Microlensing: Theory, Practice, Results, Future

Workshop 3

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Outline

In this workshop we will:

- Investigate the effect of including finite source star size

Motivation

Understanding the effect of finite source star size in planetary microlensing events is extremely important in some cases.

The exact value of planet mass ratio is a strong function of source star size.

In caustic crossing events, the enstein ring radius can be estimated by fitting for the finite source star size.

We continue to use the `coords` function to generate finite source star lightcurves.

coords

The Matlab function `coords` can produce binary lens lightcurves for both point and finite sized source stars, for any sensible lens and source system values.

`coords` is called in Matlab from the command line and takes a (variable) number of input parameters.

Type `help coords` at any time to get the help text.

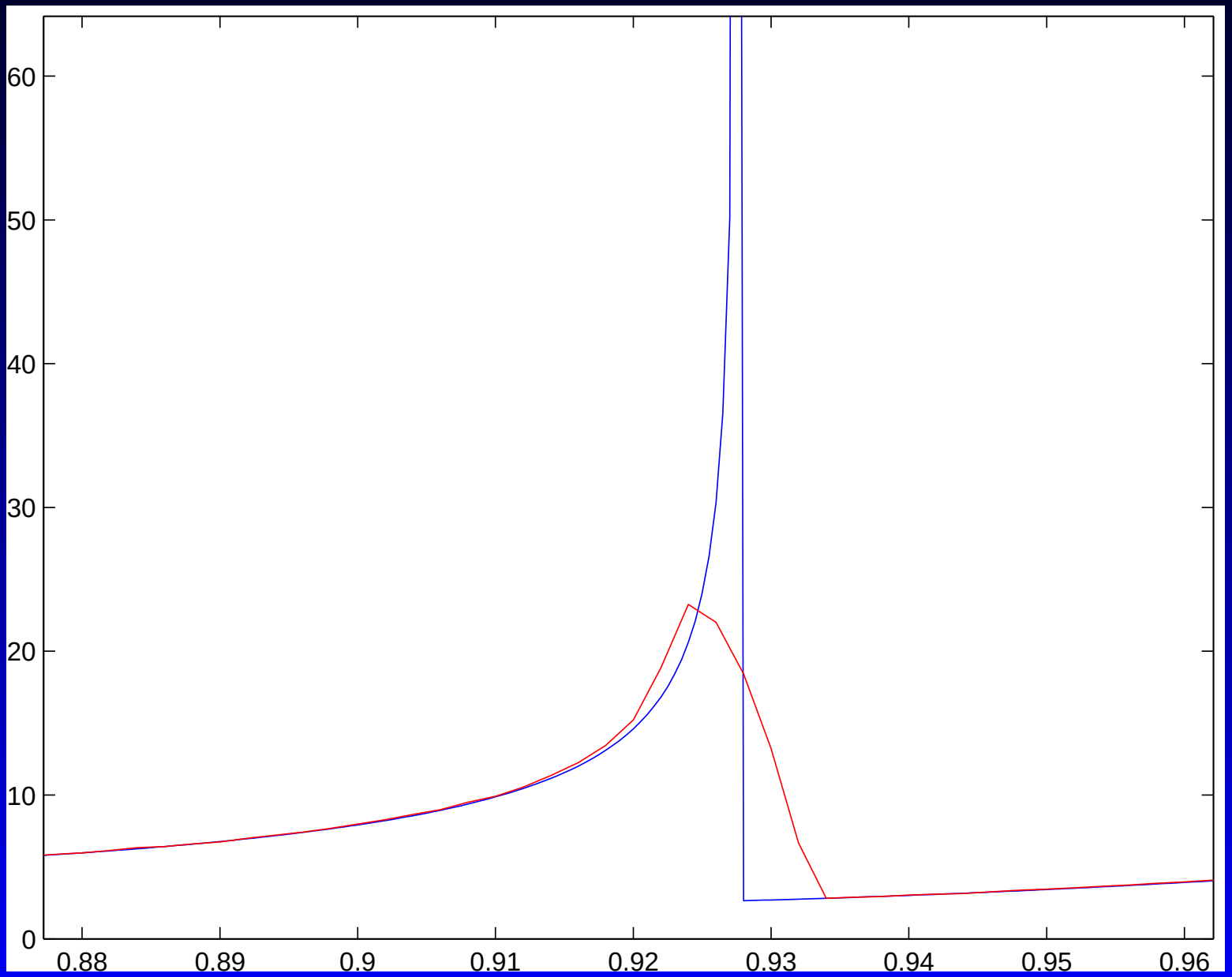
coords

Experiment now with a finite source lightcurve, for various values of r_s.

```
COORDS(Q,D,UMIN,BETA,RS,K1,K2)
coords(0.1,1.5,0.01,pi/2,2e-3,64,64)
```

- RS is source size in units of RE*Ds/Dl
- K1 and K2 are resolution parameters.
- K1 $\in \{32, 64, 128\}$
- K2 $\in \{64, 128\}$
- $r_s \in \{4 \times 10^{-4} : 1 \times 10^{-4} : 1 \times 10^{-3}\}$
- $r_s \in \{1 \times 10^{-3} : 1 \times 10^{-3} : 1 \times 10^{-2}\}$

coords(0.1,1.5,0.01,pi/2,2e-3,64,64)



coords

Try it out, see if you can get some interesting-looking lightcurves.

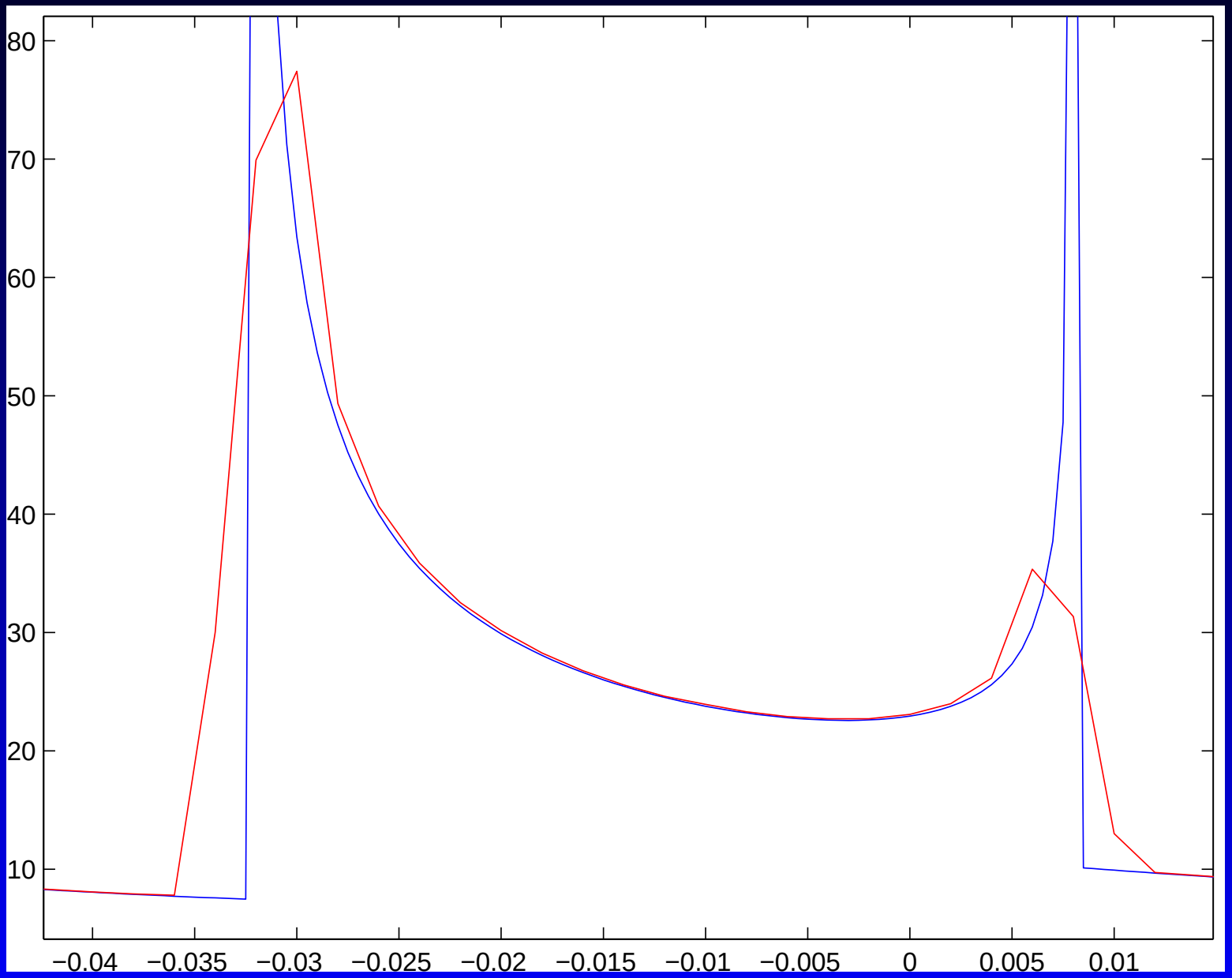
You can always (quickly) get a point source lightcurve, as in the previous workshop, and then try it with a numerical finite source to see the difference.

`coords`

Note:

- `coords` will only work for defined source star sizes and resolution values
- Takes a little time to compute numerical lightcurves, especially for smaller source sizes.
- Try a range of caustic crossing, and caustic approach events.
- The source star radius is shown in the caustic plot.
- Look closely at the source star passage over caustic lines, and relate the first and last contact of the source with the caustic with lightcurve features.

```
coords(0.1,1.5,0.1,3*pi/4,2e-3,64,64)
```



coords

Note:

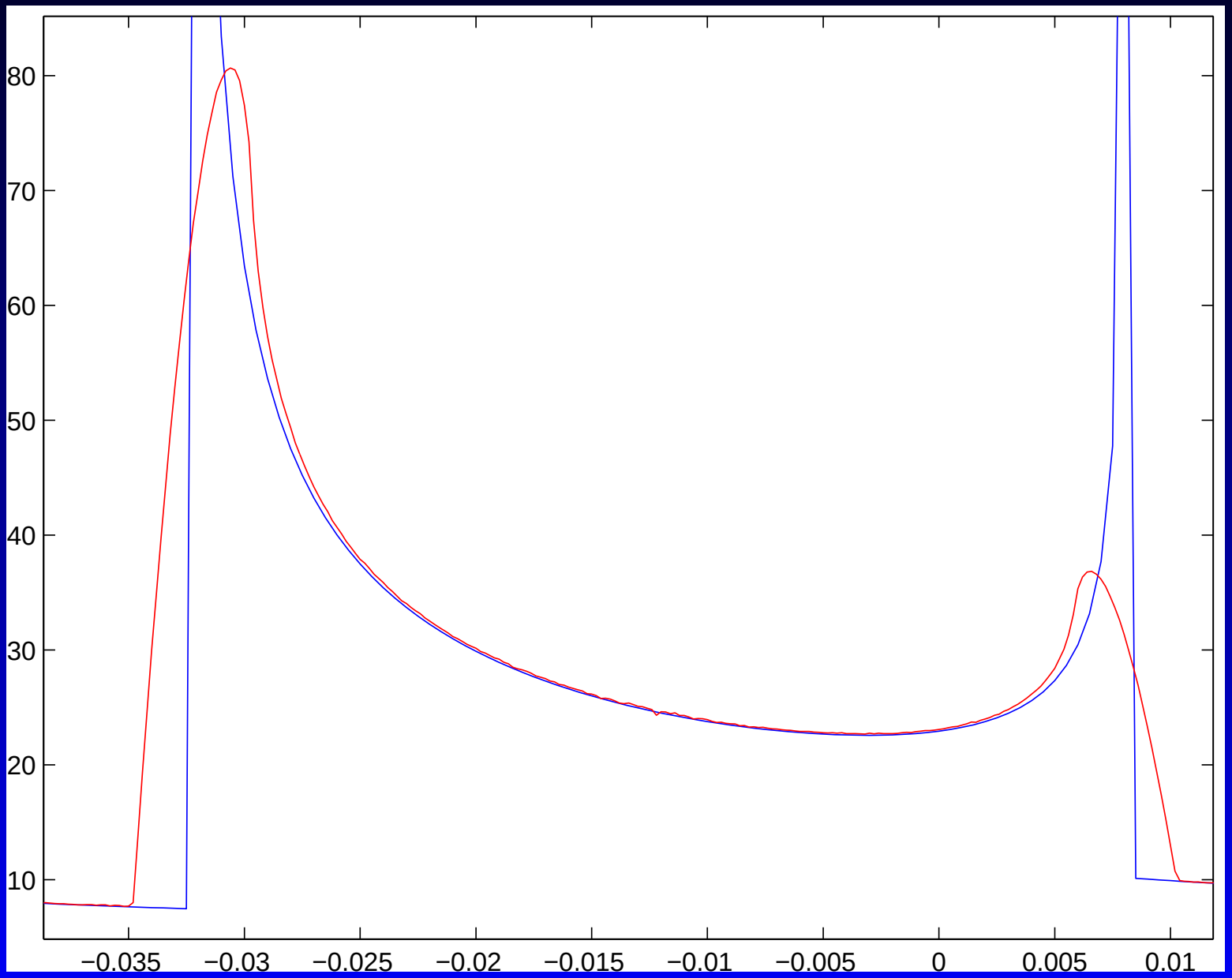
- We can set the length of the numerical lightcurve as follows:

`COORDS(Q,D,UMIN,BETA,RS,K1,K2,LEN)`

where `LEN` is +/- t_N around t_0. Default is 1.0.

```
coords(0.1,1.5,0.1,3*pi/4,2e-3,64,64,0.1)
```

```
coords(0.1,1.5,0.1,3*pi/4,2e-3,64,64,0.1)
```



coords

Note:

- We can also get a very high resolution (temporal) numerical lightcurve as follows:

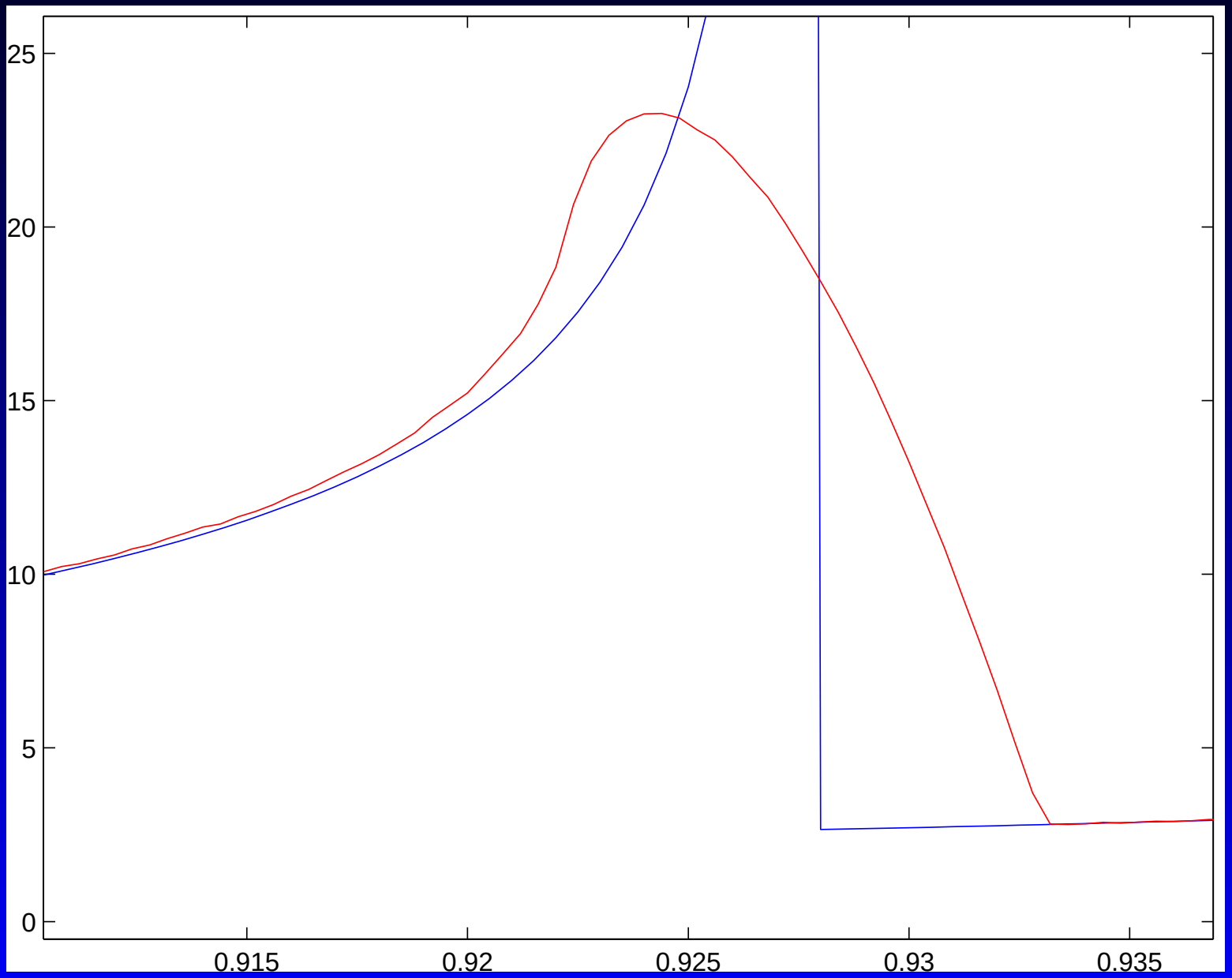
```
COORDS(Q,D,UMIN,BETA,RS,K1,K2,LEN,HIRES)
```

where `HIRES` is not zero.

```
coords(0.1,1.5,0.01,pi/2,2e-3,64,64,1.0,1)
```

Can take a little while.

coords(0.1,1.5,0.01,pi/2,2e-3,64,64,1.0,1)



Discussion Point

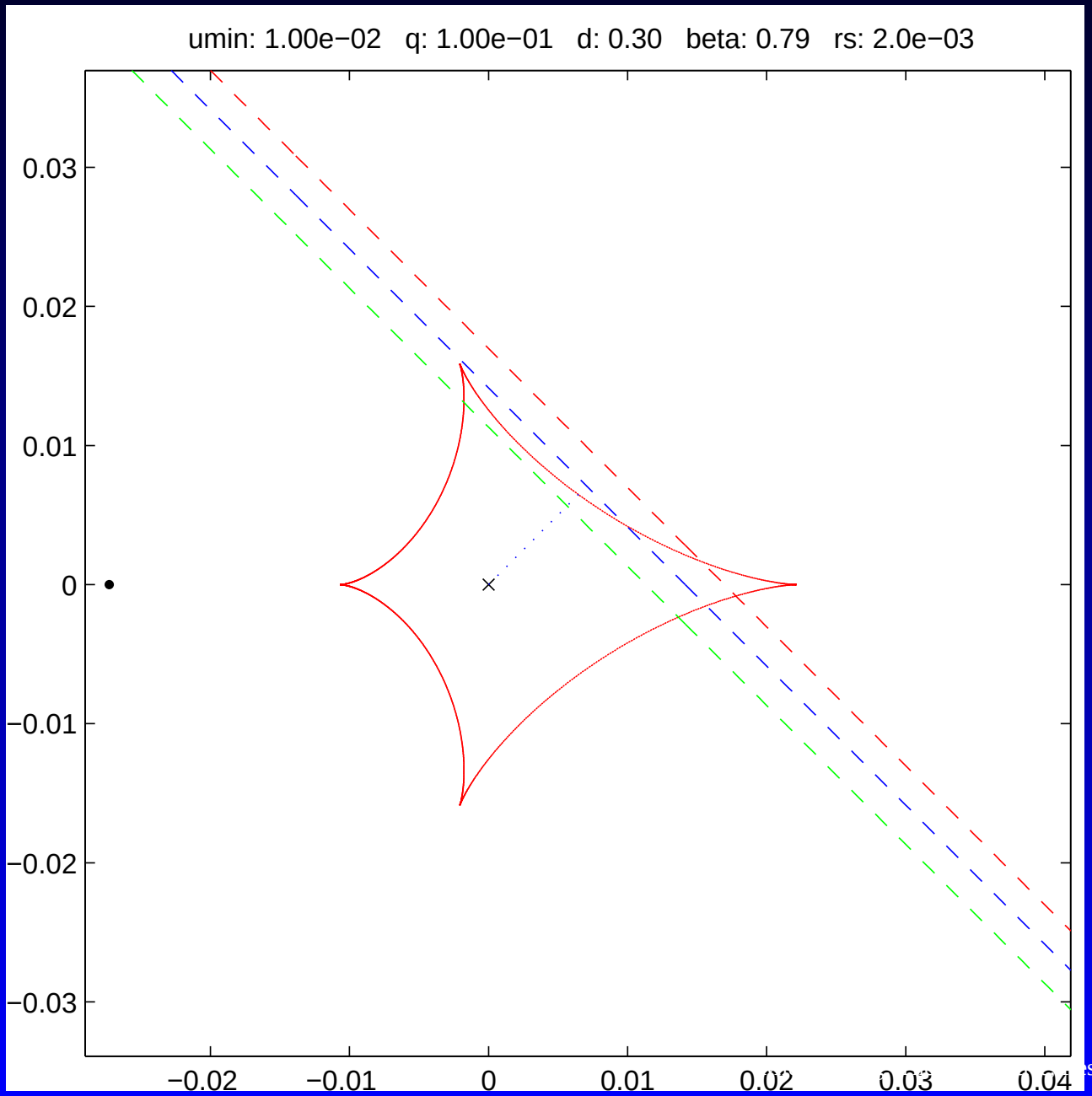
Consider the following system:

```
coords(0.1,0.3,0.01,pi/4)
```

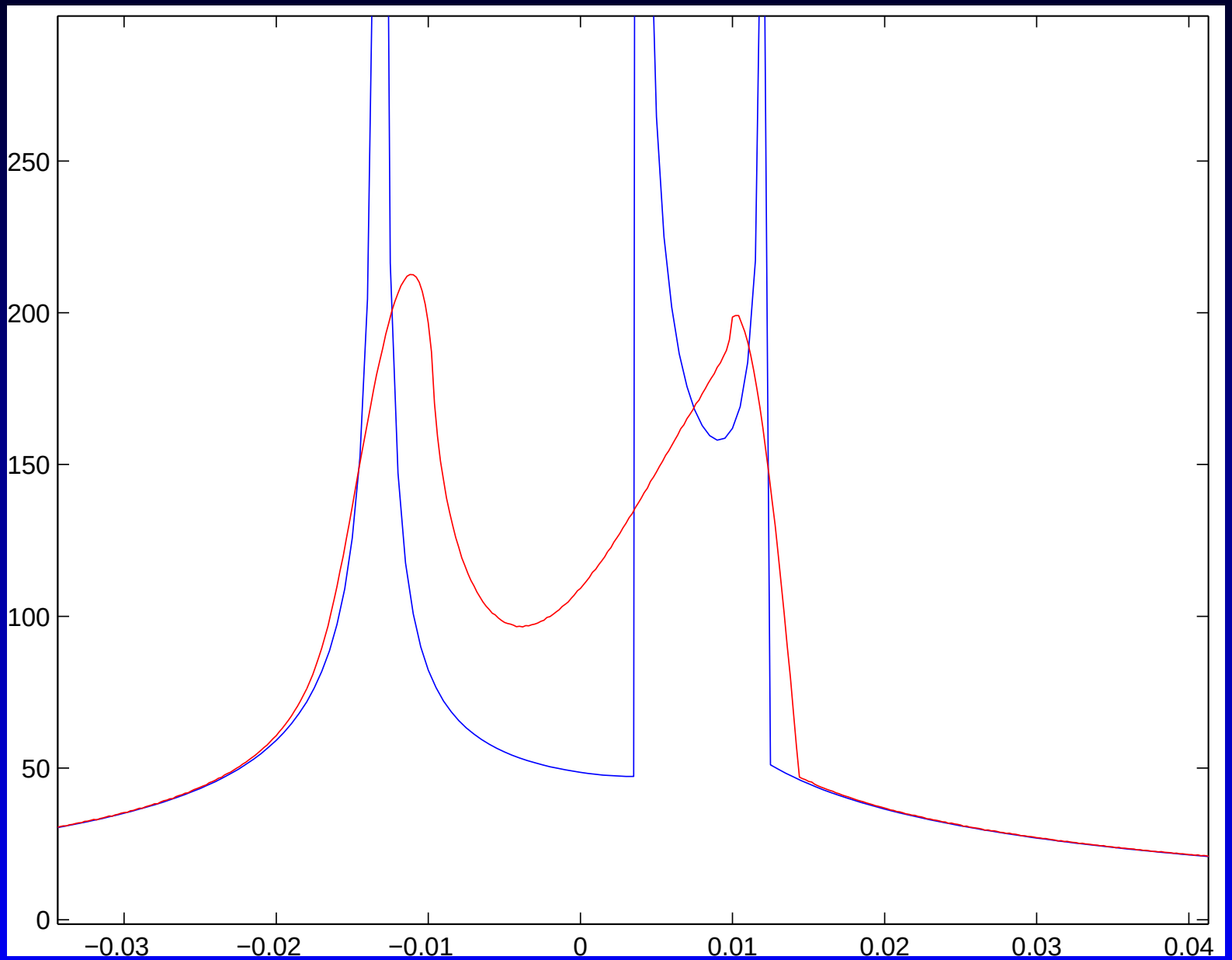
and investigate the effect of increasing the source size, e.g.

```
coords(0.1,0.3,0.01,pi/4,2e-3,64,64,0.1)
coords(0.1,0.3,0.01,pi/4,6e-3,64,64,0.1)
```

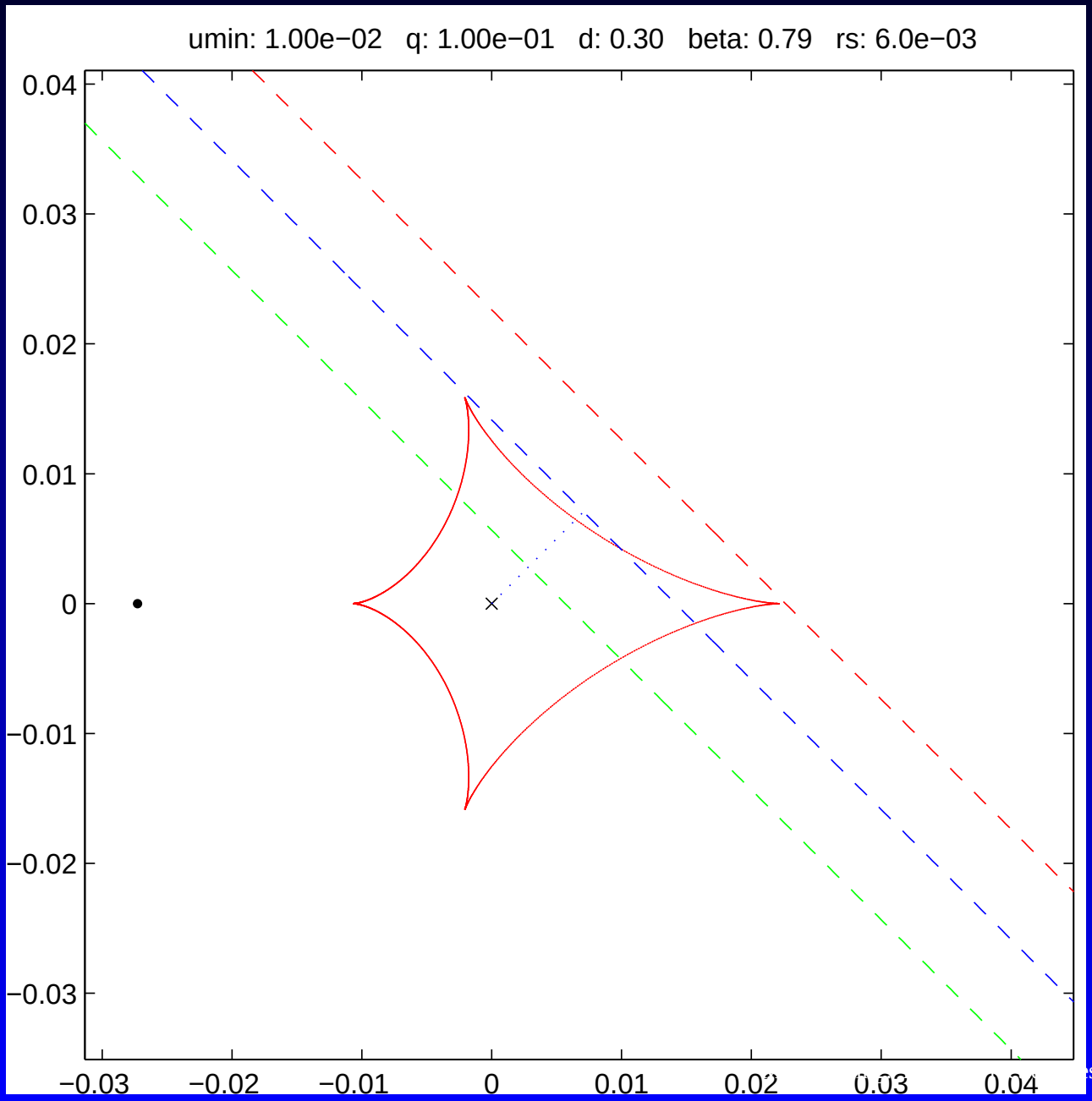
coords(0.1,0.3,0.01,pi/4,2e-3,64,64,0.1)



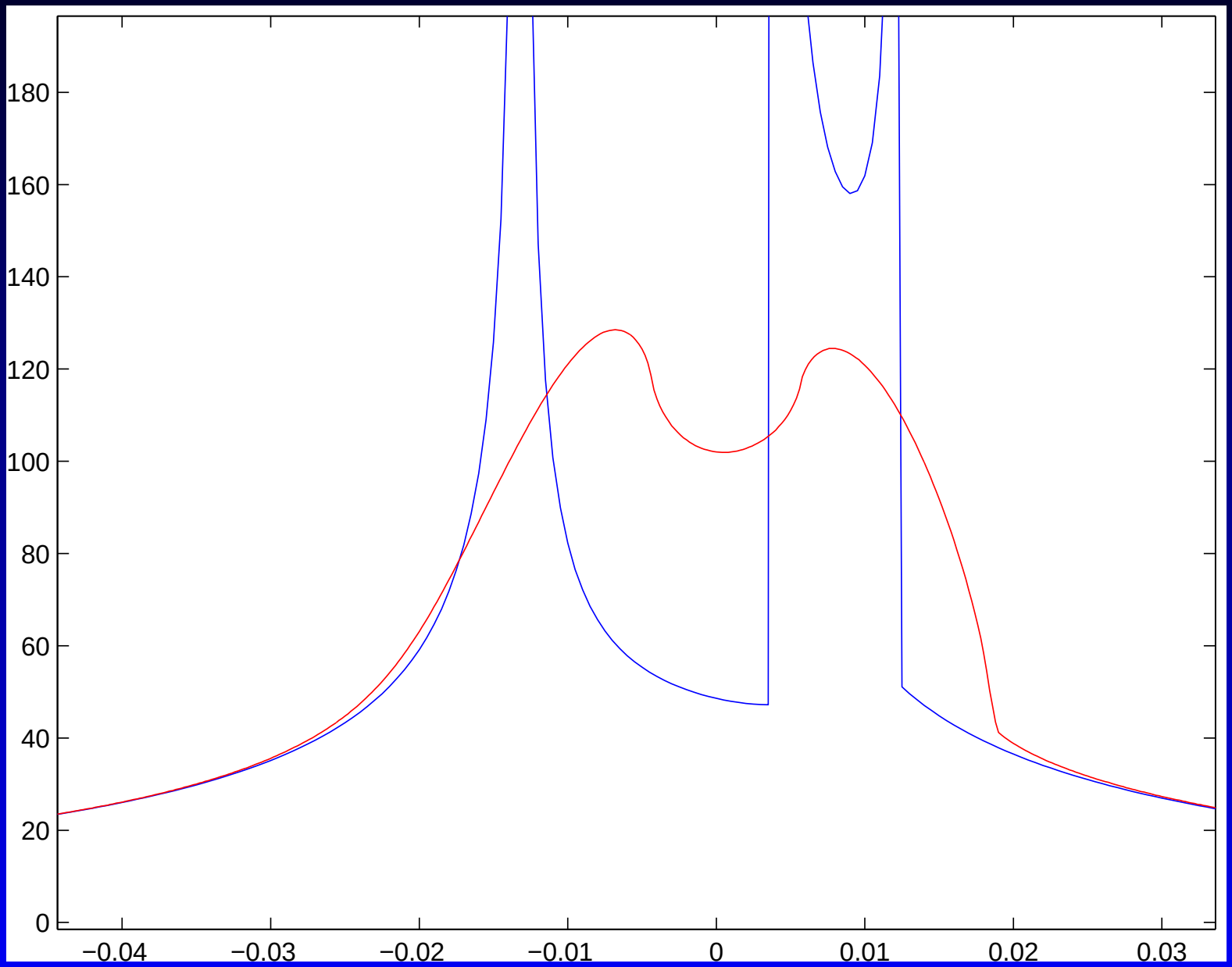
coords(0.1,0.3,0.01,pi/4,2e-3,64,64,0.1)



coords(0.1,0.3,0.01,pi/4,6e-3,64,64,0.1)



coords(0.1,0.3,0.01,pi/4,6e-3,64,64,0.1)

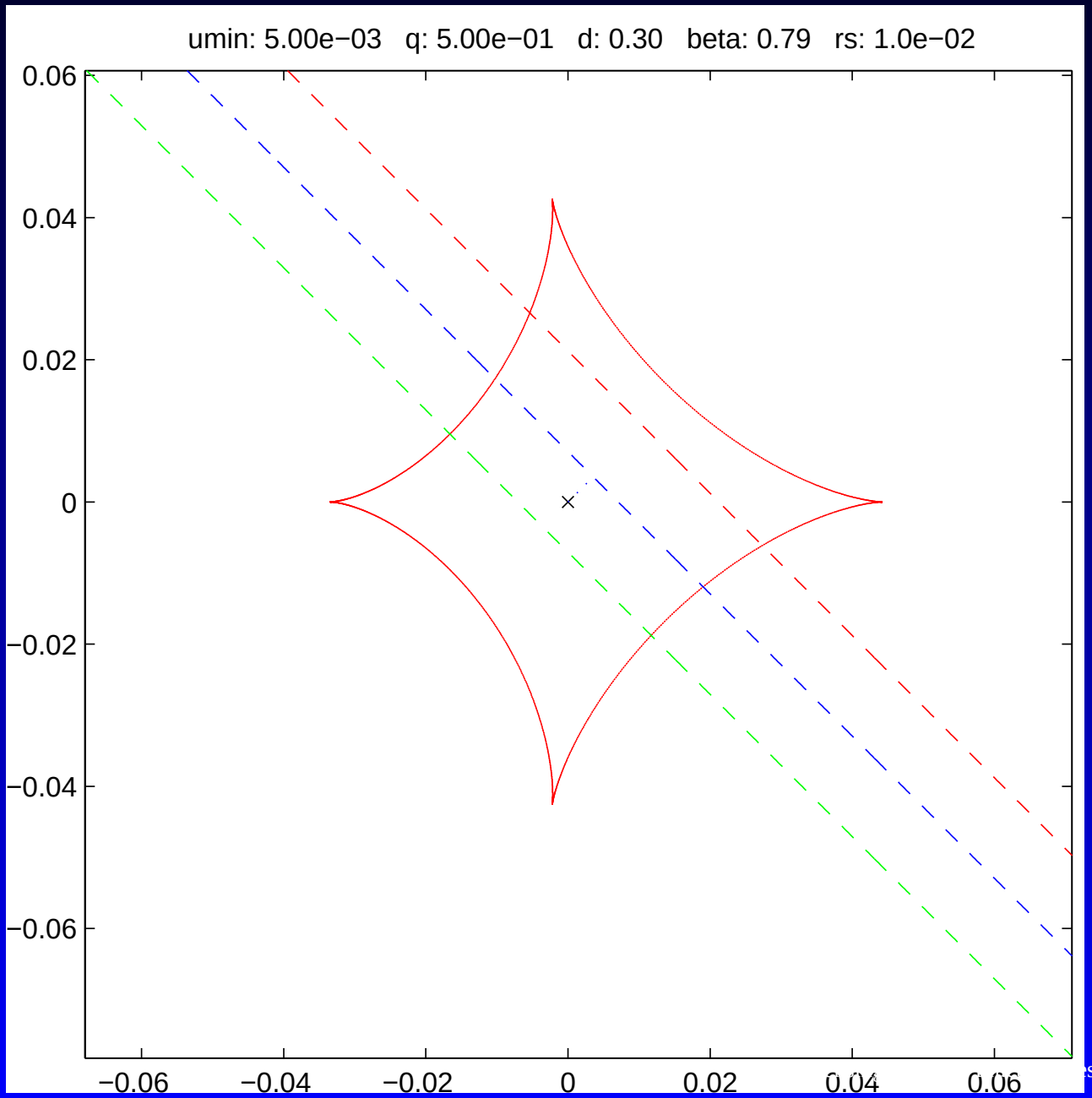


Discussion Point

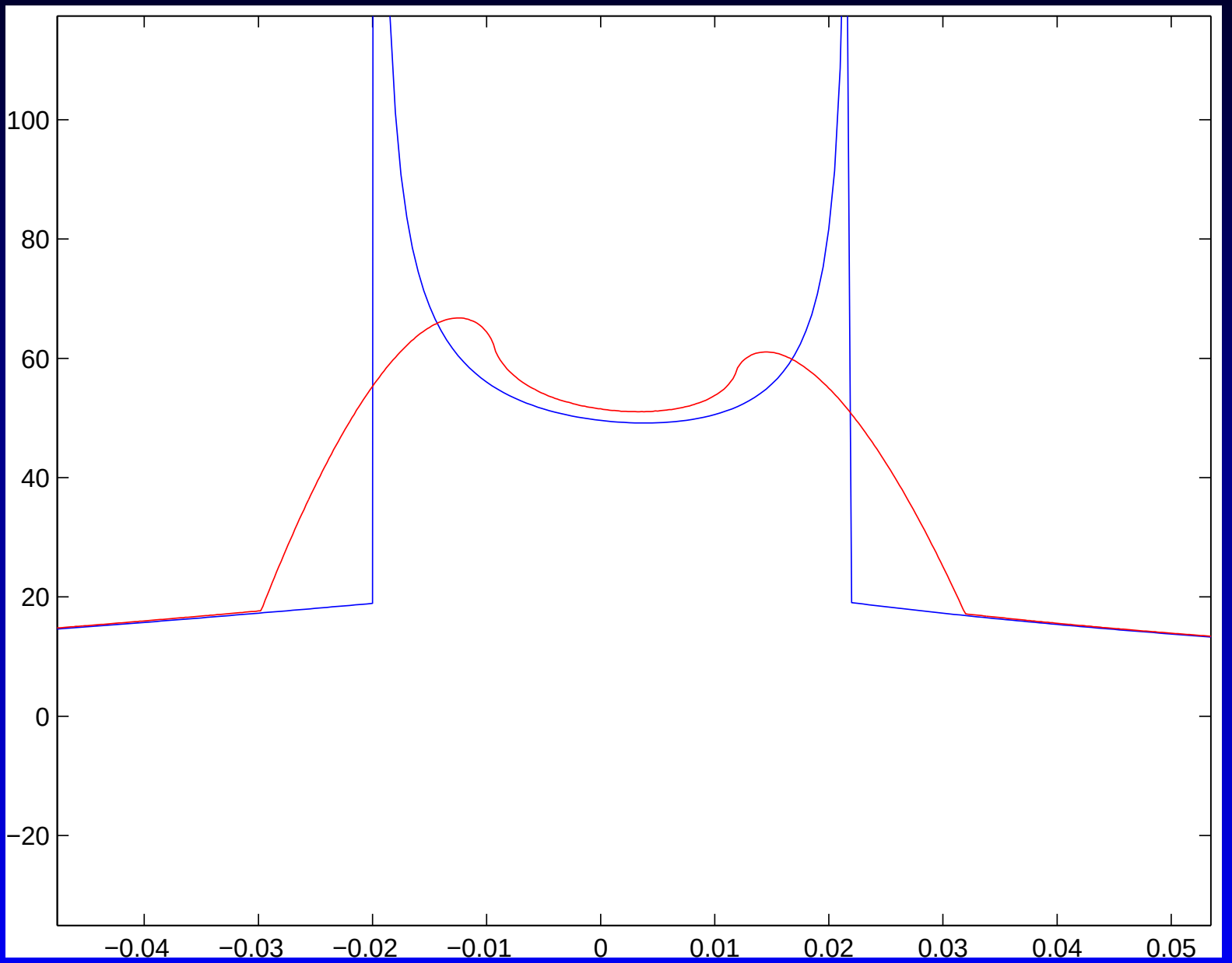
Consider the following system:

```
coords(0.5,0.3,0.005,pi/4,1e-2,32,64,0.1)
```

coords(0.5,0.3,0.005,pi/4,1e-2,32,64,0.1)



coords(0.5,0.3,0.005,pi/4,1e-2,32,64,0.1)

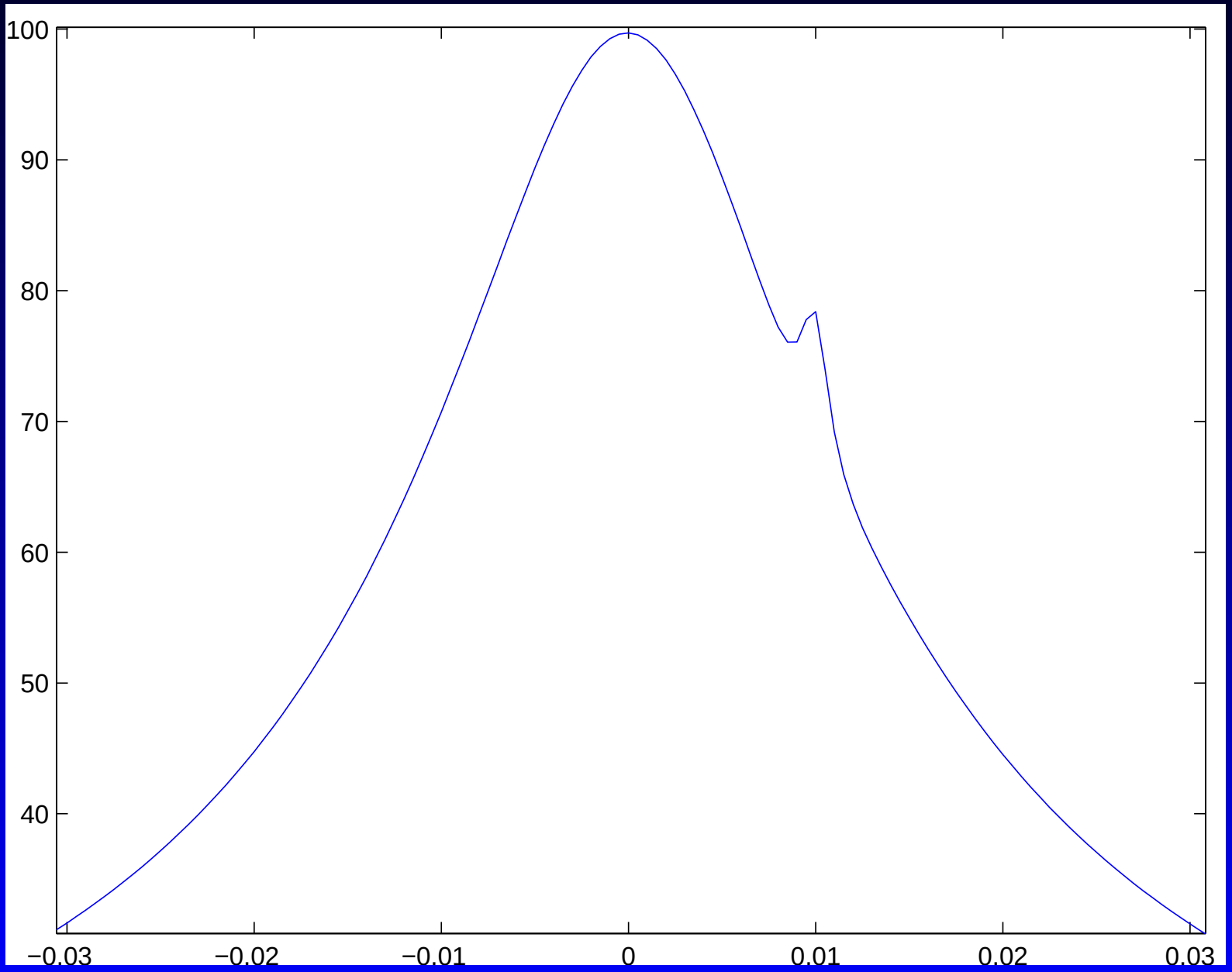


Discussion Point

Consider the following high mag event showing a planetary perturbation:

```
coords(2e-5,1.1,0.01,pi/4)
```

coords(2e-5,1.1,0.01,pi/4)



Discussion Point

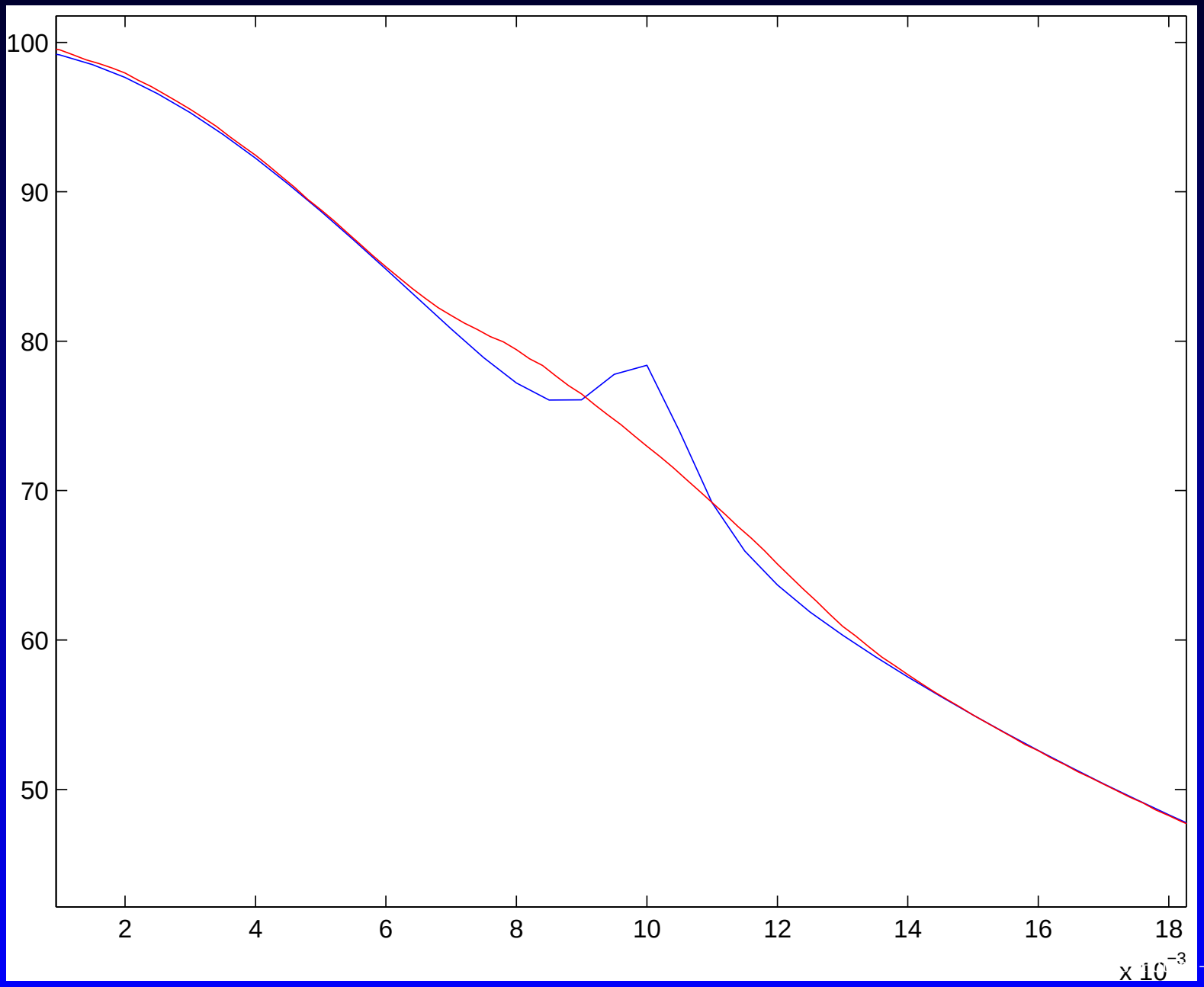
Consider the following high mag event showing a planetary perturbation:

```
coords(2e-5,1.1,0.01,pi/4)
```

And now the effect of increasing the source size:

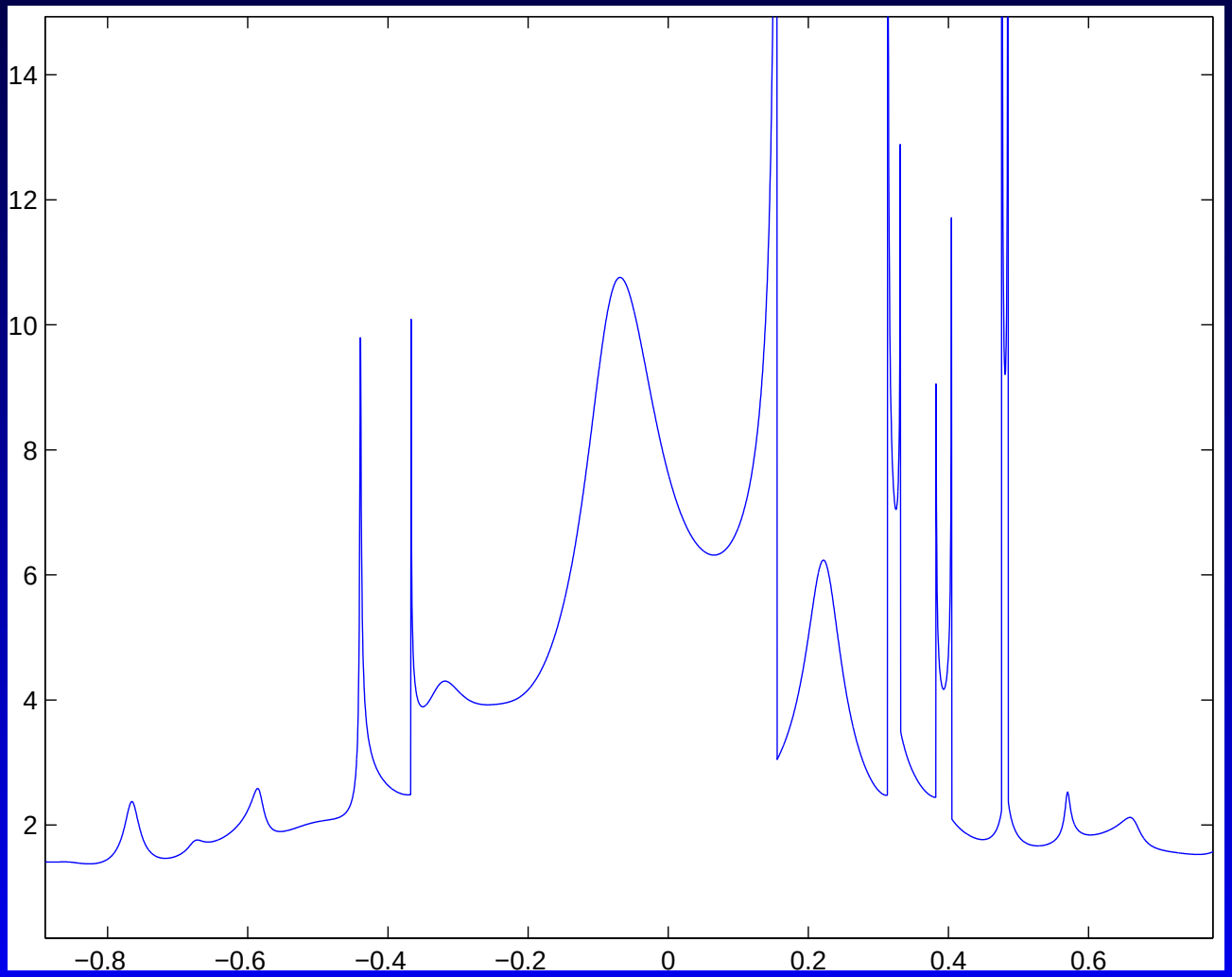
```
coords(2e-5,1.1,0.01,pi/4,2e-3,128,64,0.1)
```

coords(2e-5,1.1,0.01,pi/4,2e-3,128,64,0.1)

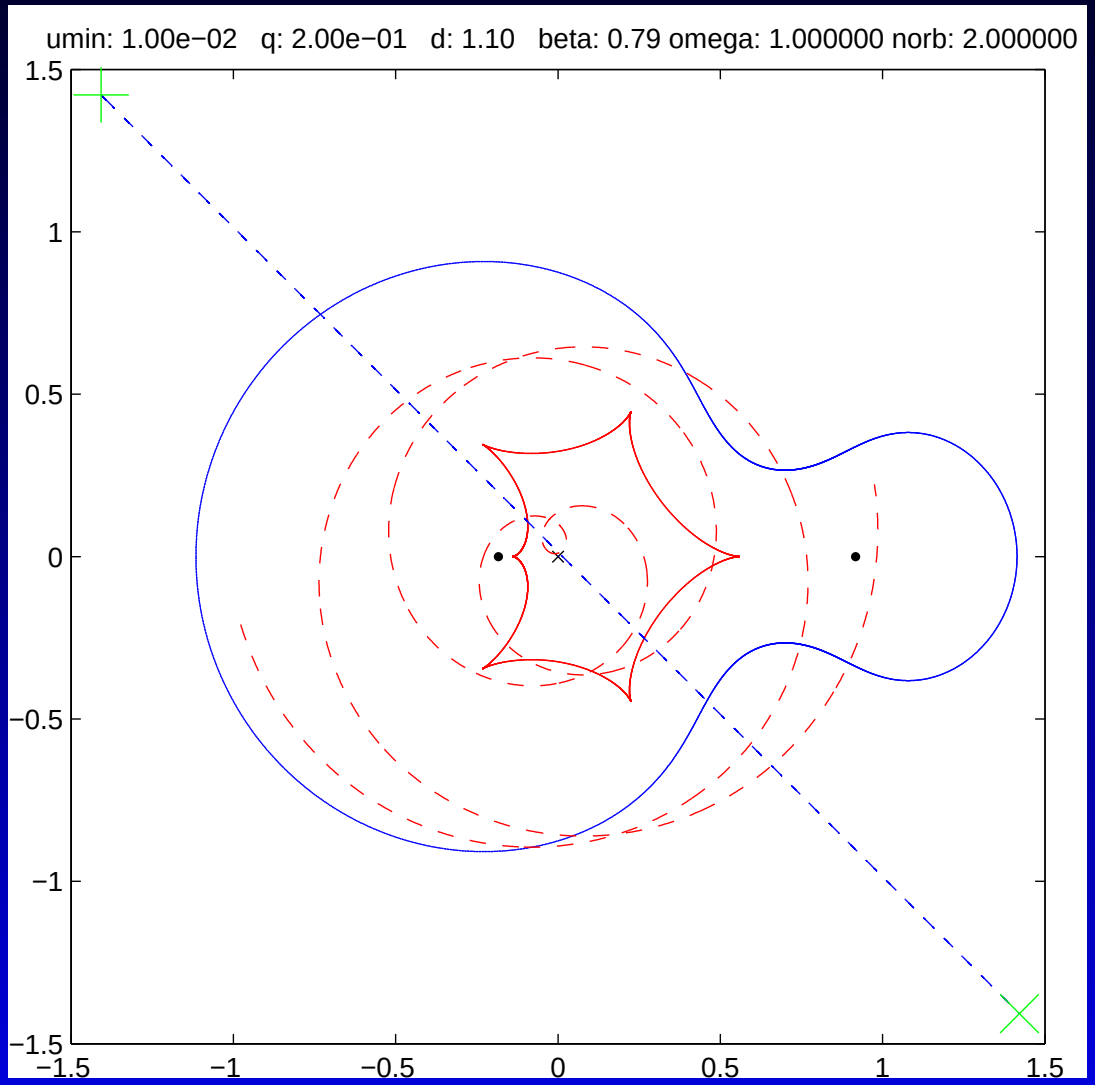


Challange

Using `coords`, try to reproduce the following lightcurve:



Unfair challange!



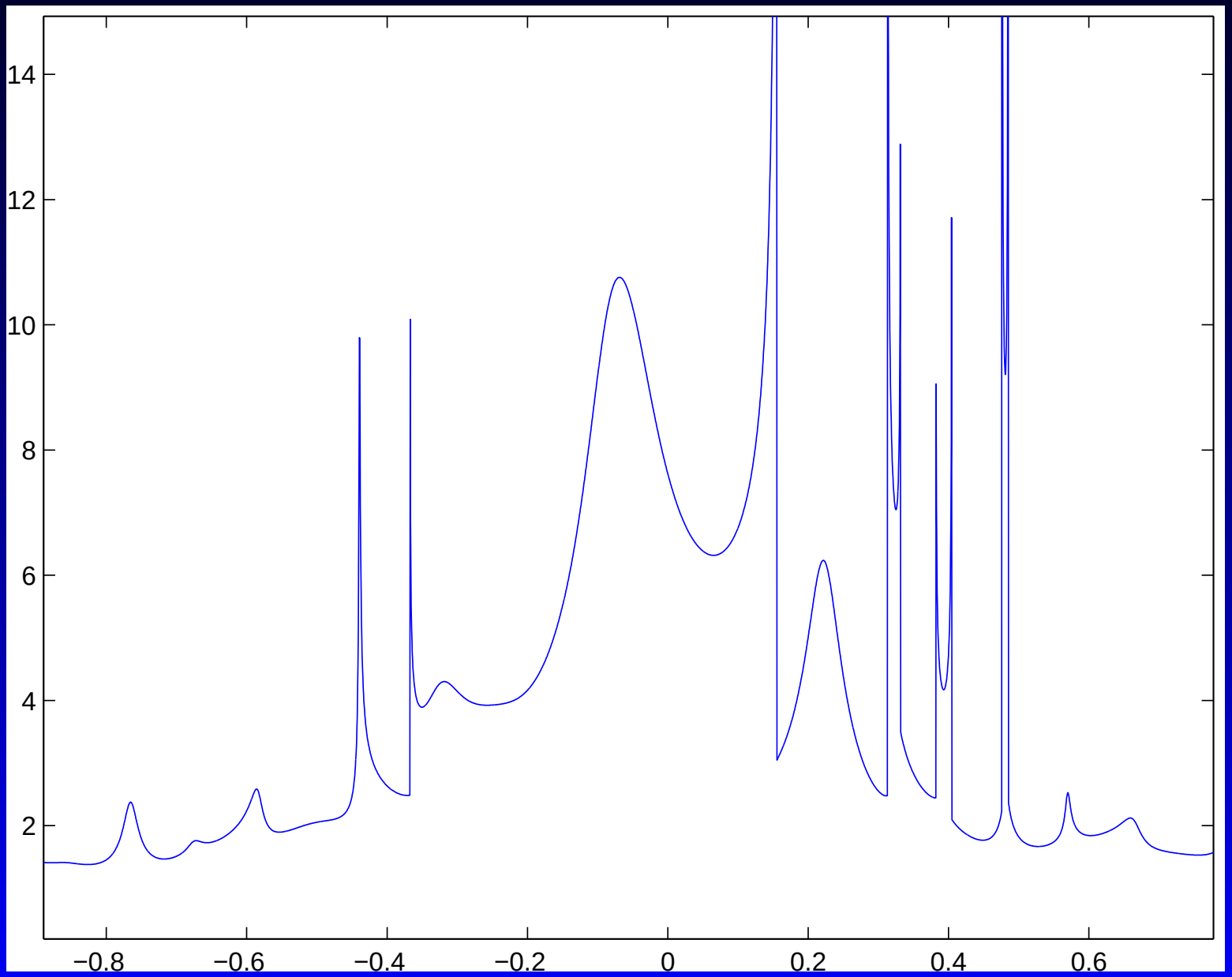
`coordsr`

The Matlab function `coordsr` can produce binary lens lightcurves for a rotating binary lens, and a point source.

`coordsr` is called in Matlab from the command line and takes a (variable) number of input parameters.

Type `help coordsr` at any time to get the help text.

coordsr(2e-1,1.1,0.01,pi/4,1.0,2.0)



coordsr

Note:

`COORDSR(Q,D,UMIN,BETA,OMEGA,NORB)`

OMEGA is the offset in radians from tangental source star track at t_0
NORB is the number of lens rotations in t_E.

Putting in a large value of NORB is a good way of seeing the effect of many caustic crossings.

You can put in markers every MARKINT (in units of t_N): `COORDSR(Q,D,UMIN,BETA,OMEGA,NORB,MARKINT)`

coordsr(2e-2,0.98,0.01,pi/4,0.0,2,0.1)