Kirkwood gaps code

- prog5.f as a starting point is in your home directory
- Includes variable declarations, format statements… a start

```
IMPLICIT NONE
 INTEGER n,nsteps
 PARAMETER(NSTEPS=10000)
 DOUBLE PRECISION vxj,vyj,vxa,vya ! velocities of jupiter, ast
 DOUBLE PRECISION vxji,vyji,vxai,vyai ! initial velocities of jup
 DOUBLE PRECISION xj,yj,xa,ya     ! positions of jupiter, aster
 DOUBLE PRECISION xja,yja        ! x,y separation between as
 DOUBLE PRECISION xji,yji,xai,yai        ! initial positions of jup
 DOUBLE PRECISION alpha,alpha_j,alpha_a,dt,time
 DOUBLE PRECISION rj,ra,rja ! separation between jupiter-sun
 DOUBLE PRECISION pi
 DOUBLE PRECISION ms,mj,ma,ekin,epot,etot,amom
```

Kirkwood gaps code, more declarations

```
      PARAMETER(dt=0.05d0) ! time step in units of years
      PARAMETER(ms=1.0d0,mj=9.55d-4,ma=4.39d-10) ! asteroi
      PARAMETER(xji=0.0d0,yji=5.200d0) ! initial position of jupite
      PARAMETER(vxji=2.75535903d0,vyji=0.0d0) ! initial velocity
c      PARAMETER(xai=0.0d0,yai=3.000d0) ! initial position of ast
c      PARAMETER(vxai=3.628d0,vyai=0.0d0) ! initial velocity of a
      PARAMETER(xai=0.0d0,yai=3.276d0) ! initial position of aste
      PARAMETER(vxai=3.471d0,vyai=0.0d0) ! initial velocity of as
c      PARAMETER(xai=0.0d0,yai=3.700d0) ! initial position of ast
c      PARAMETER(vxai=3.267d0,vyai=0.0d0) ! initial velocity of a
```

- Different initial conditions can be studied by commenting out/uncommenting the appropriate parameter statements

Initial positions/velocities

```
c set initial velocities and positions

      xj=xji
      yj=yji

      xa=xai
      ya=yai

      vxj=vxji
      vyj=vyji

      vxa=vxai
      vya=vyai
```

Opening a file for output….

```
open(unit=10,file='positions.out')
open(unit=11,file='conserved.out')
```

…. Then later on….

```
         write(10,100) time,xj,yj,xa,ya,rj,ra
         write(11,200) time,amom,ekin,epot,etot
        enddo
100     format(7f12.6)
200     format(5f12.6)
```

Instead of going to screen, output directed to files!

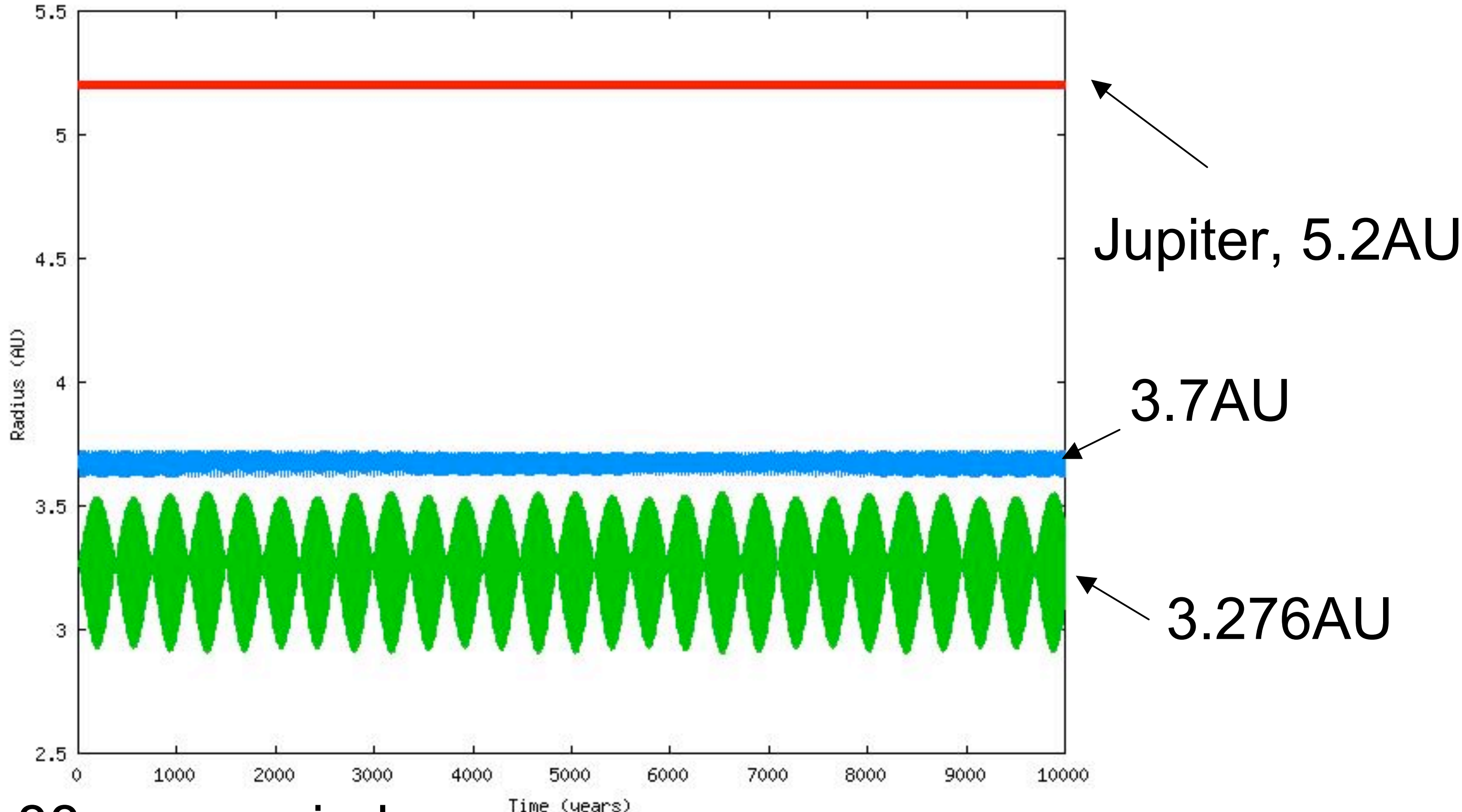
Computing conserved quantities

```
c compute angular momentum, total energy of system

      amom=mj*(xj*vyj-yj*vxj)+ma*(xa*vya-ya*vxa)
      ekin=0.5d0*mj*(vxj**2+vyj**2)+0.5d0*ma*(vxa**2+vya**2)
      epot=-4.0d0*pi**2*(mj/rj+ma/ra+(ma*mj/ms)/rja)
      etot=ekin+epot
```

We always need some way to check our code… conservation laws (energy, momentum, angular momentum, etc.) should exist for any problem… not a guarantee physics is right… but still a critical check!

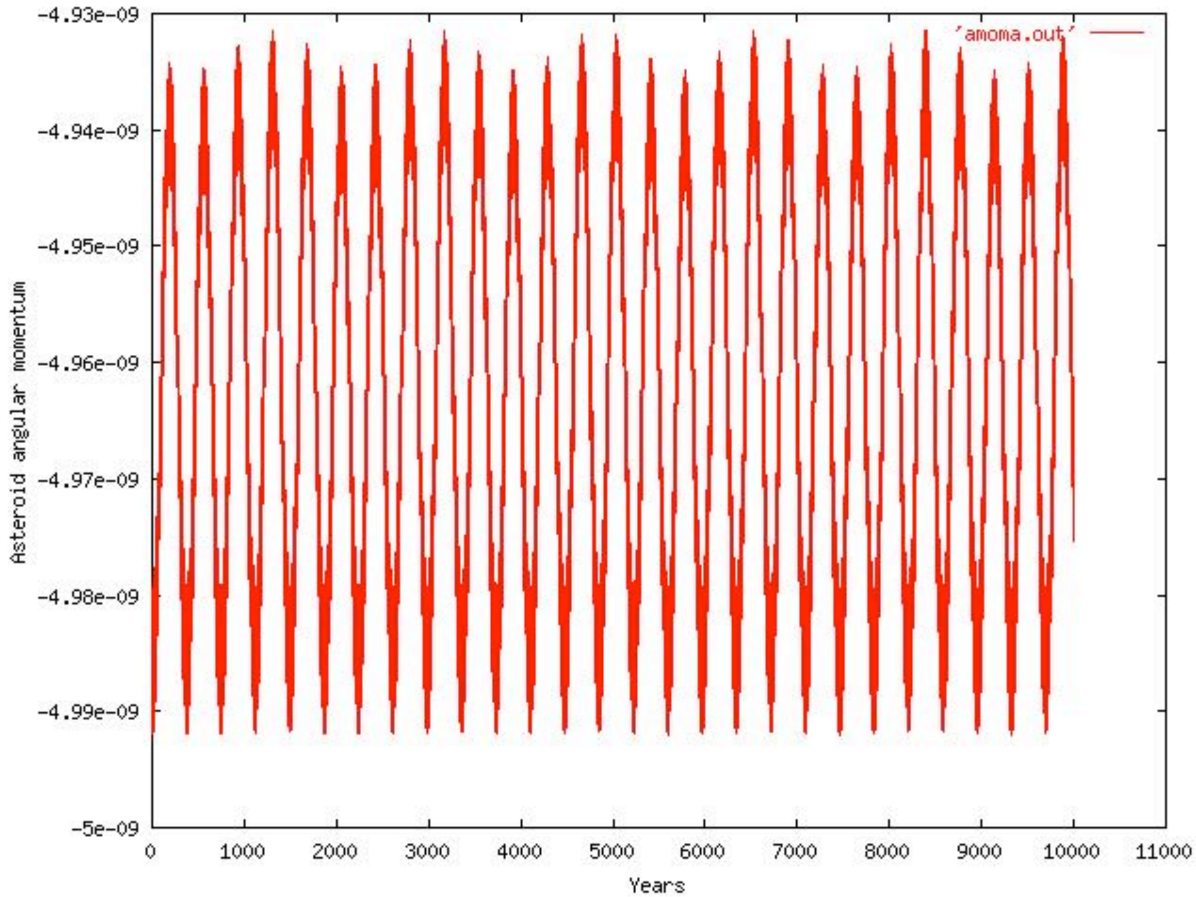
2/1 Kirkwood gap… 10,000 year simulation, dt=0.01 years



- 5.88 year period
- Slower beating, ~370 year period (about 64 orbits)

Radius starting near 3.276AU shows large fluctuations!

2/1 Kirkwood gap… 10,000 year simulation, Asteroid angular momentum



- Angular momentum of asteroid has ~ 370 year period too!
- Elliptical orbit of asteroid precesses… you can see it in the positions
- Gains/losses in angular momentum causes period to go out of resonance
- VERY long times (millions of years) orbit becomes chaotic… hard to simulate