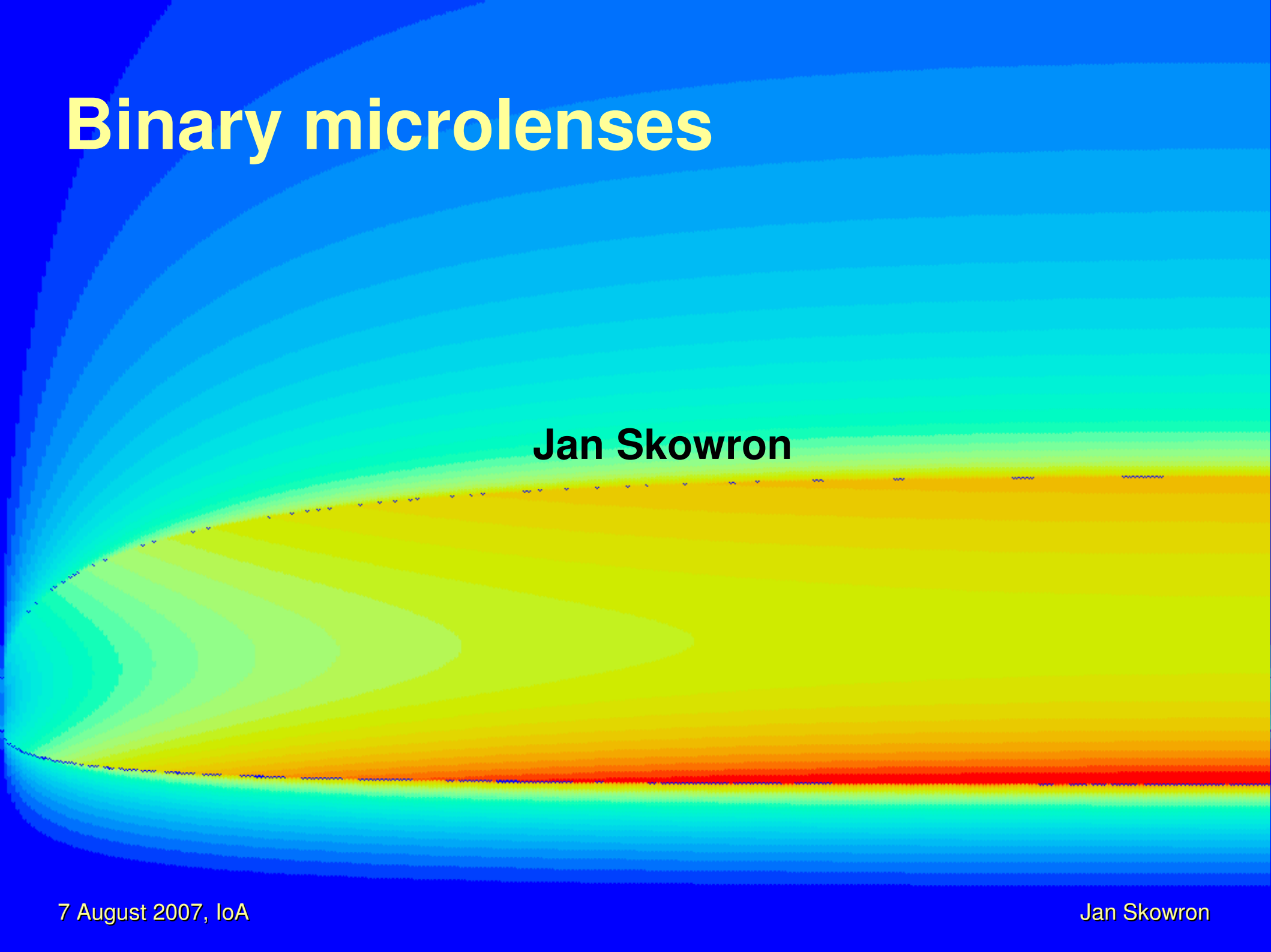
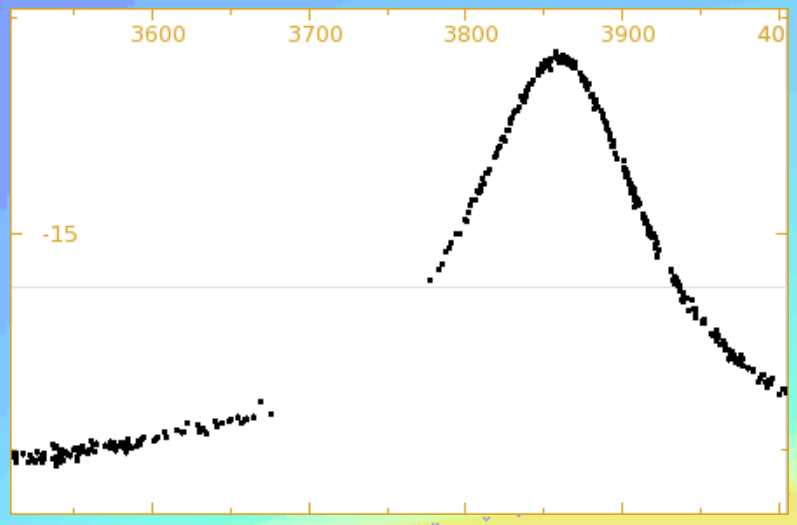
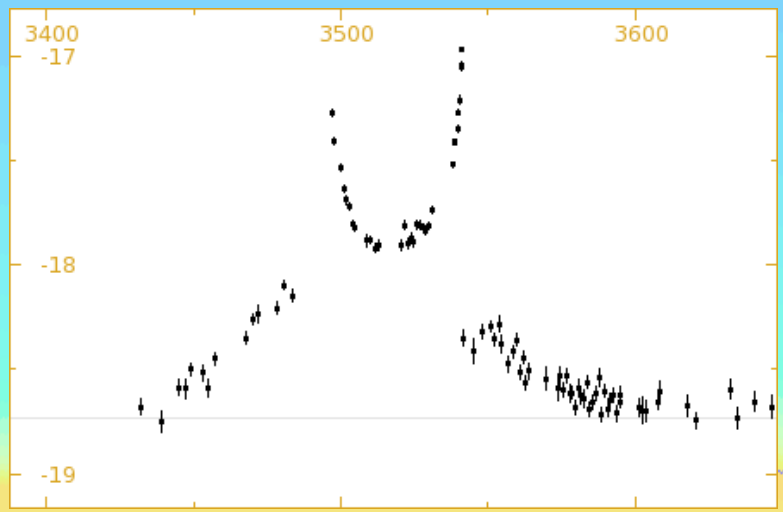
Binary microlenses

Jan Skowron



Microlensing events





- ~ 500 events per year

- 10 OGLE II 1997-1999
- 15 OGLE III 2002-2003
- 19 OGLE III 2004
- ...

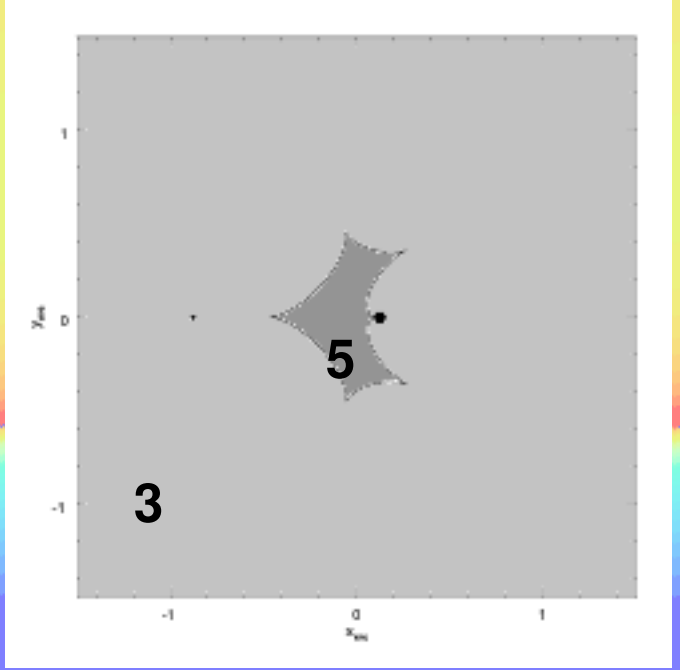
Binary lenses

- lens equation

$$\vec{b}_0 = \vec{b} - \frac{4GM_1}{c^2} D \frac{\vec{b} - \vec{b}_1}{|\vec{b} - \vec{b}_1|^2} - \frac{4GM_2}{c^2} D \frac{\vec{b} - \vec{b}_2}{|\vec{b} - \vec{b}_2|^2}$$

- 5^{th} order polynominal ⟶ 5 roots

but usualy only 3 roots are real images



mikrosoczewkowanie grawitacyjne przez układ podwójny

Soczewki:

q: 0.3000
d: 1.0000
m1 0.5000
m2 0.5000

Trasa źródła:

t: 0.5000
bet 10.000
b: 0.2000

Źródło:

Krzywa teoretyczna:

Rysuj krzywą blasku skok= 0.01000
od= -2.5000 do= 2.5000
Krzywa blasku: linia/punkty

Krzywa obserwacyjna:

Czasy i strumienie:

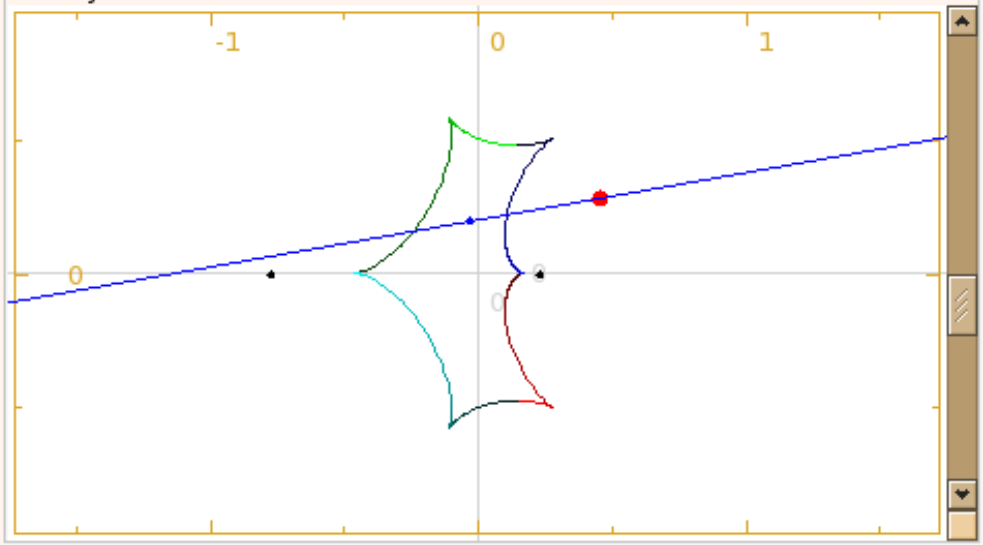
T0: 0.0000
TE: 1.000
F0: 1.000
Fs: 1.000

Dodatki:

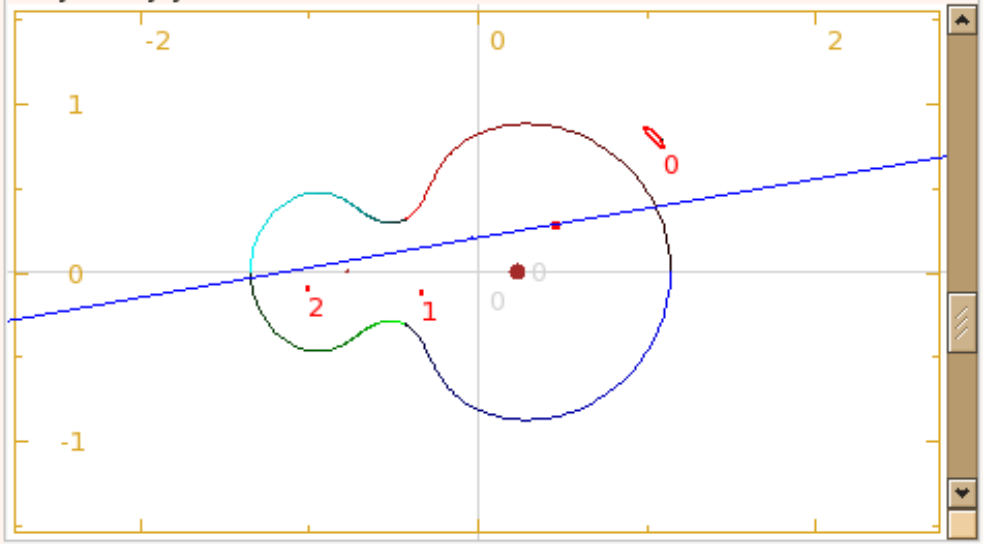
Pomoc:

Wyjście

Kaustyka



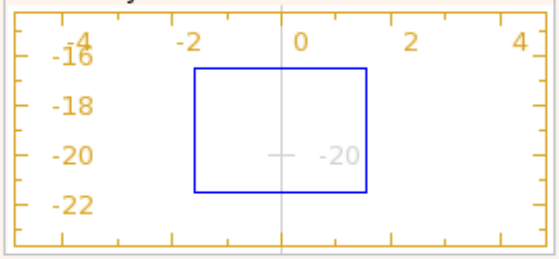
Krzywa krytyczna



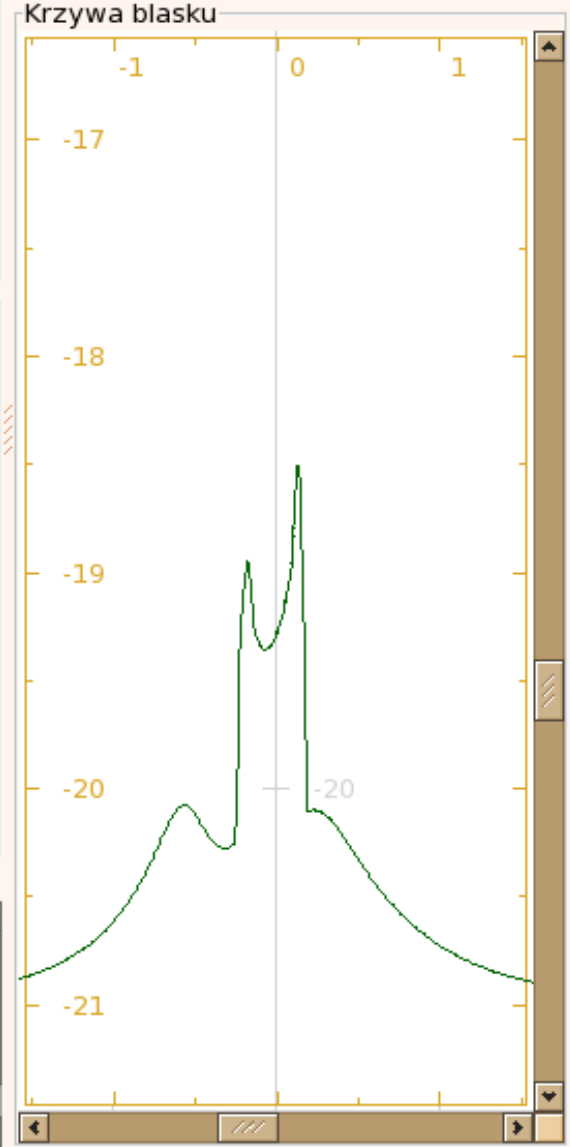
Obrazy:

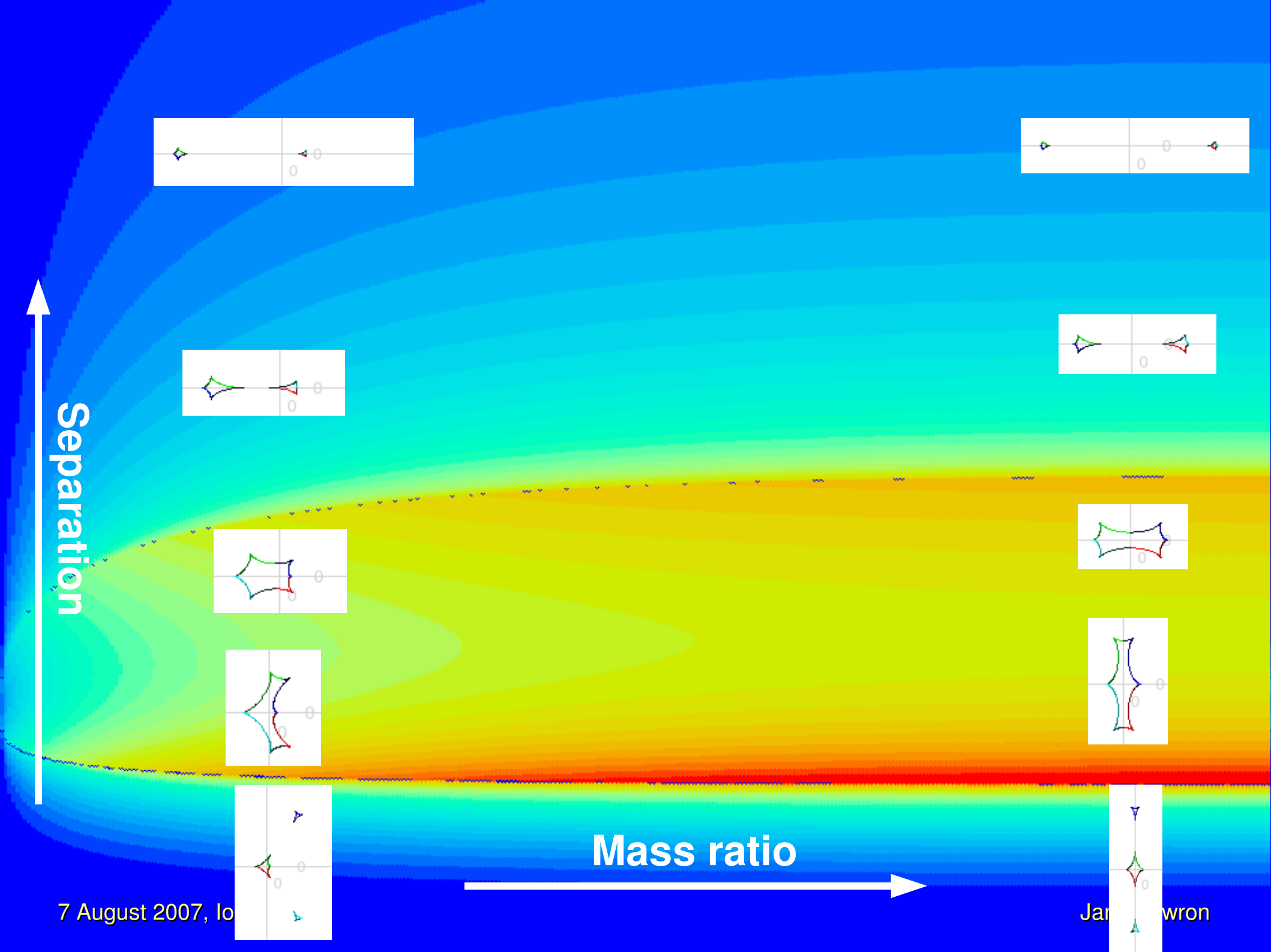
0:	1.673
1:	0.115
2:	0.067
3:	0.000
4:	0.000

Cała krzywa blasku



Krzywa blasku




Separation
Mass ratio

mikrosoczewkowanie grawitacyjne przez układ podwójny

Soczewki:

q: 0.3000
d: 1.0000
m1 0.2308
m2 0.7692

Trasa źródła:

t: 0.5000
bet 10.000
b: 0.2000

Źródło:

Krzywa teoretyczna:

Rysuj krzywą blasku skok= 0.01000
od= -2.5000 do= 2.5000
Krzywa blasku: linia/punkty

Krzywa obserwacyjna:

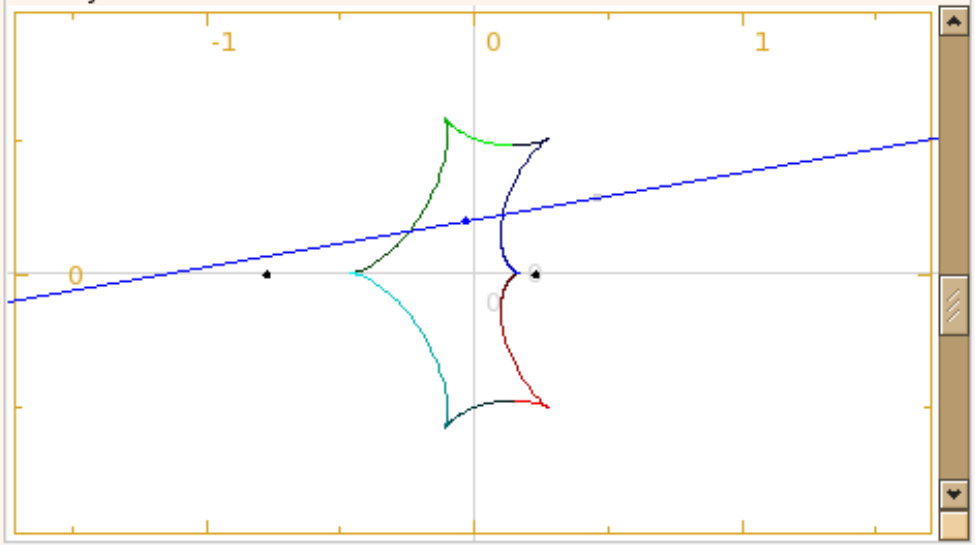
Czasy i strumienie:

Dodatki:

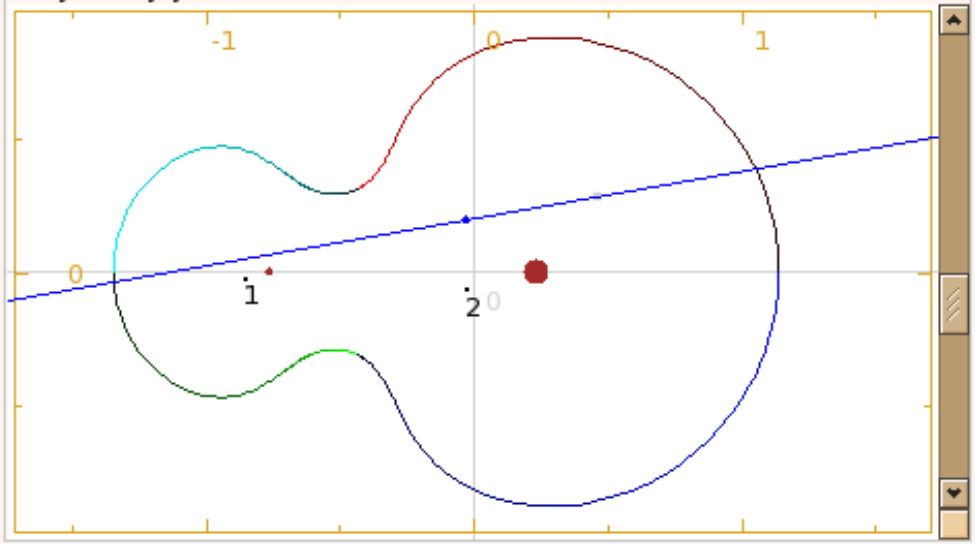
Pomoc:

Wyjście

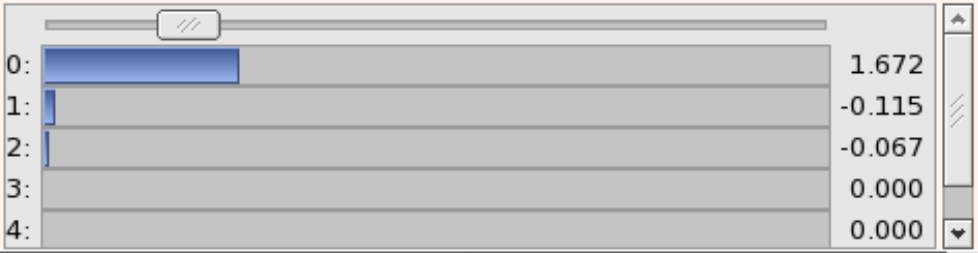
Kaustyka



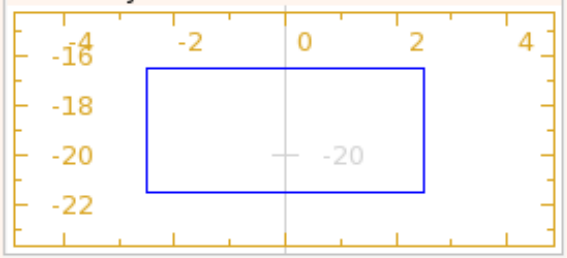
Krzywa krytyczna



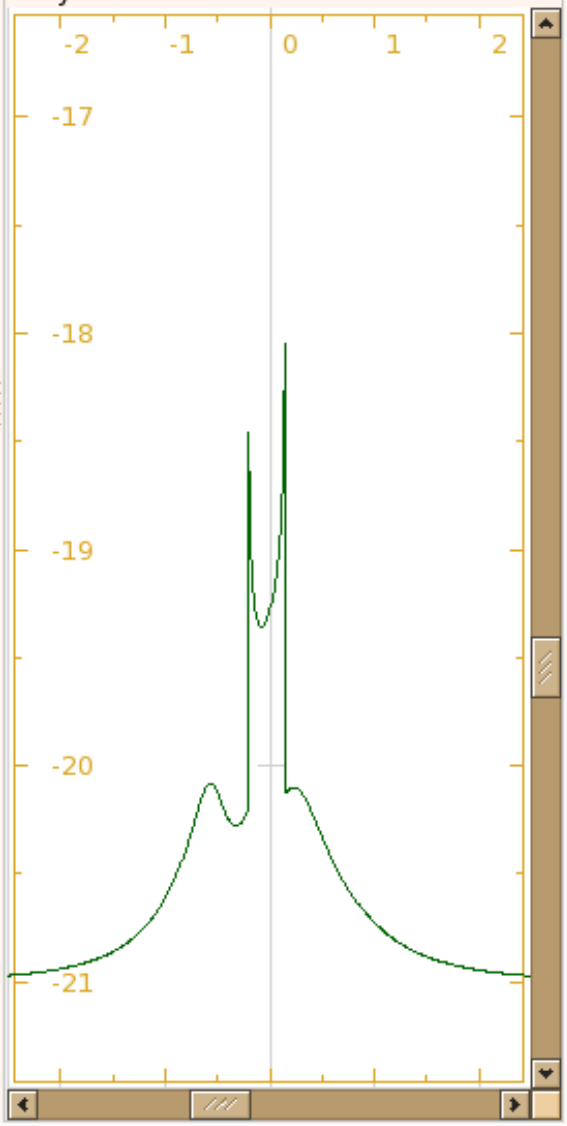
Obrazy:



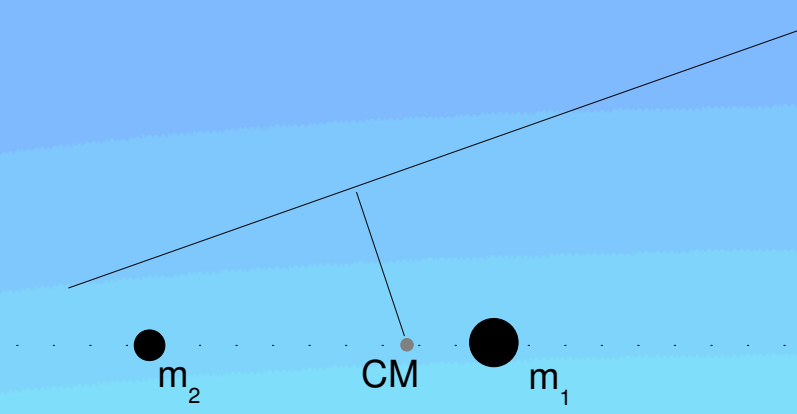
Cała krzywa blasku



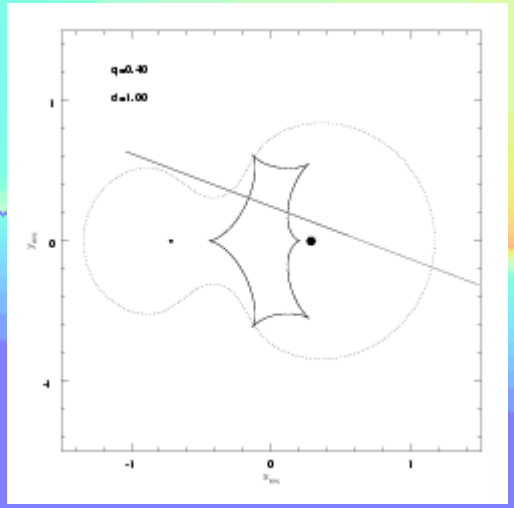
Krzywa blasku

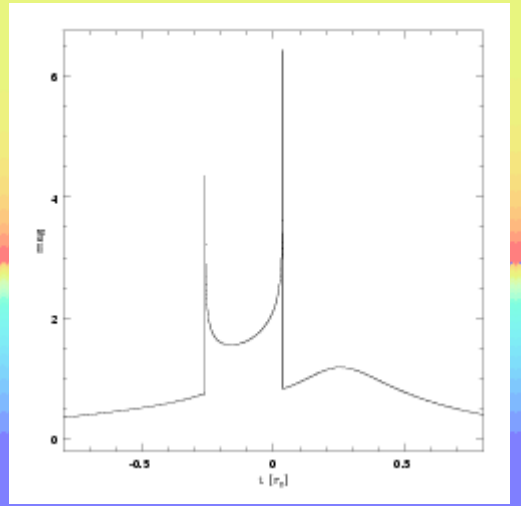


Model parameters



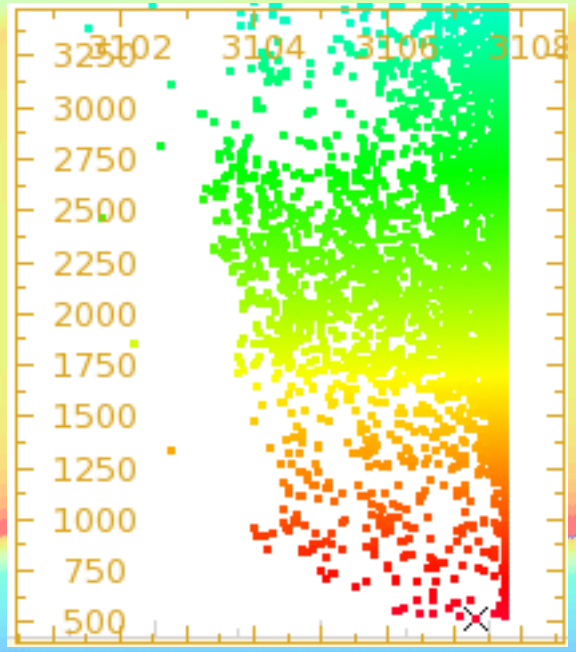
- lens
  - mass ratio
  - separation
- time
  - Einstein time
  - t_0
- trajectory
  - angle
  - distance
- source
  - source size
  - ...





Fitting the model = problems

- non smooth light curves + discrete data
  - gives non smooth χ^2 surface
  - kills standard numerical algorithms
- 6 or more parameters
  - 6-dim space
  - real domain, not grid
- degenerations



Better parametrization

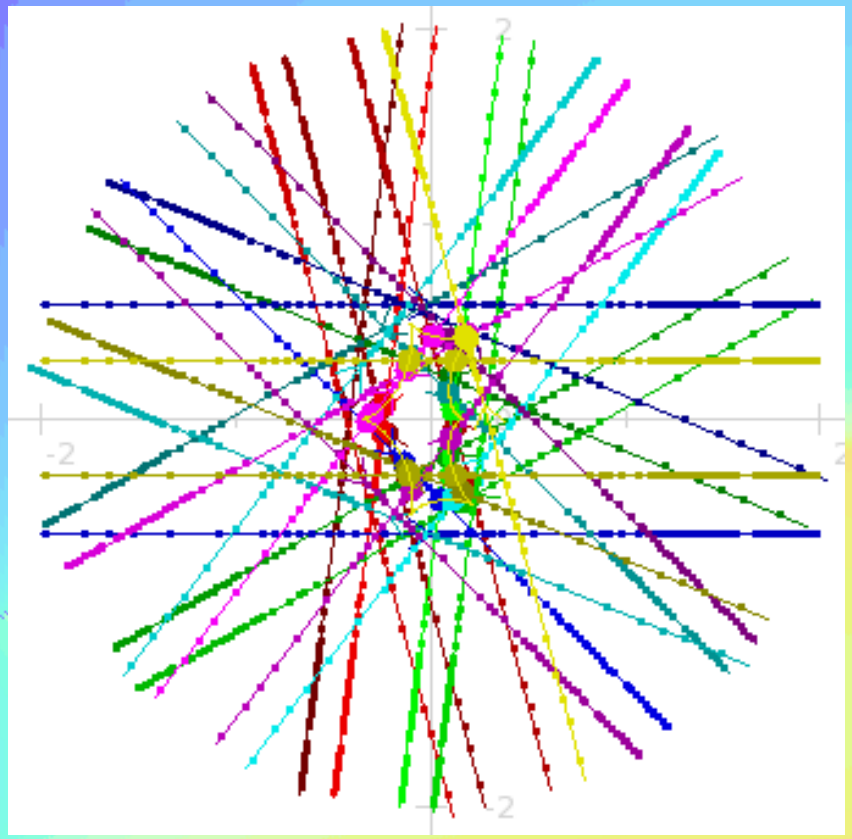
- To speed up search process we have to:
  - make use of all information we have
  - limit search area
  - lower number of parameters

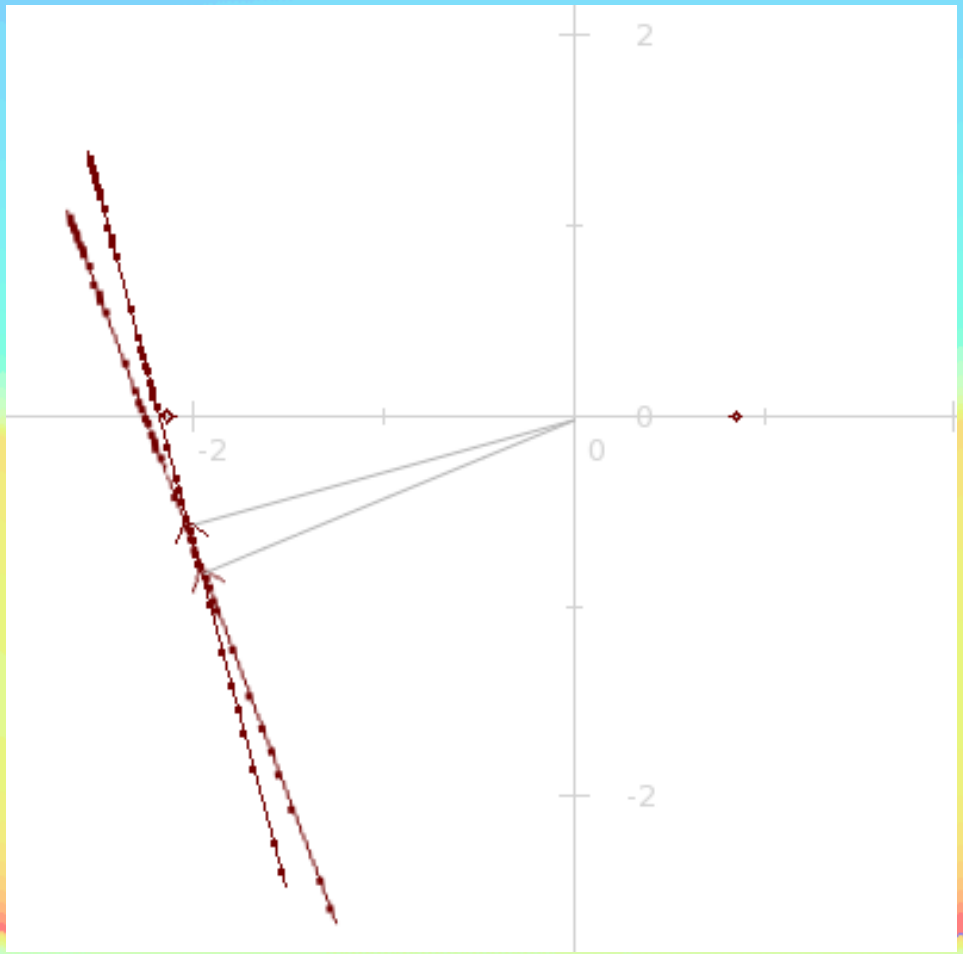
1. Times

T_0 T_E

2. Angle and impact parameter

inefficient search

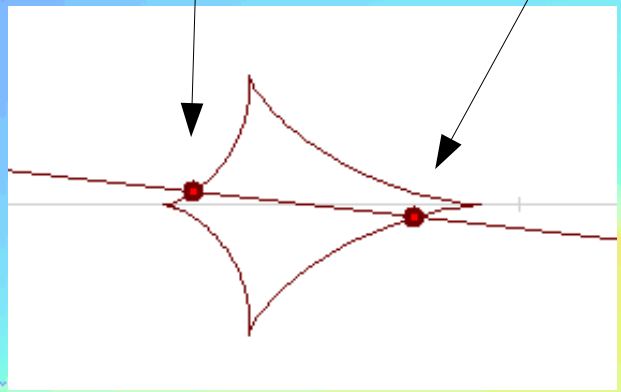


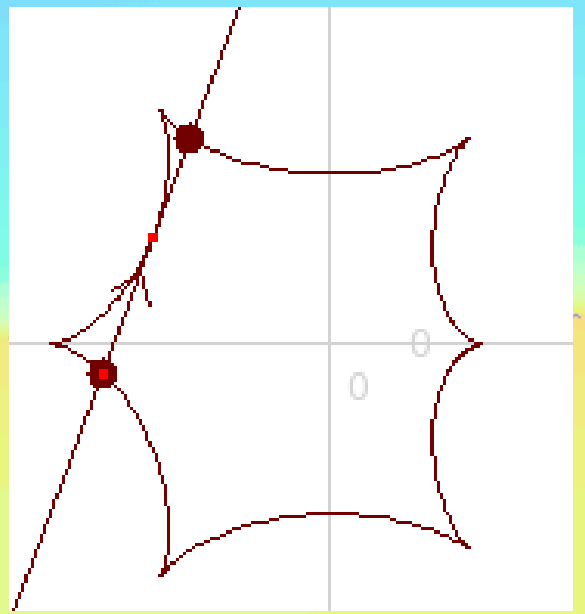


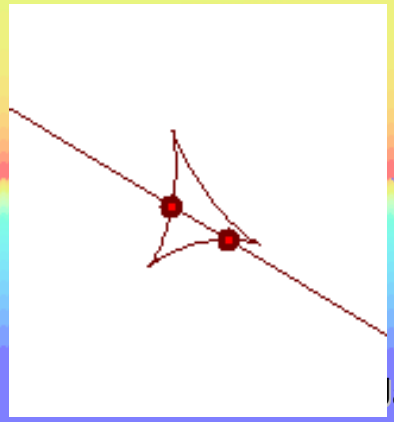
New parameters: **Positions of caustic crossings**

position 1

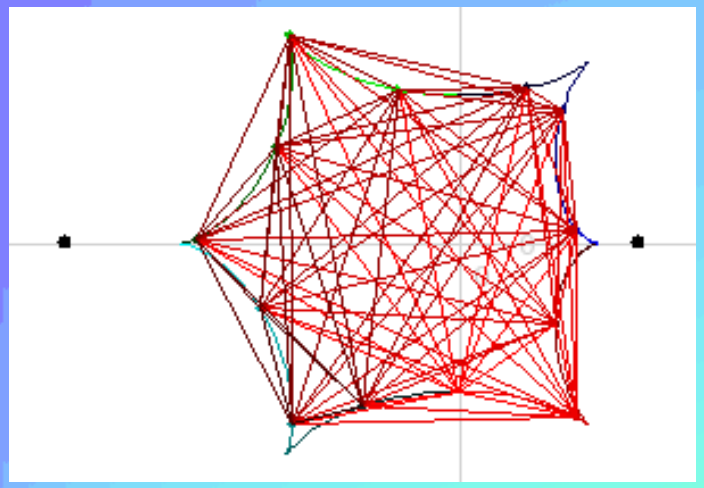
position 2

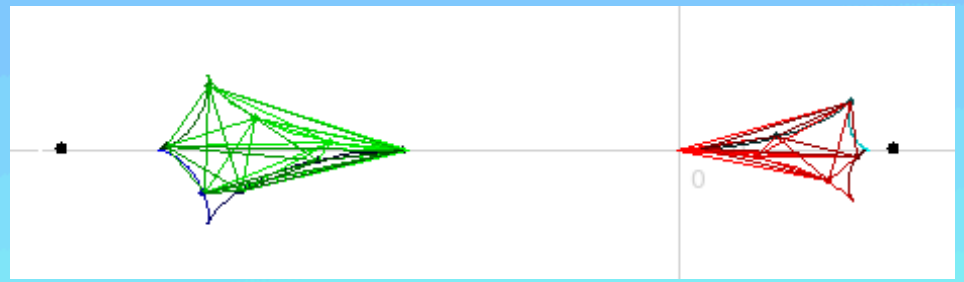


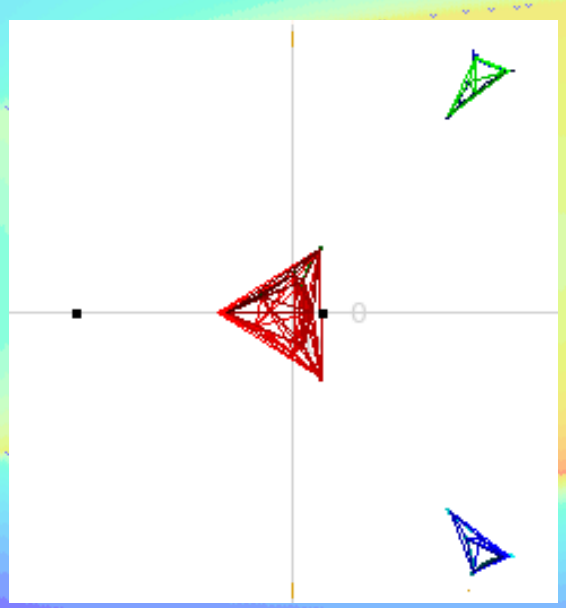




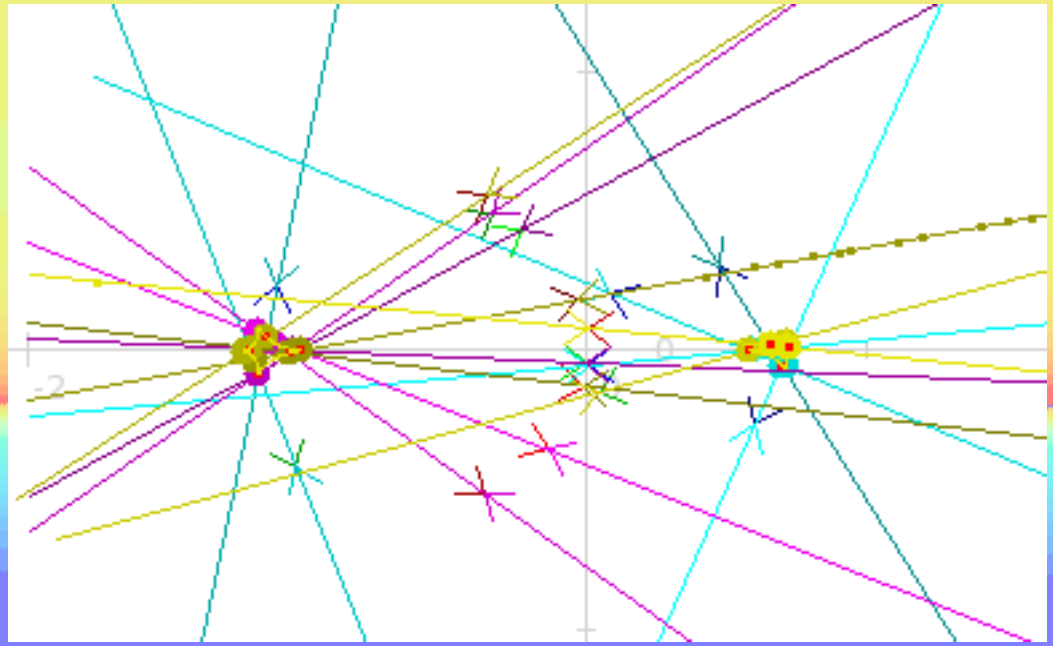
Search is easier



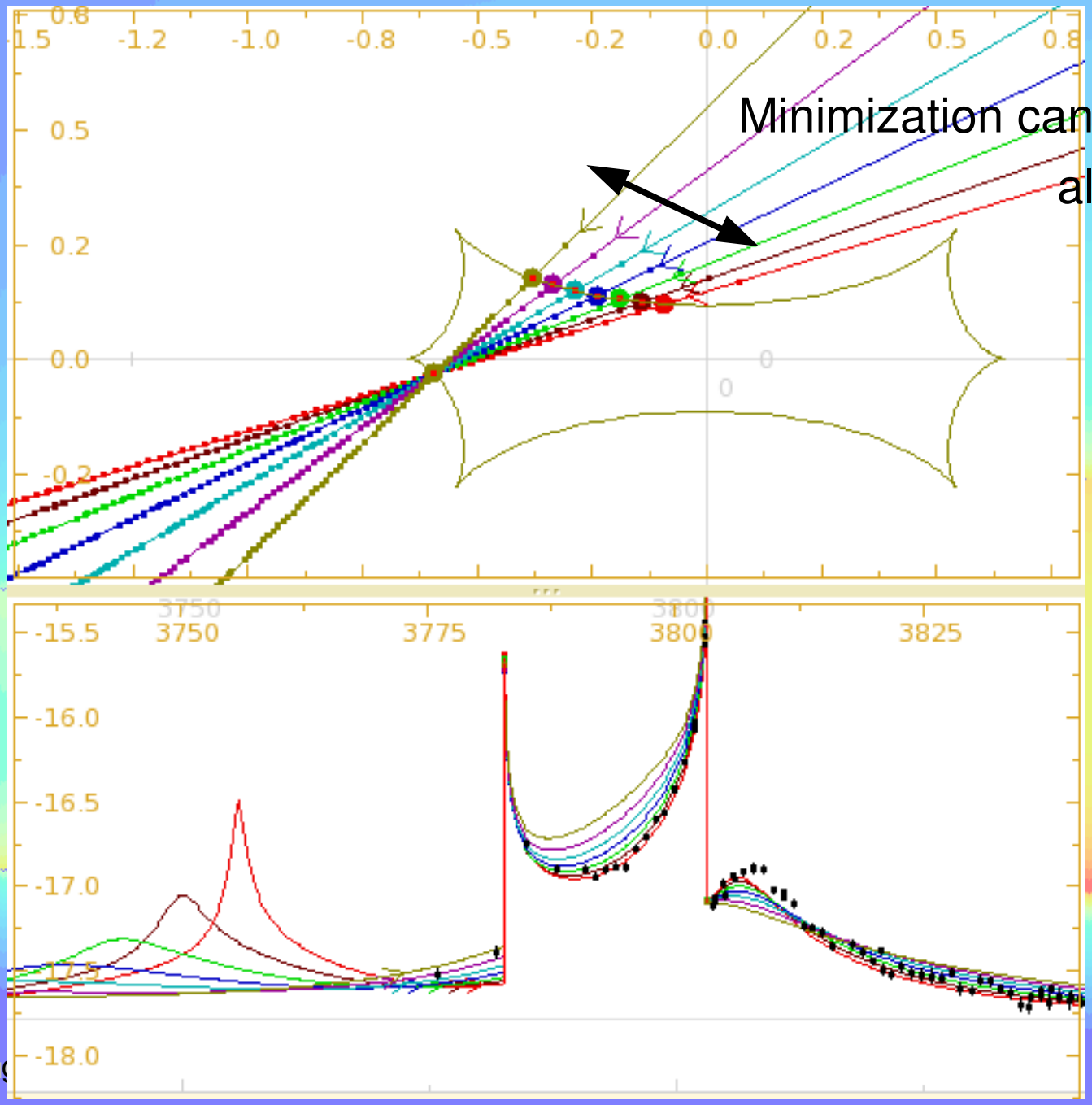




- Only interesting areas are searched

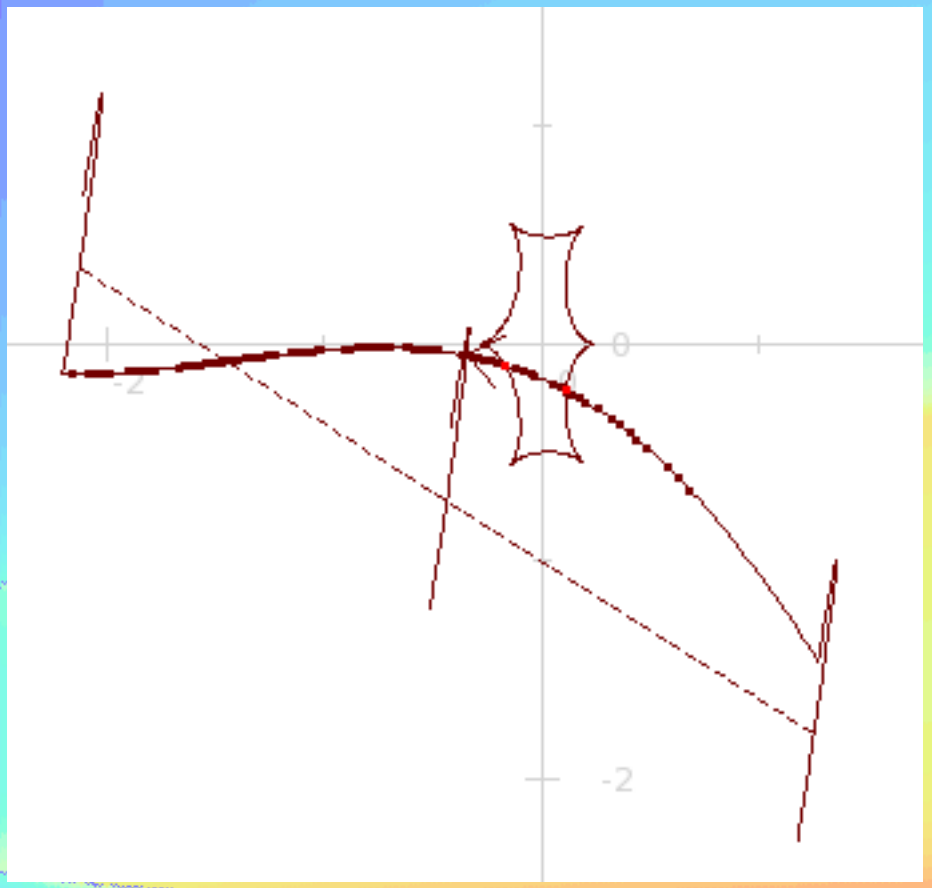


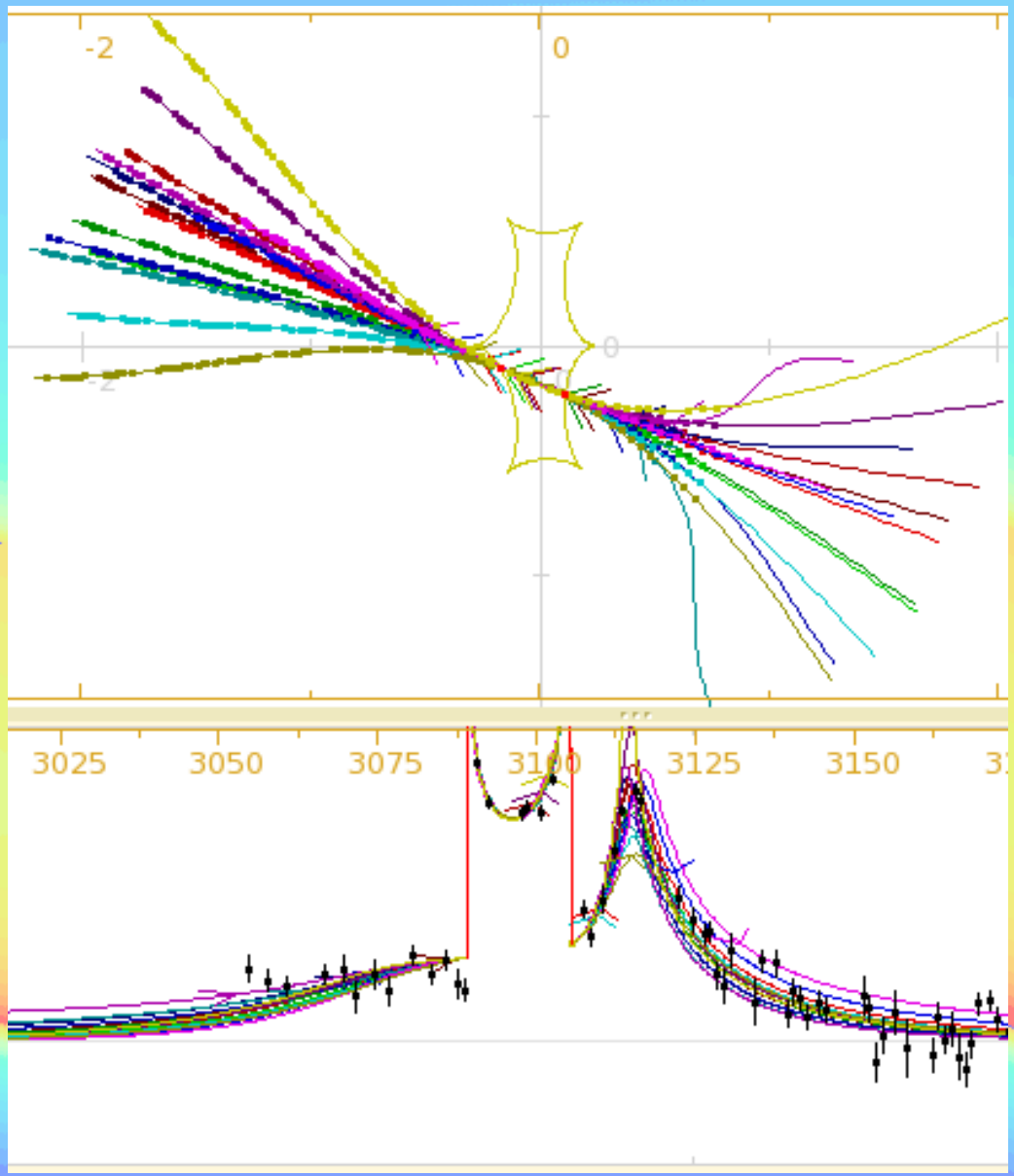
Positions of caustic crossings



Adding parallax

is easier because it doesn't ruin models



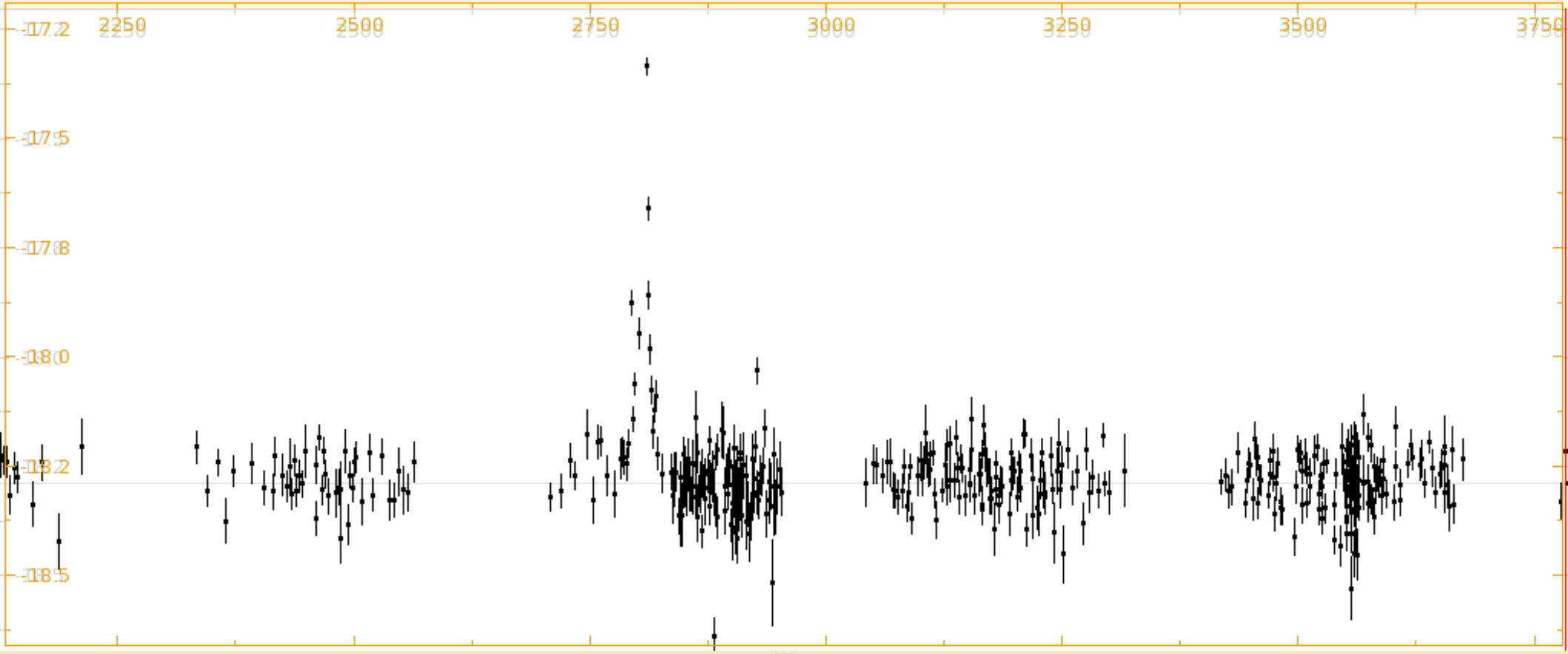


Applications Places System 0:07 22:59:04

LC Show::Krzywa

Otwórz z EWS /home/jskowron/vul/B/03/220/phot.dat 477 480

Ładuj model not loaded 0 Punkty/Linia

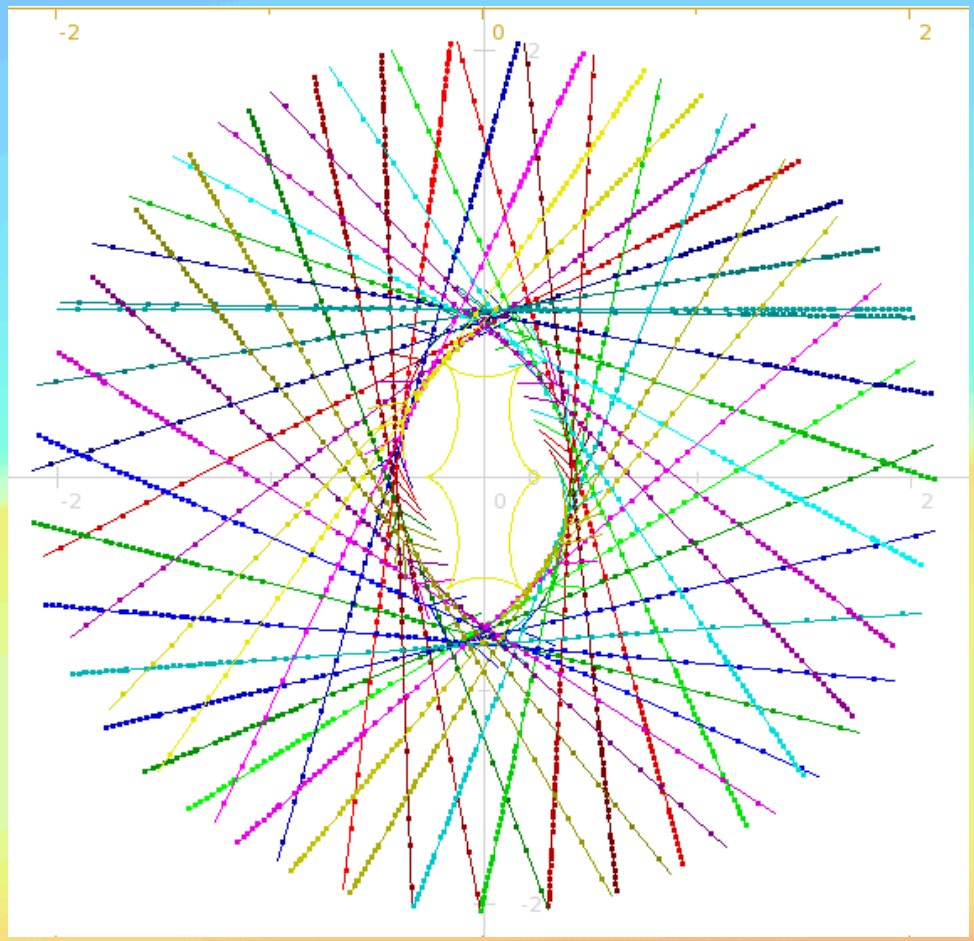


Residua Statystyka

Początek	2122.22	Koniec	3783.62
N poza	3	<Δmag> poza	0.0373333
<mag> poza	18.2877	σ mag poza	0.0760365
χ^2 poza	10.4203	σ mag/<Δmag>	2.03669

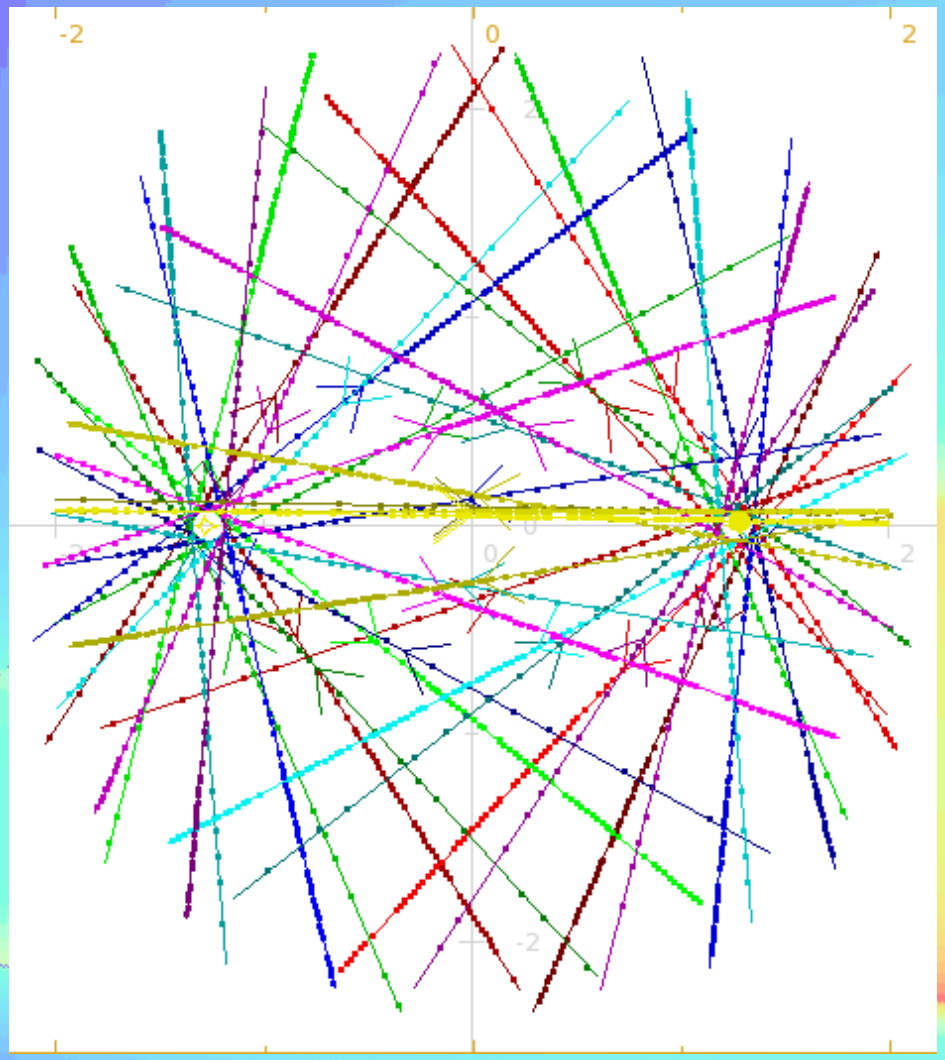
jskowron@ioa-guest25... LC Show LC Show::Krzywa

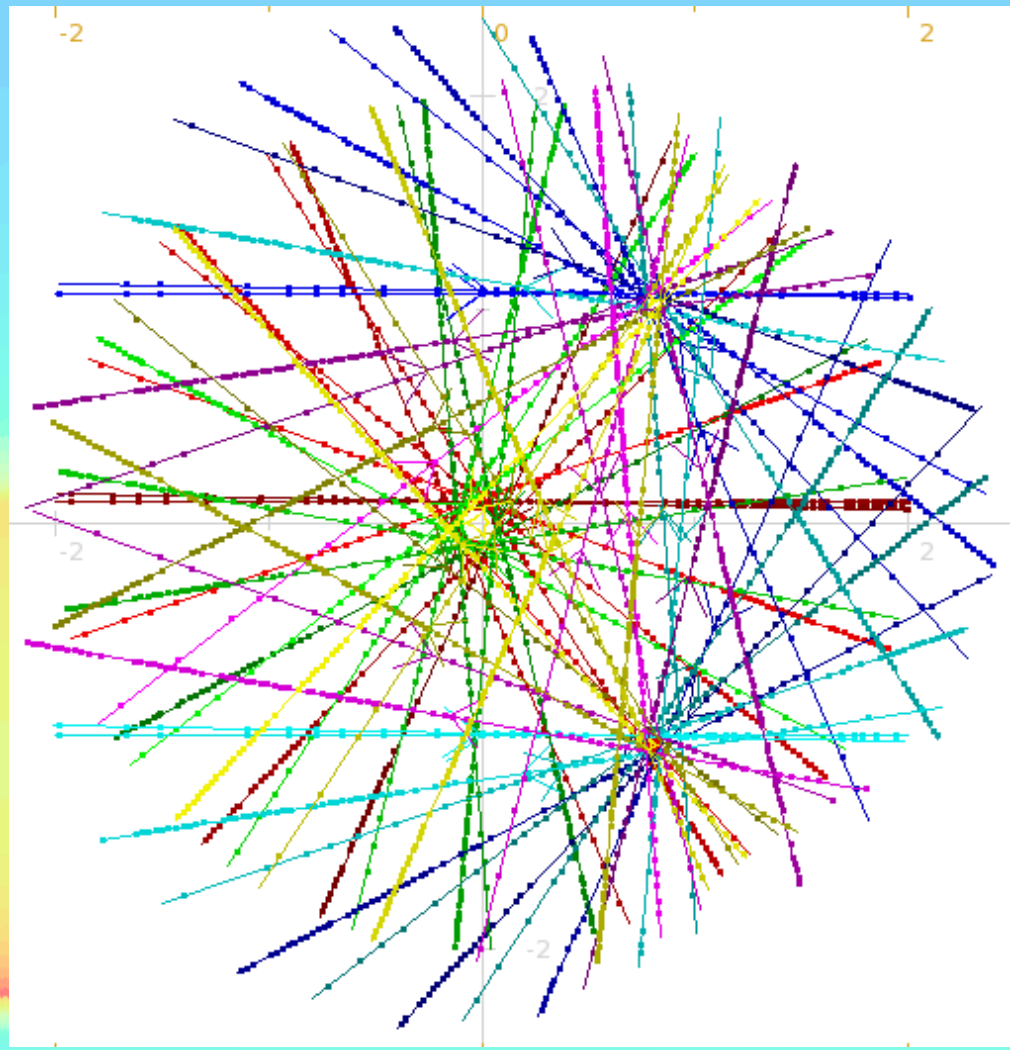
Light curves without clear caustic crossings



we are searching only perimeter or caustics

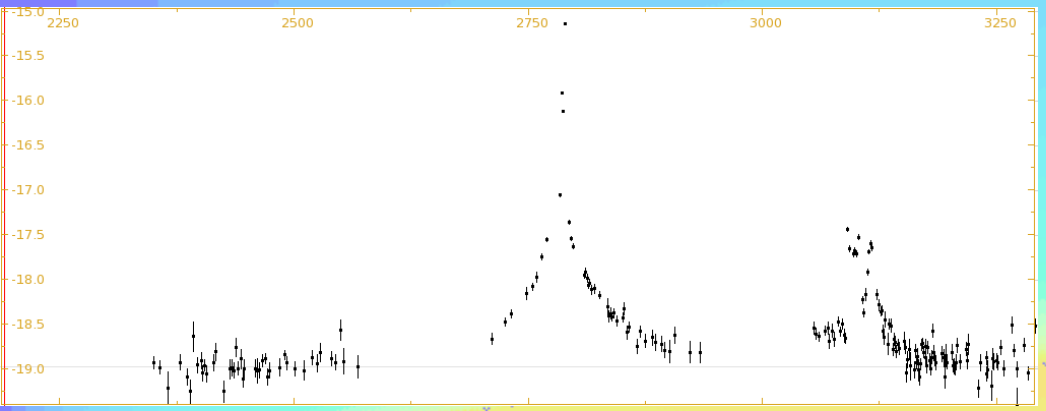
Light curves without clear caustic crossings





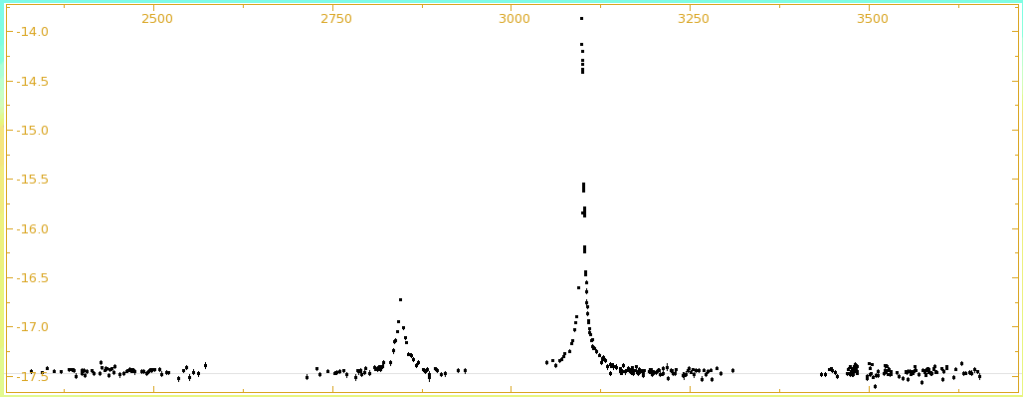
Repeated events

- 2 events on the same star in different seasons



BLG340.5.40104

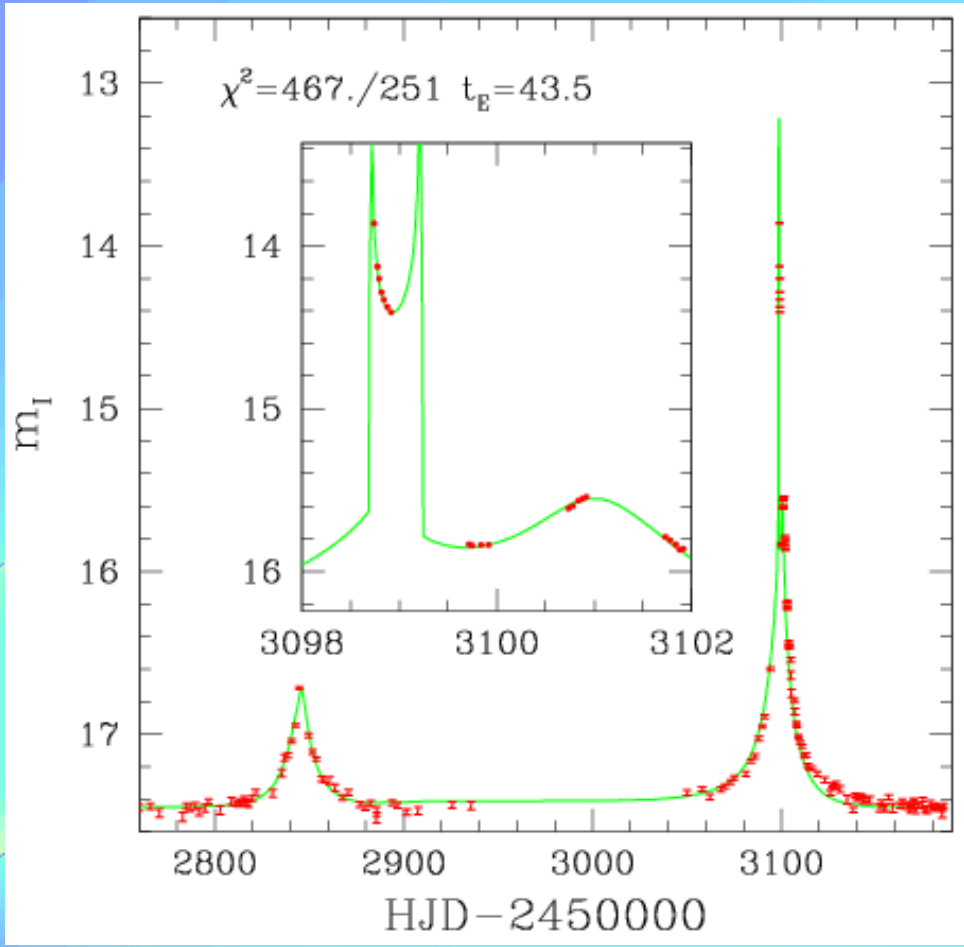
OGLE-2003-BLG-291

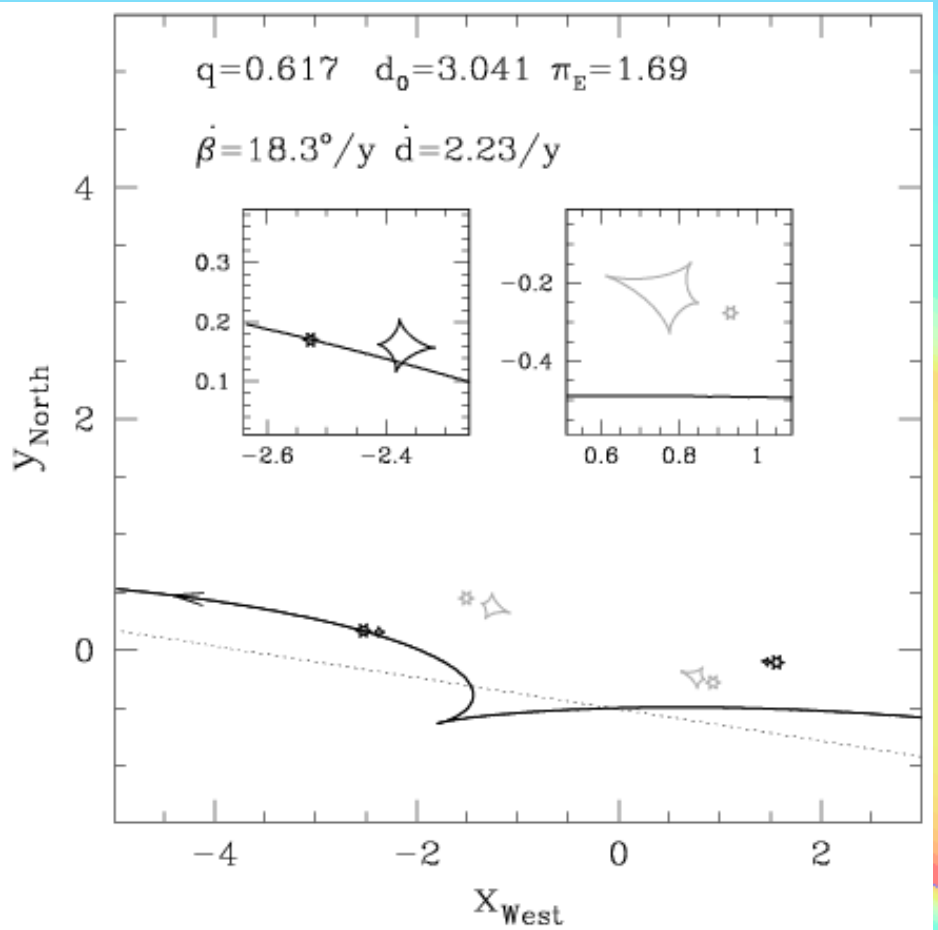


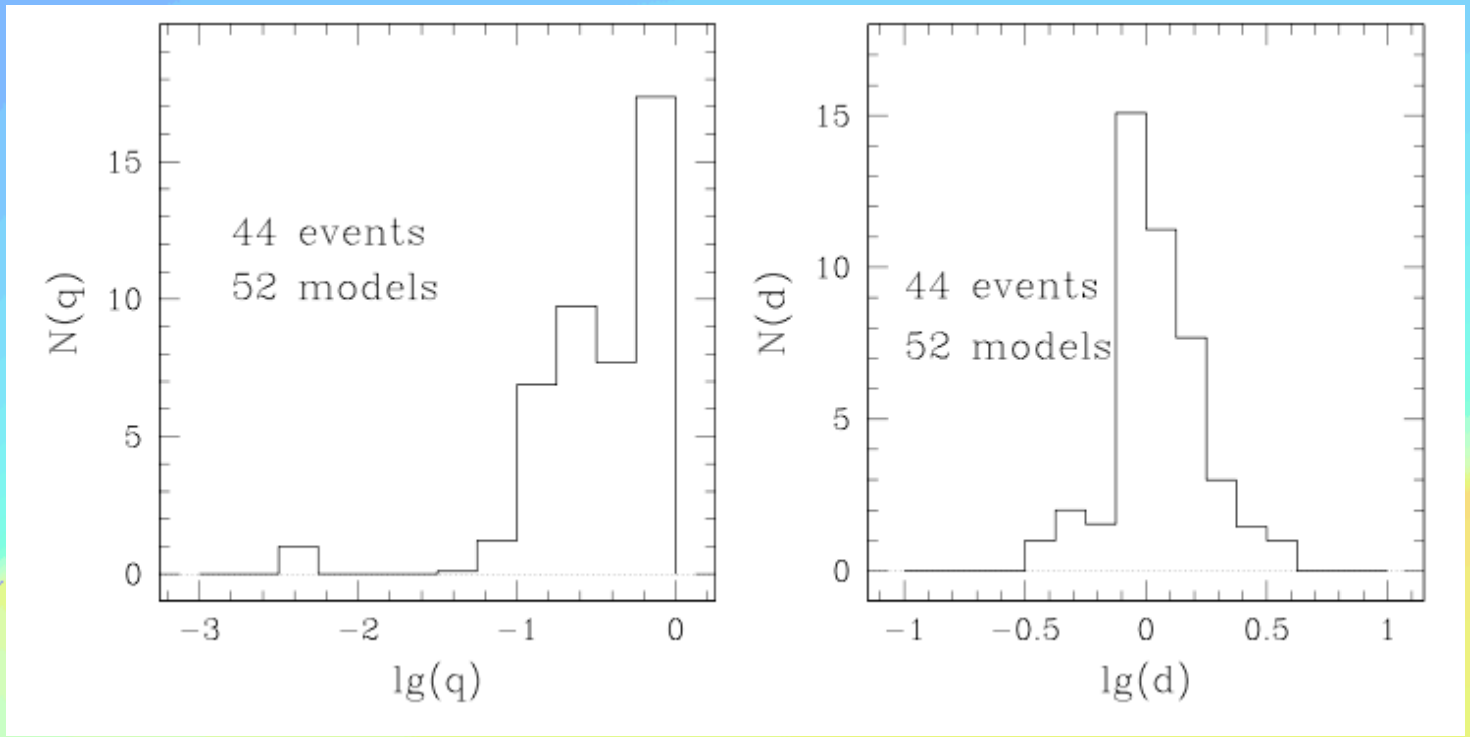
OGLE-1999-BUL-42

OGLE-2003-BLG-220

2003-BLG-291 Previous model






44 events
52 models
N(q)
lg(q)
44 events
52 models
N(d)
lg(d)

The End