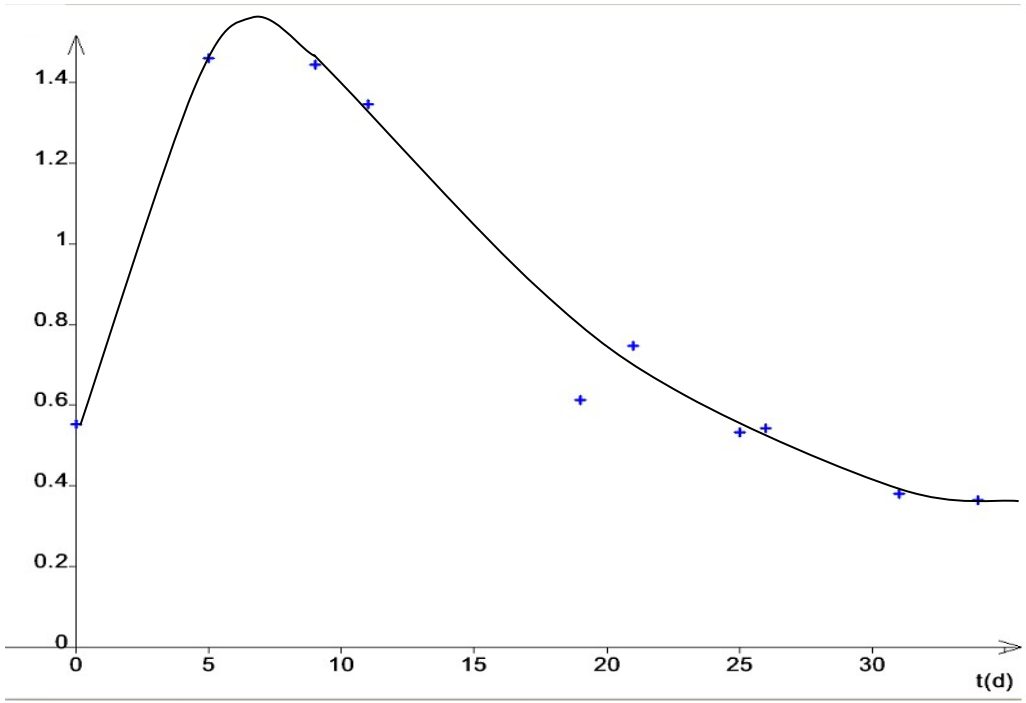


Date (Image Info)	0	5	9	11	12	19	20	21	25	26	31	34
Core of galaxy	393	561	1457	686	765	1117	1116	1181	1237	1060	916	1115
Supernova	217	819	2103	923	823	665	913	883	658	576	349	407
Supernova/Core	0.552	1.460	1.443	1.345	1.076	0.595	0.818	0.748	0.532	0.543	0.381	0.365

Draw the curve of supernova brightness according to date

(calculated with reference to galaxy core)

Supernova Brightness/ Galaxy core



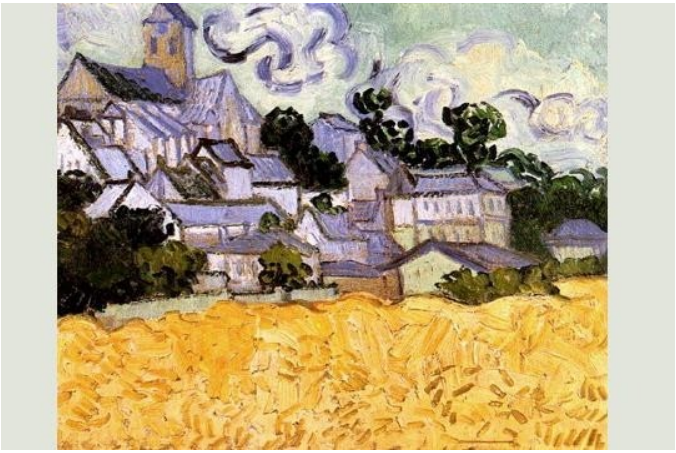
Date

Supernovae are used as cosmic candles for measuring distances in the Universe.

5th step : Galaxies with Van Gogh

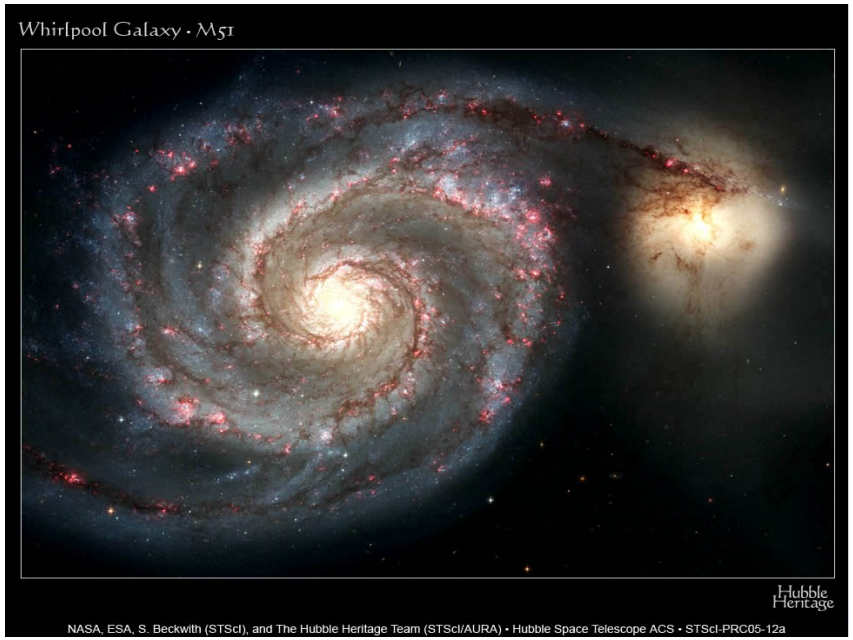
in Auvers-sur-Oise

a village near Paris



Auvers-sur-Oise, by Van Gogh

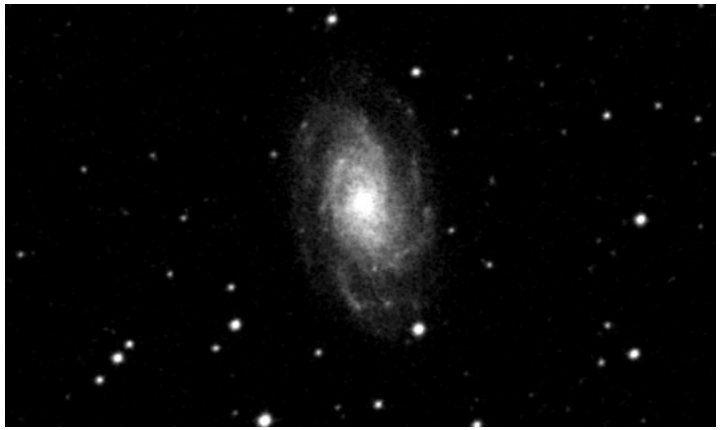
Starry night, by Vincent Van Gogh



M51, Whirlpool Galaxy(english whirlpool= french tourbillon)

Dancing with a galaxy

About galaxy NGC 7083, redshift and dark matter



Measuring Edwin Hubble's redshift and Vera Rubin's dark matter

Suzanne FAYE, Lycée Chaptal, Paris, France

Michel FAYE, Lycée Louis-le-Grand, Paris, France

mfaye2@wanadoo.fr

I - About galaxy NGC 7083

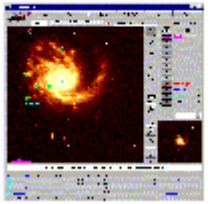
Where? in Indus Constellation (Southern hemisphere)

Why Southern hemisphere? Because of very performant telescope ESO – VLT (Chili)

http://seds.org/~spider/ngc/ngc.cgi?7083

http://simbad3.u-strabg.fr/sim-id.pl?Ident=NGC7083

Aladin Java Applet

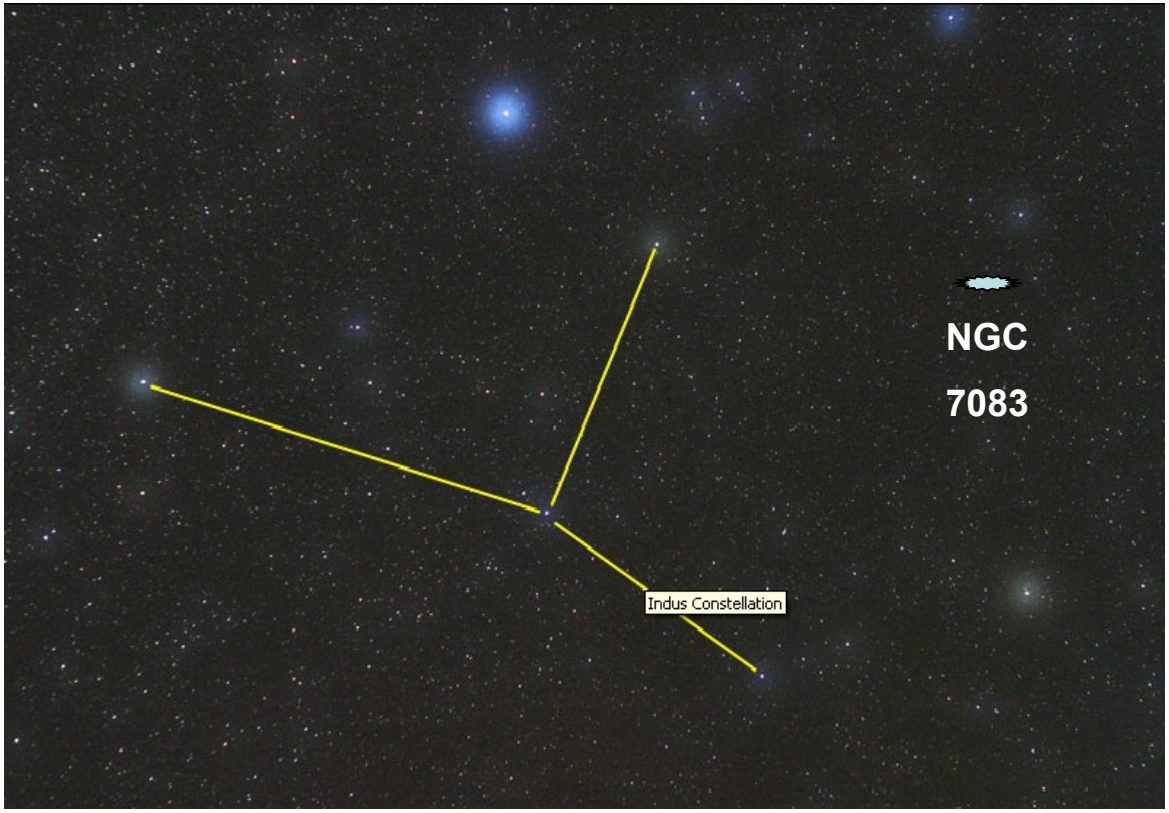


Right Ascension:	21 hours 35 minutes 45,4 s
Declination:	-63 degrees, 54 minutes 17s
Apparent Magnitude:	12
Apparent Diameters:	3.5’ long; 2,0’ wide (slide 4)

1 - About Indus Constellation, southern hemisphere (visible with VLT, Chili)

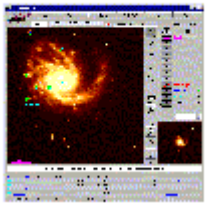
http://www.starrynightphotos.com/constellations/indus.htm

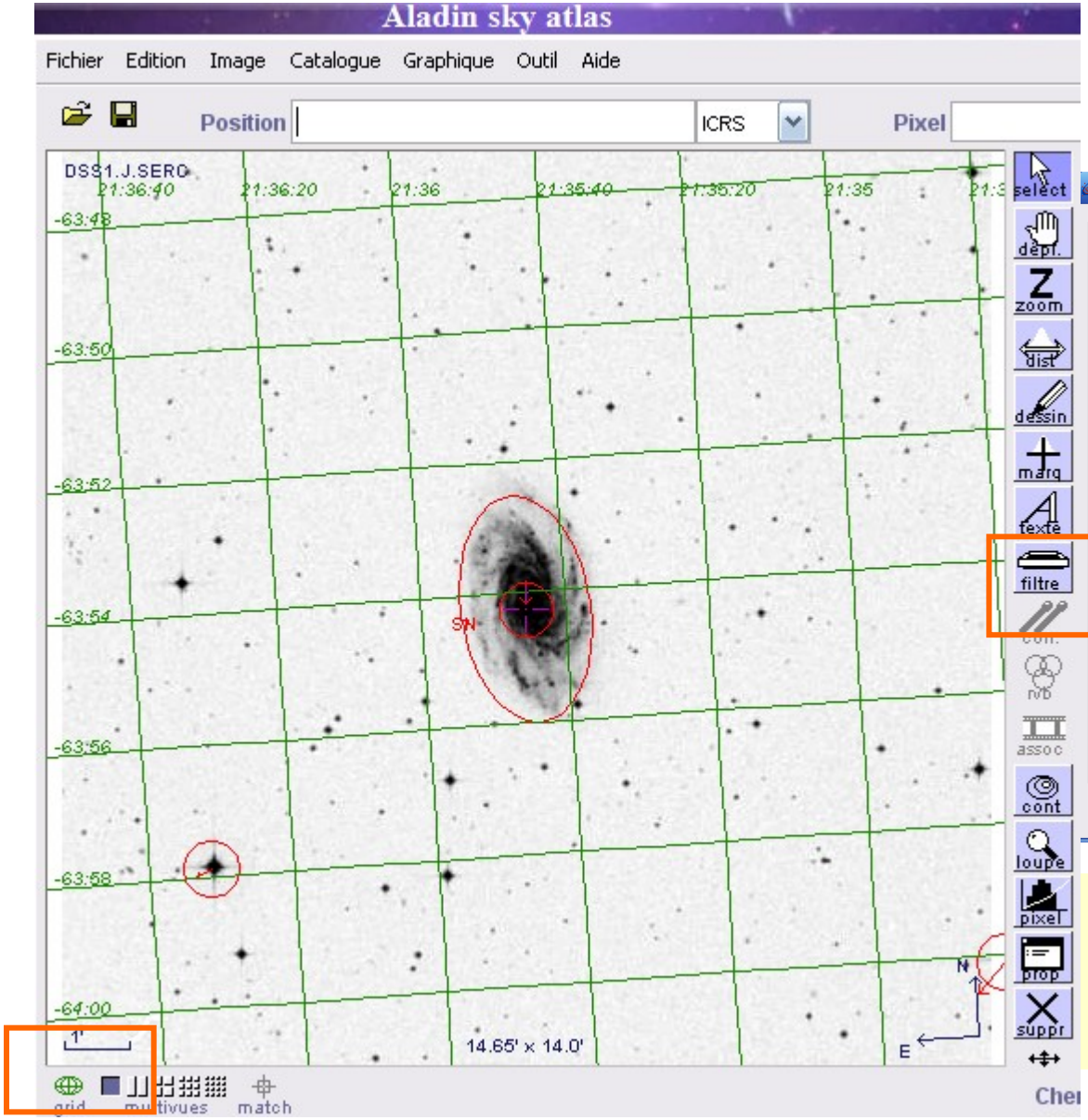
The constellation was one of twelve constellations created by Pieter Dirkszoon Keyser and Frederick de Houtman between 1595 and 1597, and it first appeared in Johann Bayer's Uranometria of 1603.
Since Indus was introduced in the 17th century, and lies in the south, it was not known to classical or early cultures thus they produced no mythology concerning it.

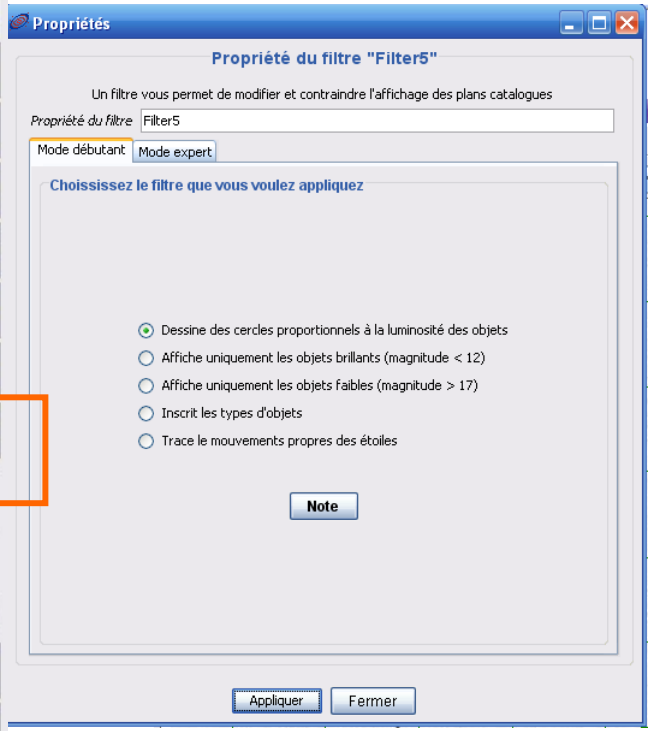


2 - http://simbad3.u-strasbg.fr/sim-id.pl?Ident=NGC7083

Aladin Java Applet





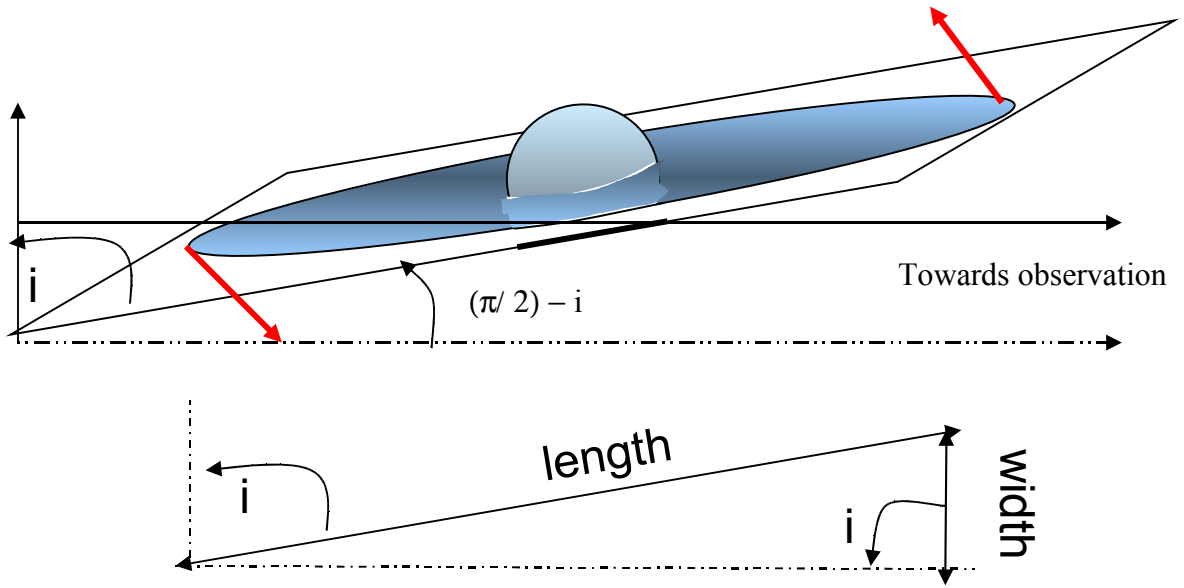


Answer for the angular sizes of the galaxy:

3,5’ long; 2,0’ wide

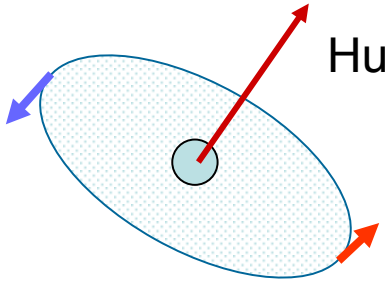
3 – What is the orientation of the *galaxy* disc plane; angle i ?

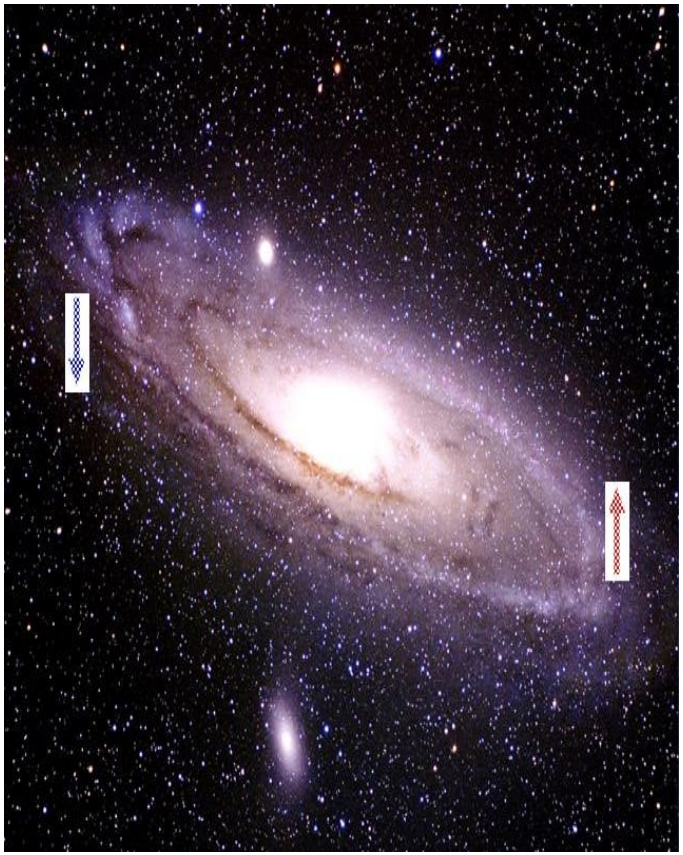
We see as an ellipse what is in fact a circle.

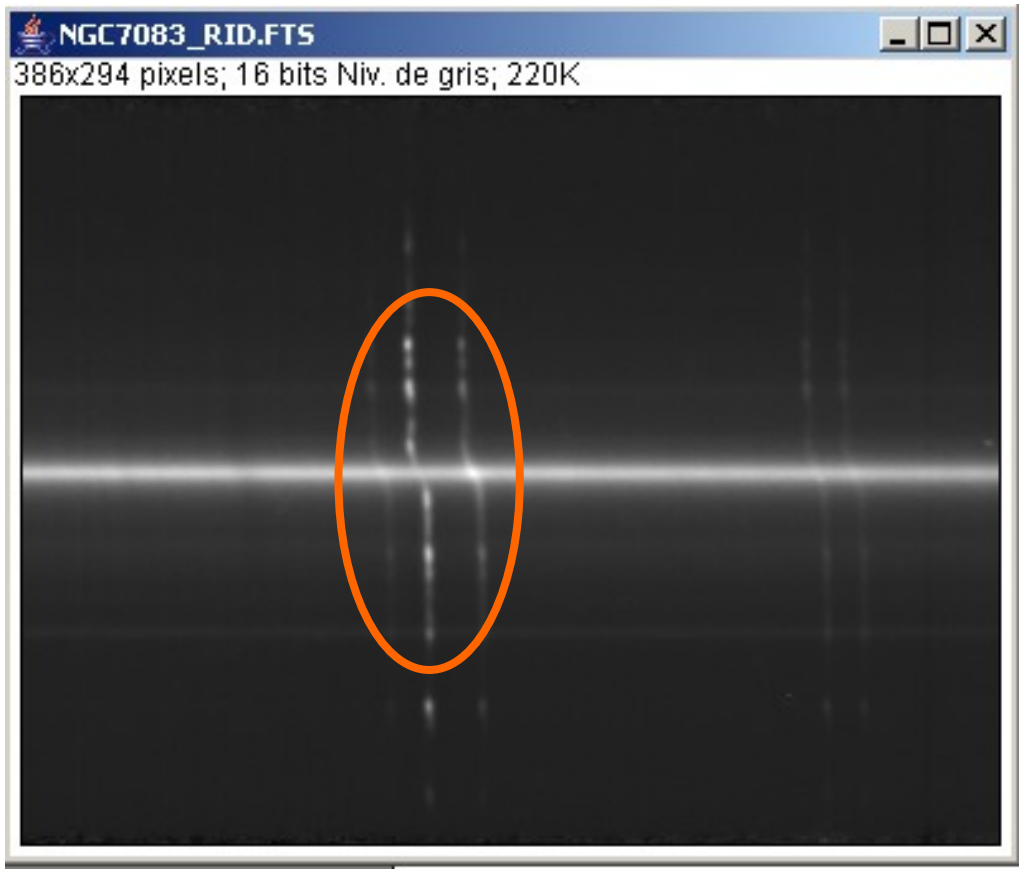


Answer for angle i : cos(i) = width/length = 2,0 / 3, 5 => i = 55°; sin(i) = 0,82

Pretty Doppler effects



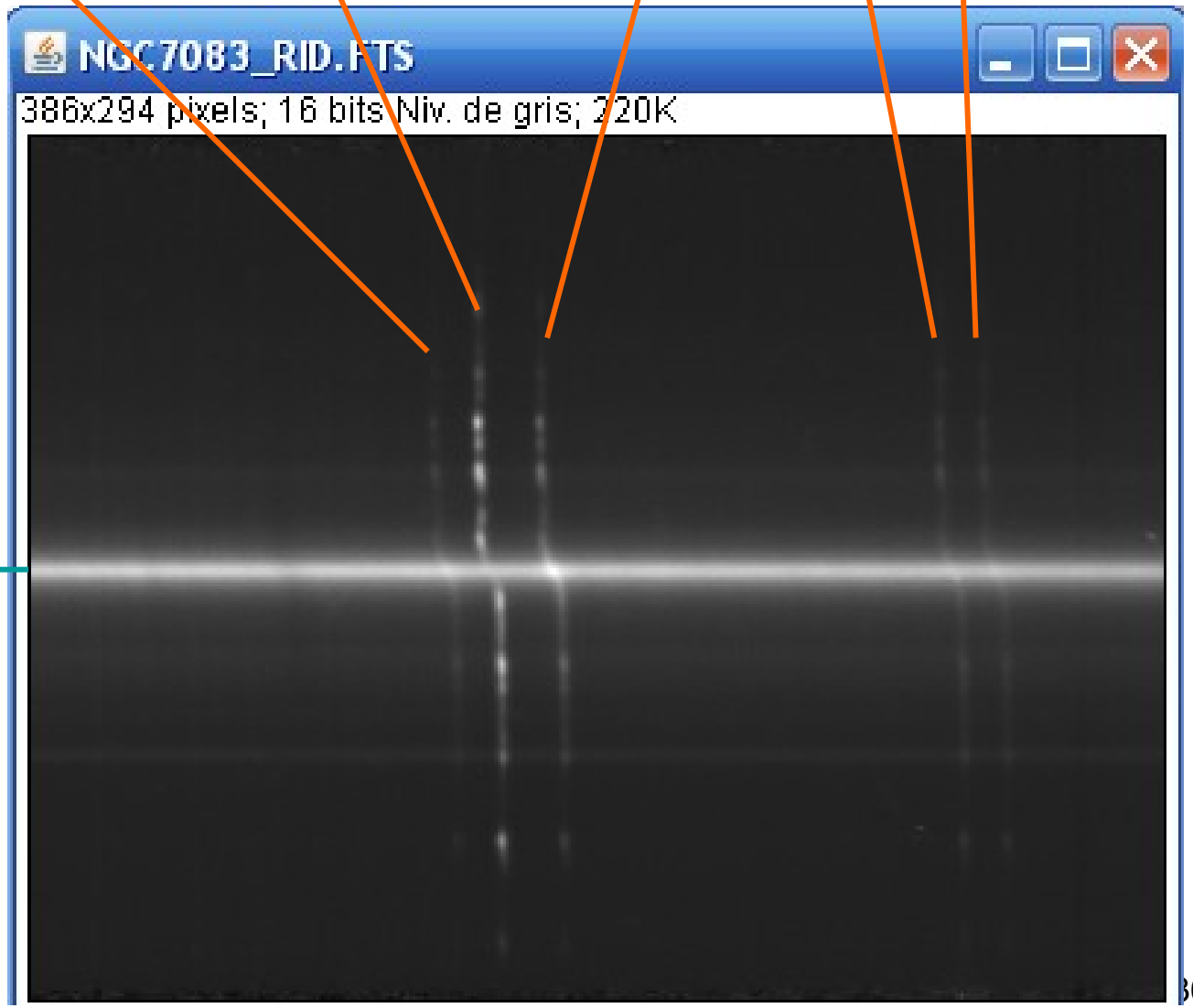




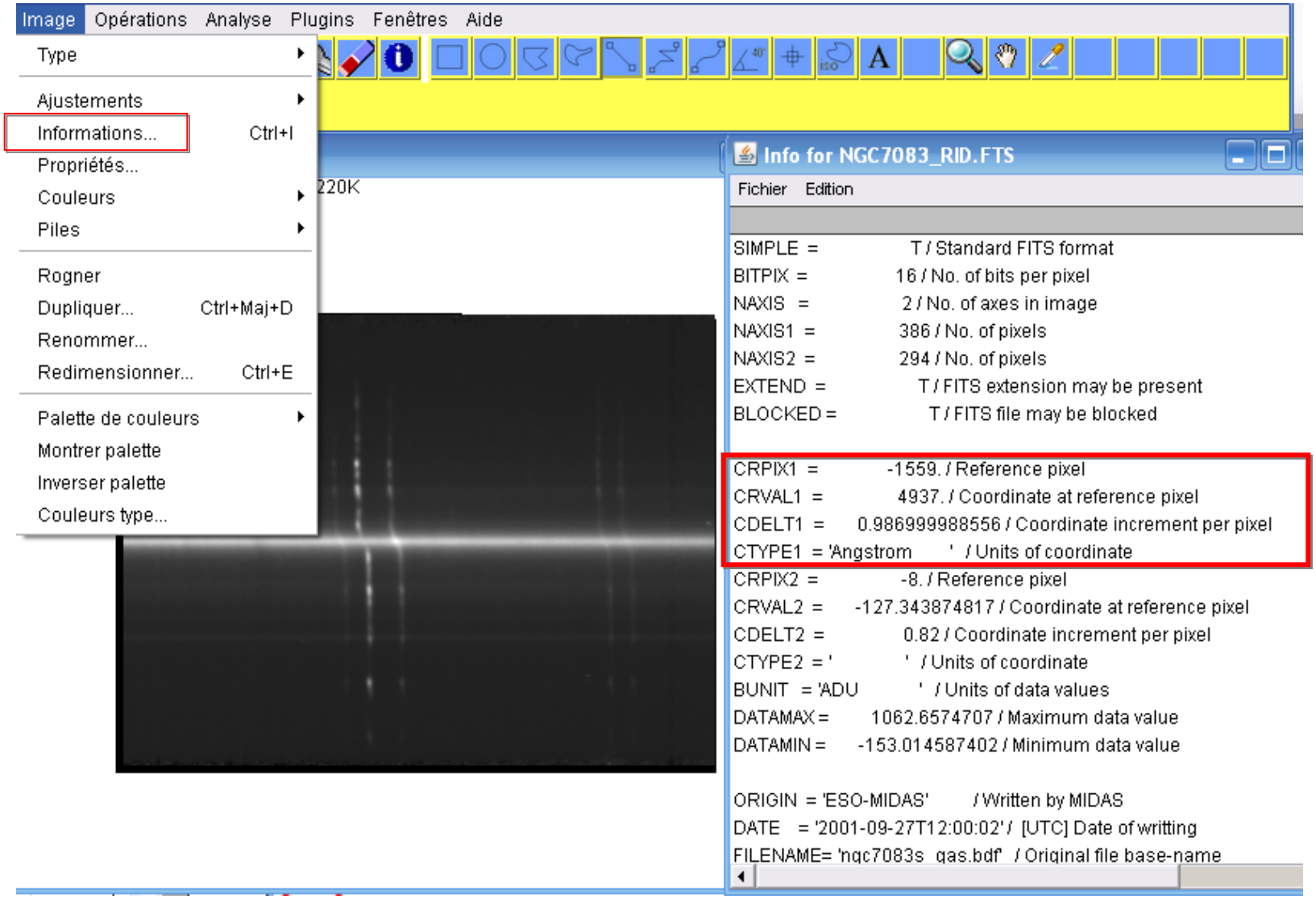
4 – Part of NGC 7083 spectrum, by VLT - ESO / cf Italy: Alessandra Zanassi, Marileva Spavone

Lines emitted by atoms from the disk of the galaxy

Continuum emitted by the core of the galaxy



5 – Have a look at Image/ Informations

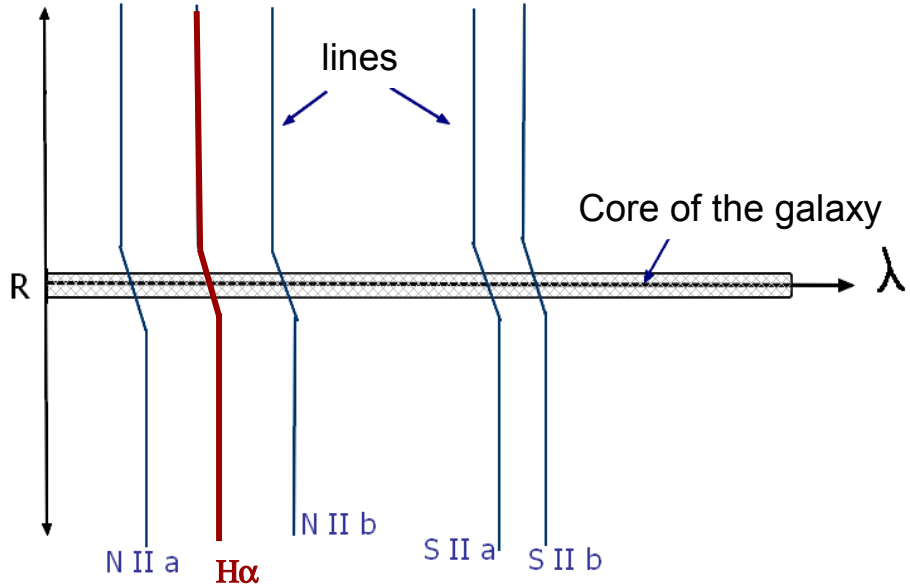


6 – Which lines did VLT astronomers have sent to us?

N nitrogen

H hydrogen

S sulfur



λ(pixel) = a*(pixel-reference) + b

=

CDELTI * (pixel+ 1559) + 4937 (Å)

Image Information:

CRPIX1 = - 1559. / Reference pixel
CRVAL1 = 4937. / Coordinate at reference pixel
CDELT1 = 0.986999988556 / Coordinate increment per pixel

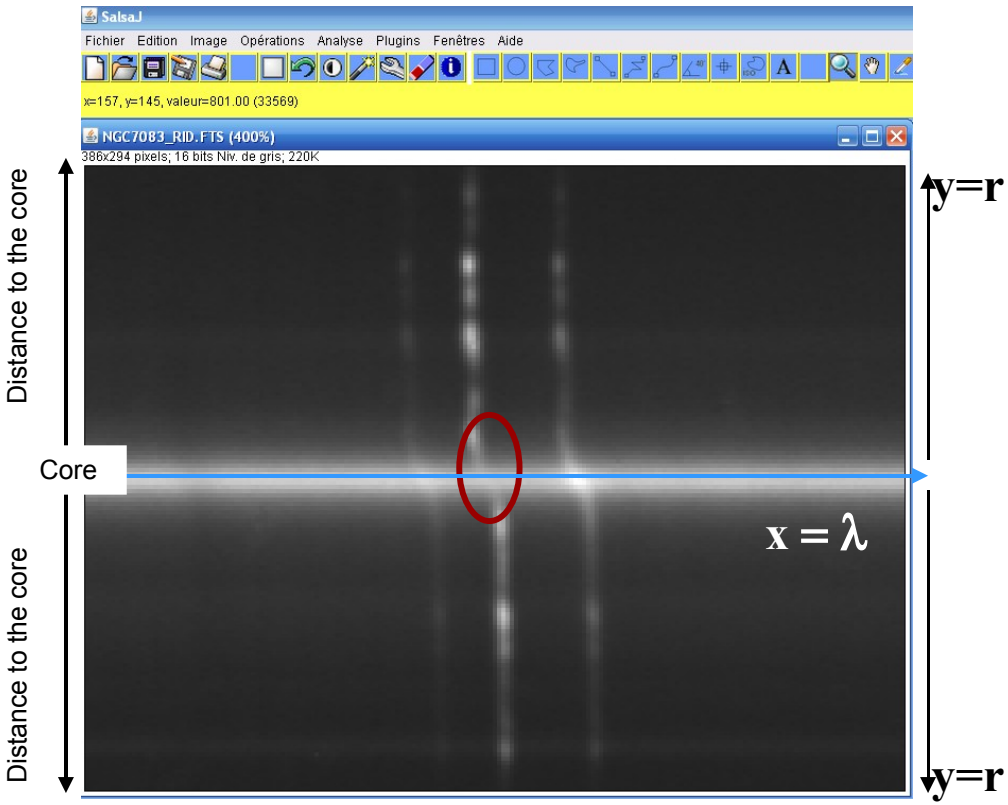
CTYPE1 = 'Angstrom ' / Units of coordinate

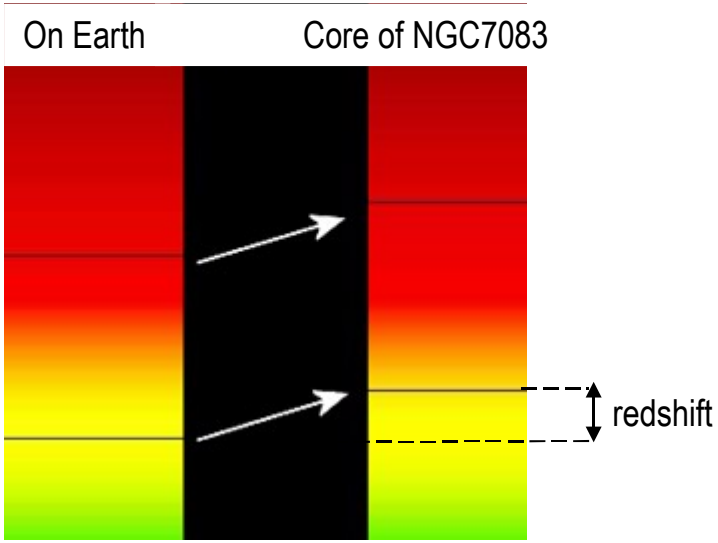
Let us remember:

1pixel$\approx$ 1 Å

7 -Spectrum of NGC 7083 - Magnifying glass

Image Information: λ_{nm} = (X + 1559)* 0,0987 + 493,7





Raie H a : X = 156

So λ = (156 + 1559) x 0,0987 + 493,7

λ = 663,0 nm

Line	Spectrum on Earth λ_1 (nm)	Spectrum of NGC 7083 X (pixel) => λ_2 (nm)	Redshift $\Delta\lambda/\lambda = (\lambda_2 - \lambda_1) / \lambda_1$	$V_{galaxie} = c.\ \Delta\lambda/\lambda$ (km/s) $c = 3.10^5$ km/s
Hα	656.28	X= 156 ; λ_2 =663.0	**0.0102**	**3060**

8 – Calculate redshift for each line

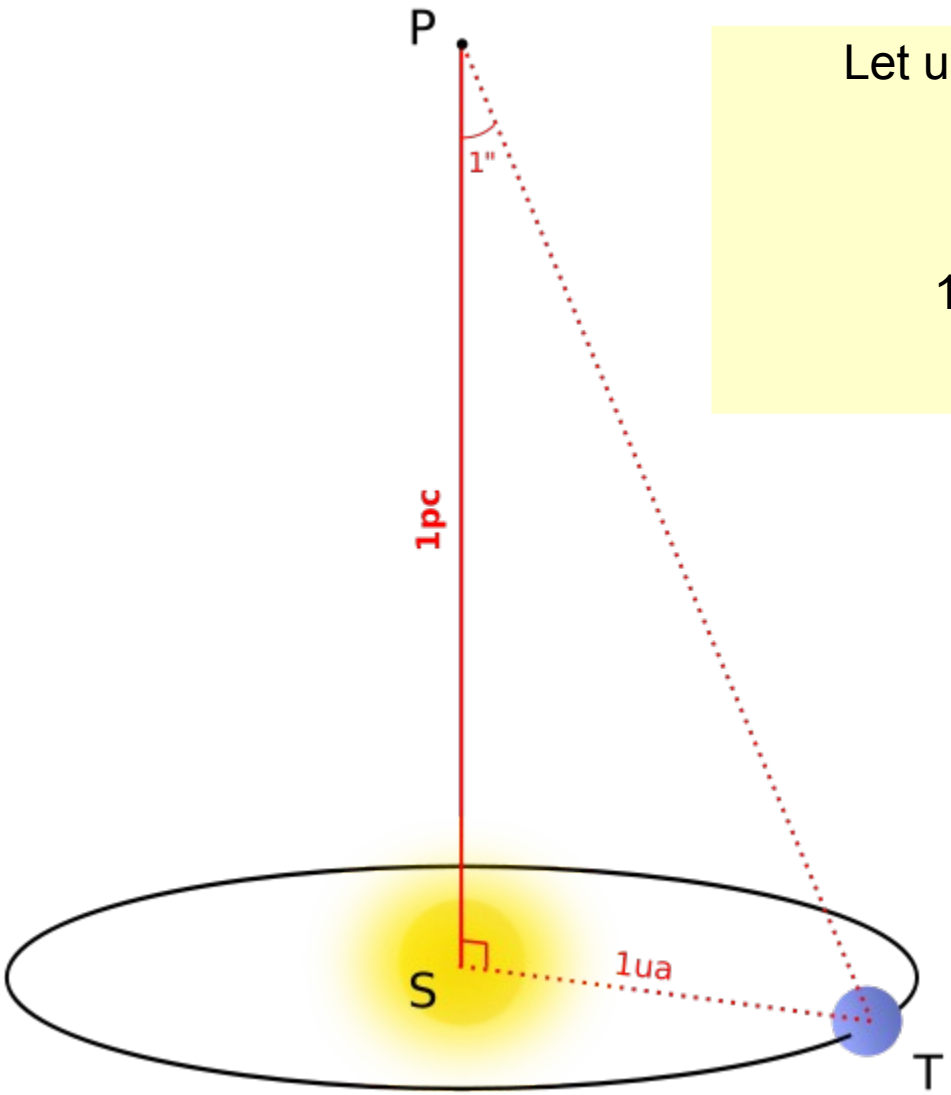
λ(pixel) = a*(pixel-reference) + b = CDELTI * (pixel+ 1559) + 4937 (Å)

Line	Spectrum on Earth λ_1 (nm)	Spectrum of NGC 7083 X (pixel) => λ_2 (nm)		Redshift $\Delta\lambda/\lambda = (\lambda_2 - \lambda_1) / \lambda_1$	$V_{galaxie} = c.\ \Delta\lambda/\lambda$ (km/s) $c = 3.10^5$ km/s
NIIa	654.80	X=140	λ_2 =661.6	0.0103	3090
Hα	**656.28**	**X=156**	**λ_2 =663.0**	**0.0102**	**3060**
NIIb	658.35	X=178	λ_2 =665.2	0.0104	3120
SIIa	671.60	X=313	λ_2 =678.6	0.0104	3120
SIIb	673.10	X=328	λ_2 =680.0	0.0102	3060

Let us keep $V_{NGC7083} = 3.09*10^3$ km/s

Good measurement!

9 – What is the distance D of galaxy NGC 7083?



Let us use Hubble law : $V_{galaxie} = H * D$,

with $H \approx 73\ km.s^{-1}.Mpc^{-1}$

1pc = 3,26 a.l. et 1a.l. ≈ $9{,}47.10^{15}$ m

$D = V_{NGC7083} / H = 3090/73$

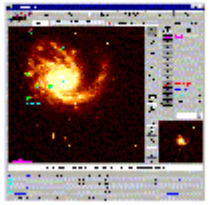
= 42,3 Mpc = 4,23 x10^7 pc

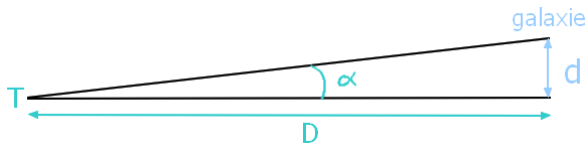
D = 13,8 x10^7 a.l.

D = 1,31 x10^{24} m

10 - Measuring the size $d_{NGC7083}$ of the galaxy

Aladin Java Applet





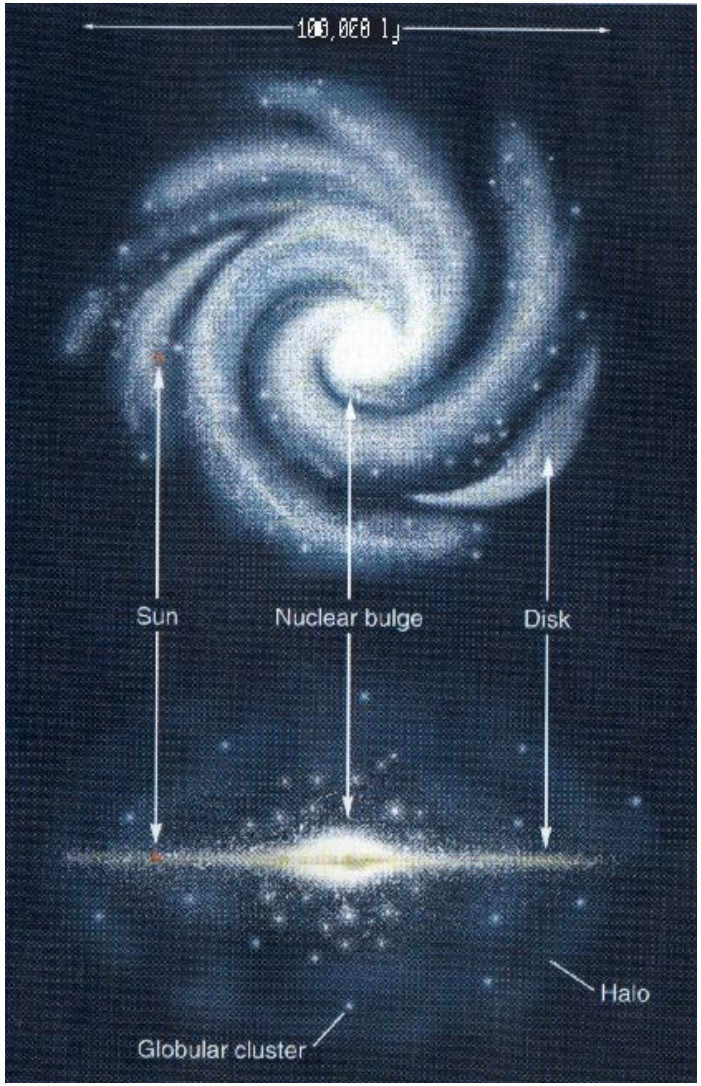
d_{galaxy} = α(en radians) * D

$\alpha_{NGC\ 7083} \approx 3{,}5' = 1{,}02.\ 10^{-3}$ rad

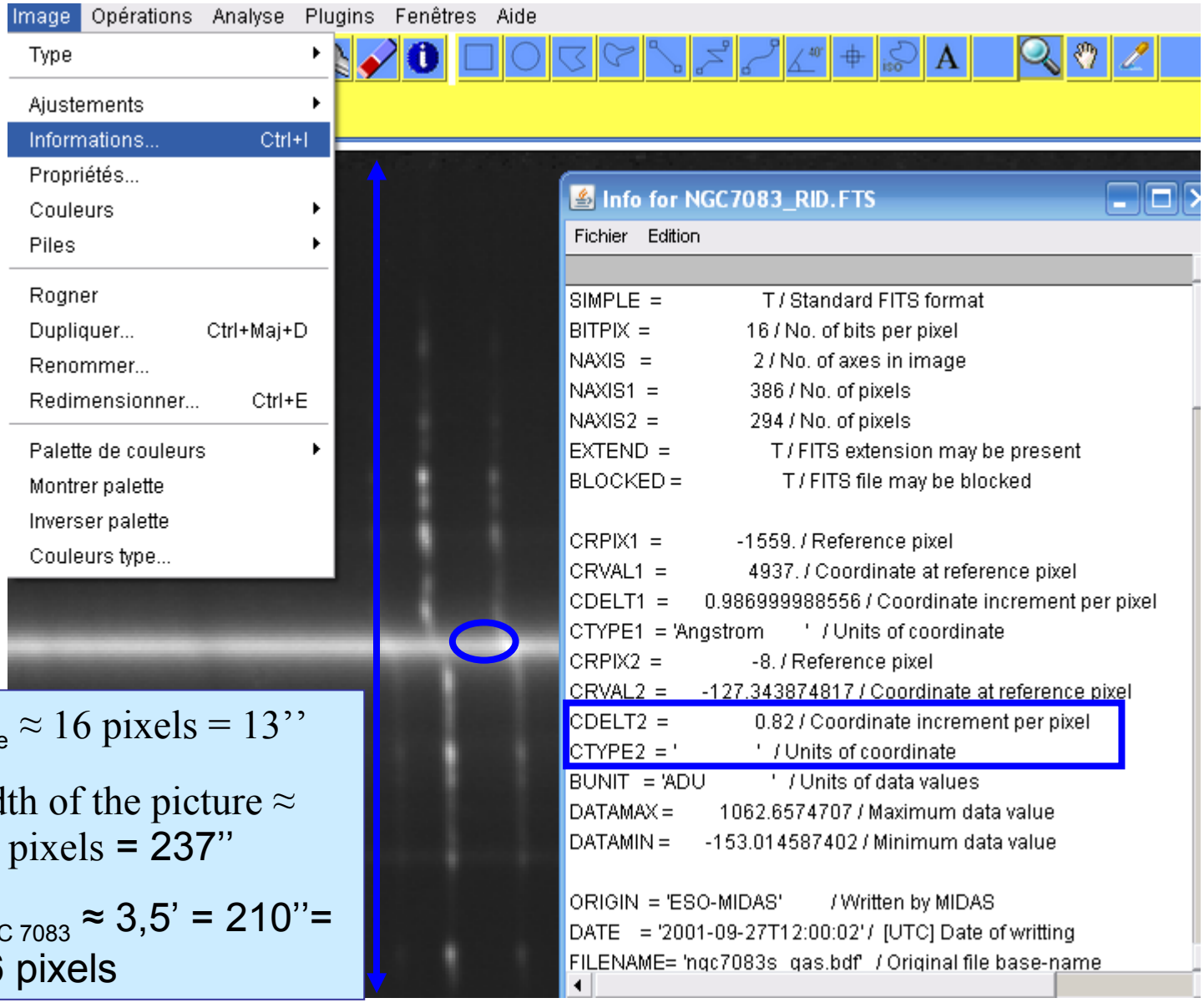
D = 4,23 x10^7 pc

Our Galaxy, Milky Way : $d_{Milky\ Way}$ = 25 000 pc

NGC 7083: $d_{NGC7083} = 4{,}3\ .\ 10^4$ pc = 1,7 * $d_{Milky\ Way}$



11 – Have sizes of the galaxy with Image/ Informations and apparent diameters

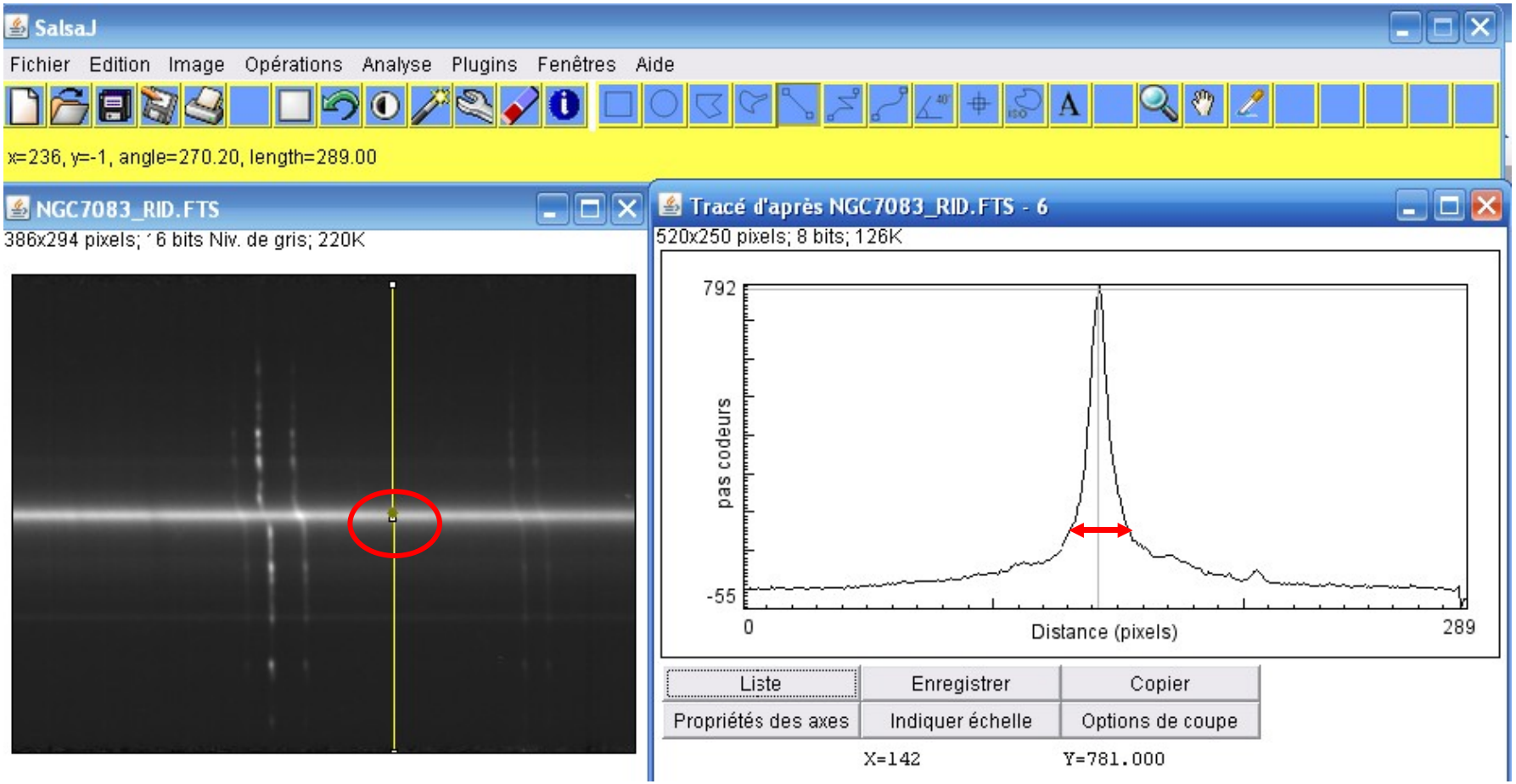


$\alpha_{core} \approx 16$ pixels = 13''

Width of the picture ≈ 289 pixels = 237''

$\alpha_{NGC\ 7083} \approx 3{,}5' = 210'' =$ 256 pixels

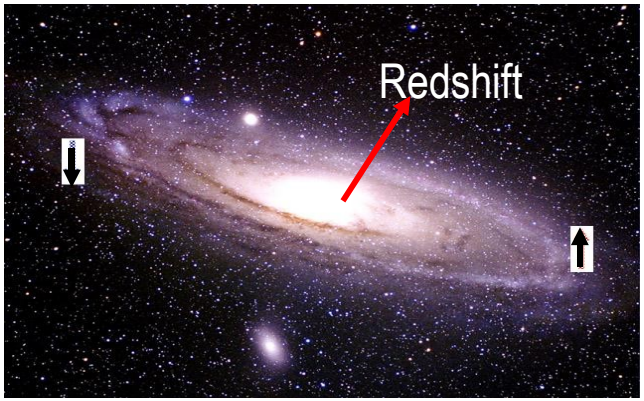
12 – Measuring the size d_{core} of the core of the galaxy : « vertical » slice



Let us evaluate: core = 16 pixels; $d_{NGC7083} \approx 256$ pixels

=> d_{core} / d_{galaxy} = 16/256 et $d_{NGC7083} = 4{,}3.\ 10^4$ pc ; so $\mathbf{d_{core}} \approx 2{,}7.10^3$pc= $8{,}3.10^{19}$ m

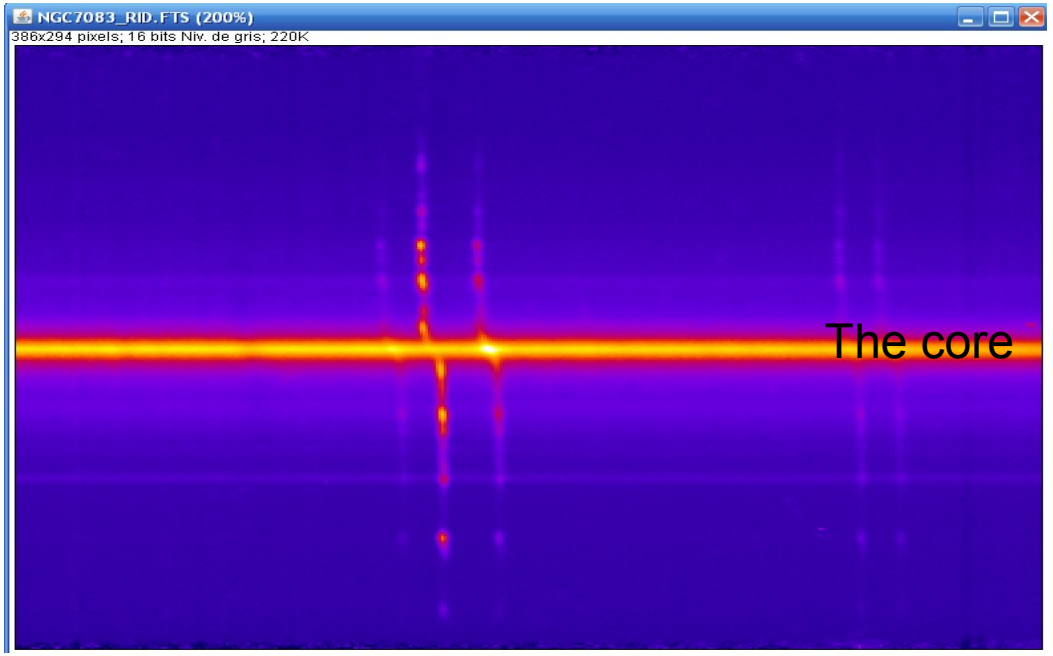
II – Dancing with a galaxy

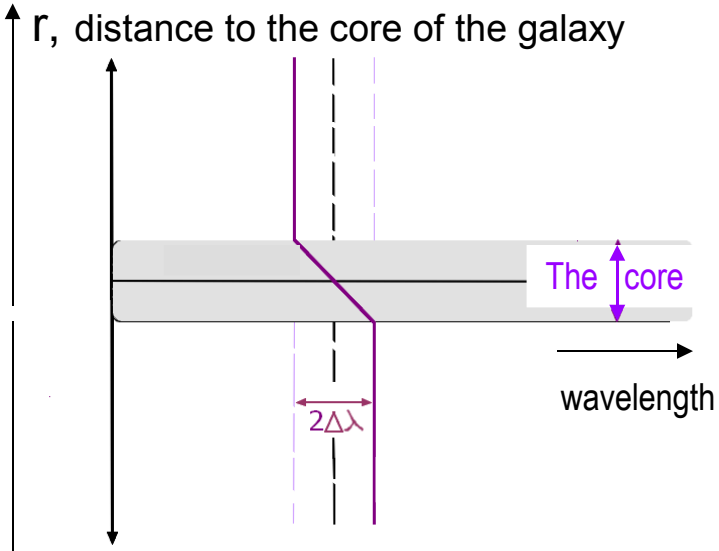


Redshift of the core

+

« Relative » Doppler shift by rotating around the core

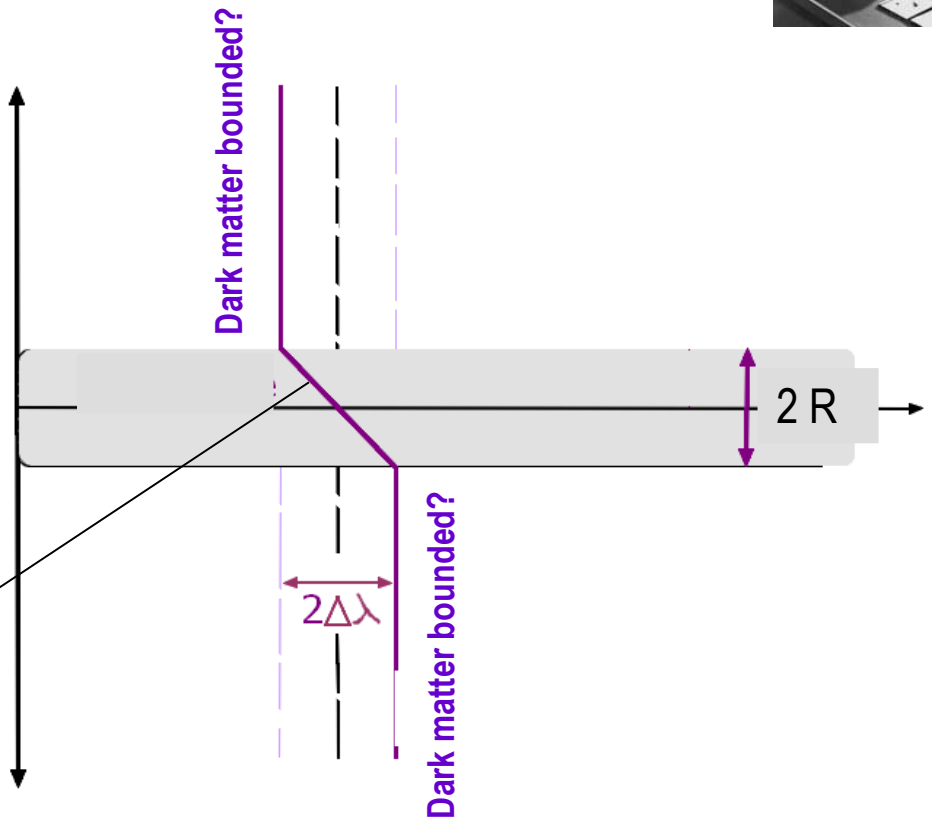




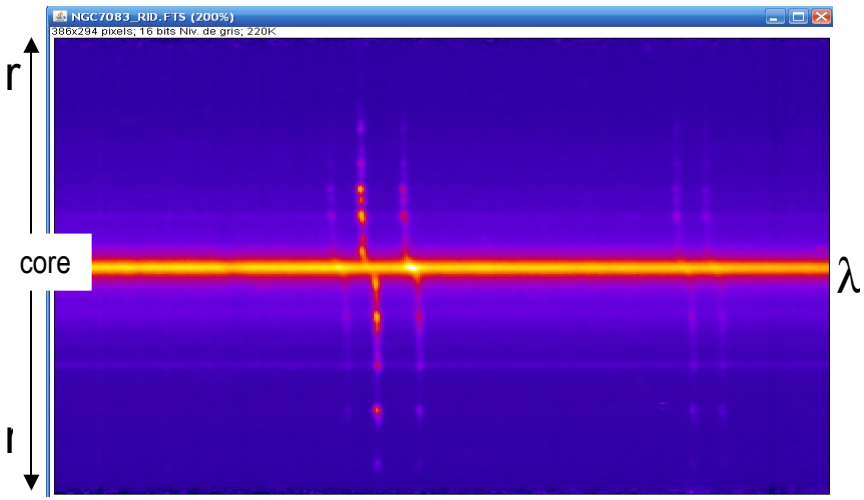
1 – Why is the shift of the spectrum constant for r > R ?

Vera Rubin *(born 1928) is an astronomer who has done pioneering work on galaxy rotation rates. Her discovery of what is known as "flat rotation curves" is the most direct and robust evidence of* ***dark matter****.*

Turning around the core



Danse with a galaxy / Dark matter



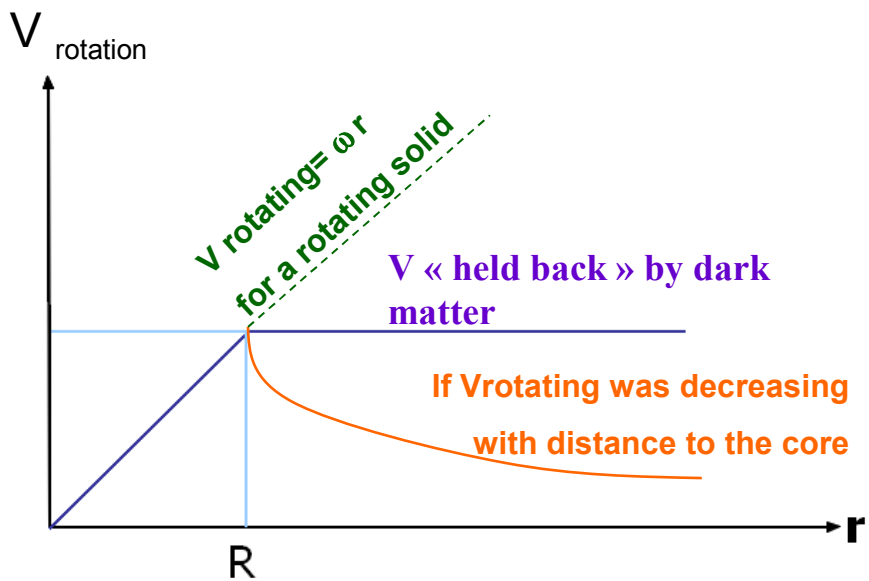
* Doppler shift $\Delta\lambda$ is constant for r > R,

which means that the relative velocity is then constant

* Because of the inclination i of the galaxy plane, $\Delta\lambda / \lambda = V_{relative} * \sin(i) / c$

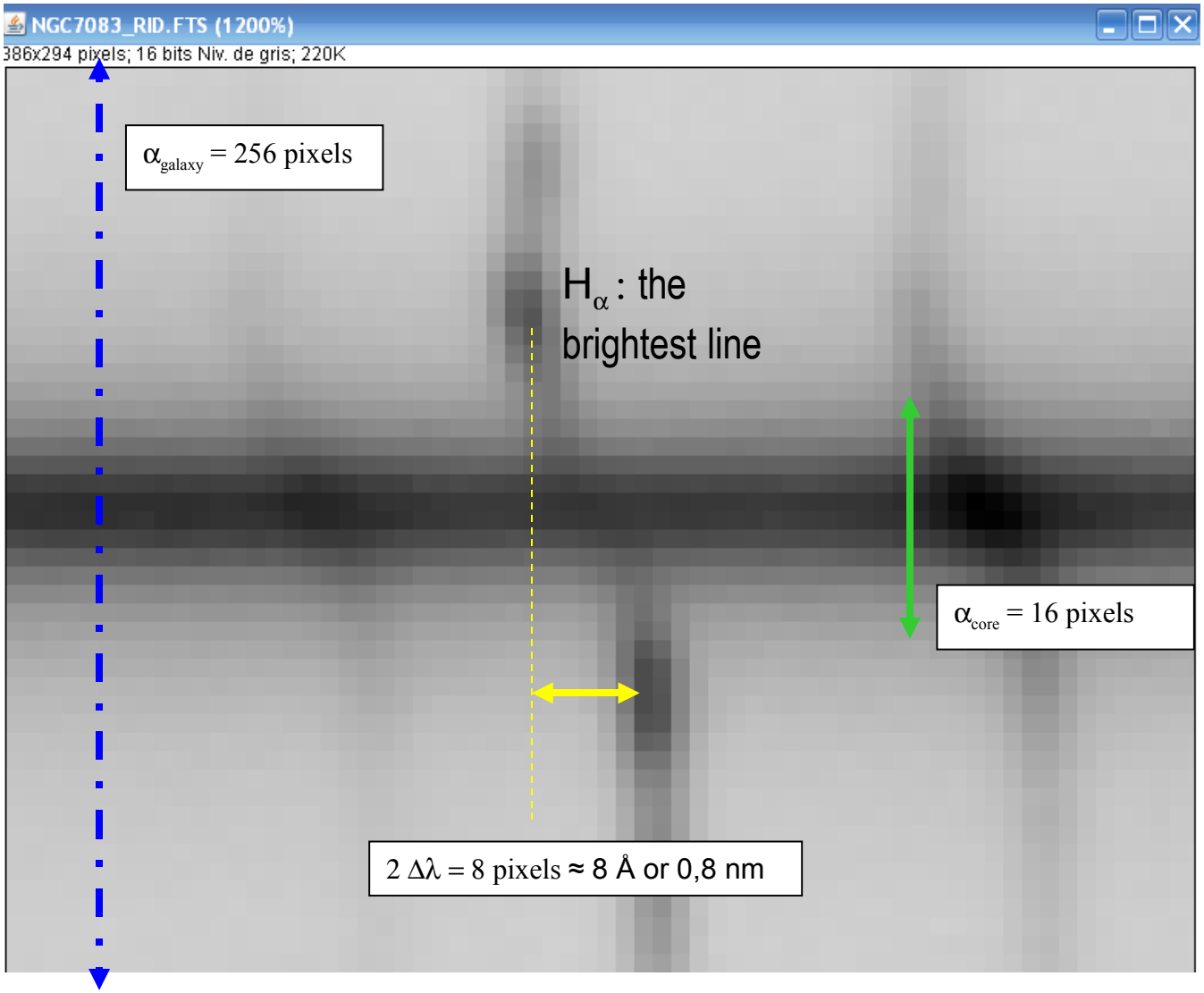
Let us imagine that the arms of the dancer are «held back » by ???

Dark Matter!!!



3 – How can we measure $\Delta\lambda / \lambda$?

*You can **either use quotient in pixel**, **or use CDELT1: 1 pixel ≈ 1 Å** or 0,1 nm*



$V_{rotation}$ =

$[\Delta\lambda/\lambda] * c / \sin(55)$

We use line H_α ,

with rotation shift

$\lambda\ (H_\alpha / \text{core}) \approx 6630 Å$

So:

$V_{rotation} \approx (4/6630)^* c/0.82$

$V_{rotation} \approx 2{,}21.\ 10^5$ m/s

Around the core of the galaxy:

$mV^2 / r = G\ m\ M / r^2$

so $M_{core} = V^2 R / G$

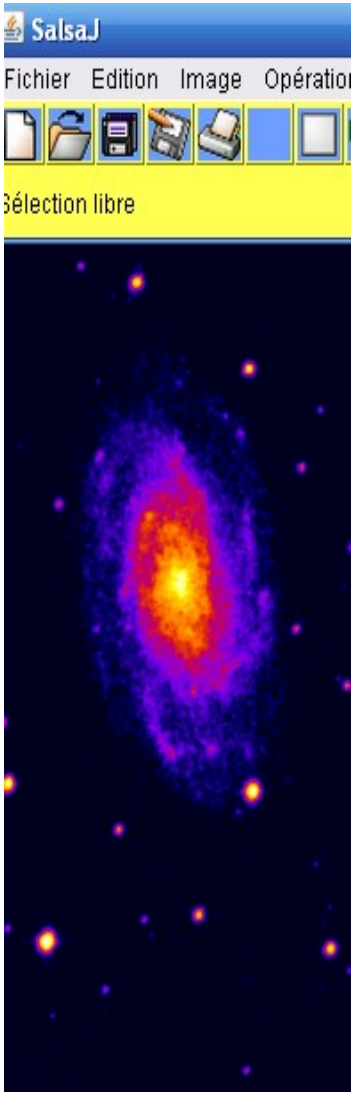
$G = 6{,}67.\ 10^{-11}$ SI

$R = d_{core}/2$ $4{,}15.10^{19}$ m

$M_{core} = 3.\ 10^{40}$ kg

Simplier:

Total Mass / Visible Mass= 256/16= 16



For the core of the galaxy:

$mV^2 / R = G\, m\, M_{core} / R^2$

so $M_{core} = V^2 R / G$

$G = 6{,}67.\ 10^{-11}$ SI

$R = d_{core}/2 \approx 4{,}15.10^{19}$ m

$\mathbf{M_{core} = 3.\ 10^{40}\ kg}$

For the whole galaxy:

$mV^2 / r_{whole} = G\, m\, M_{whole} / r_{whole}^{\ 2}$

so $M_{whole} = V^2 r_{whole} / G$

$G = 6{,}67.\ 10^{-11}$ SI

$r_{whole} = d_{galaxy}/2 \approx 6{,}65.10^{20}$ m

$\mathbf{M_{whole} = 4{,}8.\ 10^{41}\ kg}$

$M_{whole} = 16 * M_{core} >$ Brighting mass

Here is **dark matter**, a challenge for researchers !!☺:::☺!!

Bright galaxies, dark matters, by Vera Rubin

Yes, dark matter proposed by the astronomer Vera Rubin in the seventies

(A pretty pricess rescues a prince ; her clothes are all in a mess)

When the Prince saw her, he said : « You are very dirty and look like a paperbag; please, go and get cleaner before I can marry you. ».

The princess answered: « So don't I! »She would have been a great scientist!

Paper bag Princess, de Robert Munsch, traduction française *La princesse dans un sac*
Bright galaxies, dark matter, de Vera Rubin.