Assignment 9

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Contents

1 Equilibrium points of the circular RTBP and associated invariant manifolds - CODE

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c*************************************************************
c
c  MAIN_RTBP_FLOW.f
c
c       We integrate the harmonic oscillator field with Taylor
c       from t=ti up to t=tmax
c       idir= +1 (integration forward in time); =-1 (backward)
c       np= number of intermediate points (apart from the initial one)
c           that we want to write on the file orbit.d. If np=1
c           only the initial and final points are written
c
c  input: xi,ti,tmax,idir,np
c*************************************************************
      implicit real*8 (ah,oz)
      parameter (n=4,m=40)

      dimension xi(n),x(n),O(m,m),mat(n,n),RR(n),RI(n),VR(n,n),VI(n,n)
      dimension v(n),p(2),yf(n)
      common/param/xmu


      open(10,file='orbit.d',status='unknown')
         write(*,*)'iregion'
      read(*,*)iregion
         write(*,*)'idir? (1 or -1)'
      read(*,*)idir
         write(*,*)'ncrossing?'
      read(*,*)ncrossing
      ti=0.d0
      tmax=2*3.1415
      np=30
      xmu=0.1
      CALL peq(xmu,xl1,xl2,xl3,cl1,cl2,cl3)
         write(*,*)'xl3',xl3
```

```
   write(*,*)'cl3',cl3
C=cl3
x(1)=xl3
x(2)=0
x(3)=0
x(4)=0
CALL jacmat(n,x,xmu,mat)
   write(*,*)'mat'
do i=1,n
   write(*,*)(mat(i,j),j=1,n)
enddo
CALL vapvep(mat,n,RR,RI,VR,VI)

RR(1)=0
RR(2)=0
RR(3)=0.5016
RR(4)=0.5016
VR(1,3)=0.2894
VR(2,3)=0.8457
VR(3,3)=0.1452
VR(4,3)=0.4242
VR(1,4)=0.2894
VR(2,4)=0.8457
VR(3,4)=0.1452
VR(4,4)=0.4242

if (idir.gt.0)then
   do i=1,n
if (RR(i).gt.0)then
k=i
endif
enddo
else
   do i=1,n
if (RR(i).lt.0)then
k=i
endif
enddo
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```
      endif
     do i=1,n
      v(i)=VR(i,k)
      enddo
      p(1)=RR(k)
c     p(2)=RI(2)
         write(*,*)'Eigenvalue',p(1)
         write(*,*)'v',(v(i),i=1,n)
      s=1.d6
      if (iregion.lt.0)then
      s=s
      endif
      x=x+s*v
         write(*,*)'initialpoint',(x(i),i=1,n)


      CALL jac(x,C,xmu,n)
      ti=0
      do j=1,ncrossing
      t=0.d0
         write(10,*)t,(x(i),i=1,n)
      CALL jac(x,C,xmu,n)
      CALL POINC1(j,xmu,n,m,x,yf,tfinal,idir,ti)
      ti=ti+tfinal
      enddo
      end



      subroutine jac(x,C,xmu,n)
      implicit real*8(ah,oz)
      dimension x(n)
      ro=dsqrt((x(1)xmu)*(x(1)xmu))
      rt=dsqrt((x(1)xmu+1.d0)*(x(1)xmu+1.d0))
      ome=0.5d0*(x(1)*x(1))+(1.d0xmu)/ro+xmu/rt+0.5d0*xmu*(1.d0xmu)
      Cnew=2*ome
      Cdiff=dabs(CCnew)
      if (Cdiff.gt.1.d3)then
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         write(*,*)'jac constant not conserved'
      endif
      end



      SUBROUTINE POINC1(j,xmu,n,m,YI,YF,tfinal,idirorig,ti)
      IMPLICIT REAL*8 (AH,OZ)
      DIMENSION YI(n),YF(n),DGG(n),F(n)
      icont=0
      idir=idirorig


      CALL SECCIO(YI,GG,DGG)
      IF(DABS(GG).LT.1.D9)GG=0.d0
      GA=GG
      hab=.1e16
      hre=.1e16
      pabs=dlog10(hab)
      prel=dlog10(hre)
      istep=1

      pas=0.4d0
      ht=0.d0
      t=ti

 1     tmax=t+idir*pas
      CALL taylor_f77_eq_rtbp_var_(t,yi,idir,istep,pabs,prel,
     & tmax,ht,iordre,ifl)


  CALL SECCIO(YI,GG,DGG)
      IF(GG*GA.LT.0.D0)goto22
         write(10,*)t,(yi(ii),ii=1,n)
      GA=GG
      GO TO 1
```

```
 22   continue
      icont=icont+1
      if (icont.gt.20)then
            write(*,*)'problems finding the section'
      stop
      end if
      CALL FIELD(xmu,T,YI ,N,F)
      P=0.D0
      do 3 I=1,N
 3     P=P+F(I)*DGG(I)
      H=GG/P
      if (h.ge.0.d0)idir=1
      if (h.lt.0.d0)idir=1
      tmax=t+h


      CALL taylor_f77_eq_rtbp_var_(t,yi,idir,istep,pabs,prel,
     & tmax,ht,iordre,ifl)

      CALL SECCIO(YI ,GG,DGG)
      IF (DABS(GG).GT.1.D13)GO TO 22
      do 4 I=1,N
 4     YF(I)=YI(I)
      tfinal=t

       write(*,*)'t final point time',tfinal
      write(*,*)(yf(ii),ii=1,n)
           write(10,*)t,(yf(ii),ii=1,n)

      return
      t=tfinal
      end


C*************************************************************
C *
C THE SURFACE g OF SECTION,IN THIS CASE
C INPUT PARAMETERS:
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```
C Y(*) POINT
C OUTPUT PARAMETERS:
C GG FUNCTION THAT EQUATED TO 0 GIVES THE SURFACE OF
C SECTION
C DGG(*) GRADIENT OF FUNCTION GG
C *
C************************************************************
      SUBROUTINE SECCIO(Y,GG,DGG)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION Y(2),DGG(2)
      GG=Y(2)
      DO 1 I=1,2
  1  DGG(I)=0.D0
      DGG(2)=1.d0
      RETURN
      END
C
C FIELD.F
C


C*************************************************************
C
C EQS OF MOTION IN synodical VARIABLES
C X TIME
C Y(*) POINT (Y(1),Y(2),....Y(n))
C NEQ NUMBER OF EQUATIONS
C OUTPUT PARAMETERS:
C F(*) VECTOR FIELD
C
C**************************************************************
      subroutine field(t,x,neq,f)
      implicit real*8 (a-h,o-z)
      common/param/xmu
      dimension x(20),f(20)
c
      umu=1.-xmu
```

```
d1=x(1)-xmu
d2=x(1)+umu
r12=d1*d1+x(2)*x(2)
r22=d2*d2+x(2)*x(2)
r0=dsqrt(r12)
r1=dsqrt(r22)
r032=r12*r0
r132=r22*r1
r052=r12*r032
r152=r22*r132
omex=x(1)-(umu*(-xmu+x(1))/r032)-(xmu*(x(1)+umu)/r132)
omey=x(2)*(1.-(umu/r032)-(xmu/r132))
omexx=1.-(umu*((r0*r0)-3.*d1)/(r0*r0*r0*r0*r0))
. -(xmu*( (r1*r1)-(3.*(umu+x(1))*(umu+x(1))) )/(r1*r1*r1*r1*r1))
omexy=x(2)*(((3.*umu*d1)/(r0*r0*r0*r0*r0))
. +(3.*xmu*(x(1)+umu))/ (r1*r1*r1*r1*r1))
omeyy=(1.-(umu/(r0*r0*r0))-(xmu/(r1*r1*r1))) + ( x(2)* ((3.
. *umu*x(2))/ (r0*r0*r0*r0*r0) )+ (xmu*3.*x(2))
. / (r1*r1*r1*r1*r1) )

f(1)=x(3)
f(2)= x(4)
f(3)=2.*x(4)+omex
f(4)=-2.*x(3)+omey
f(5)=x(13)
f(6)=x(14)
f(7)=x(15)
f(8)=x(16)
f(9)=x(17)
f(10)=x(18)
f(11)=x(19)
f(12)=x(20)
f(13)=x(5)*omexx+x(9)*omexy+2.*x(17)
f(14)=x(6)*omexx+x(10)*omexy+2.*x(18)
f(15)=x(7)*omexx+x(11)*omexy+2.*x(19)
f(16)=x(8)*omexx+x(12)*omexy+2.*x(20)
f(17)=x(5)*omexy+x(9)*omeyy-2.*x(13)
f(18)=x(6)*omexy+x(10)*omeyy-2.*x(14)
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```
f(19)=x(7)*omexy+x(11)*omeyy-2.*x(15)
f(20)=x(8)*omexy+x(12)*omeyy-2.*x(16)
return
end
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2 OUTPUTS AND PLOTS

2.1 a)

Point L3 and C(L3)
$xl3 = 1.0416089091893053$
$Cl3 = 3.1895781531155980$

$$A = \begin{pmatrix} 0.0000000000000000 & 0.0000000000000000 & 1.0000000000000000 & 0.0000000000000000 \\ 0.0000000000000000 & 0.0000000000000000 & 0.0000000000000000 & 0.0000000000000000 \\ 3.1833839641328692 & 0.0000000000000000 & 0.0000000000000000 & 2.0000000000000000 \\ 0.0000000000000000 & -9.1691982066434363E-002 & -2.0000000000000000 & 0.0000000000000000 \end{pmatrix}$$

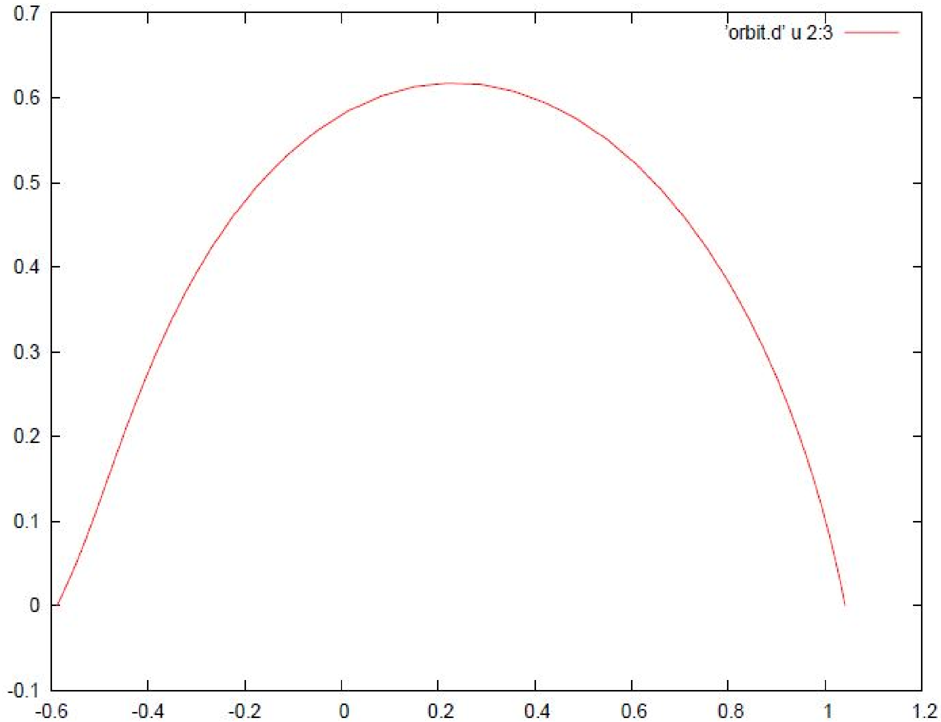
2.2 b)

Eigenvalue and eigenvector for L3 and iregion=+1
$\lambda_1 = 0.5016$
$v_1 = (0.2894, 0.8457, 0.1452, 0.4242)$
$\lambda_{-1} = 0.5016$
$v_{-1} = (0.2894, 0.8457, 0.1452, 0.4242)$

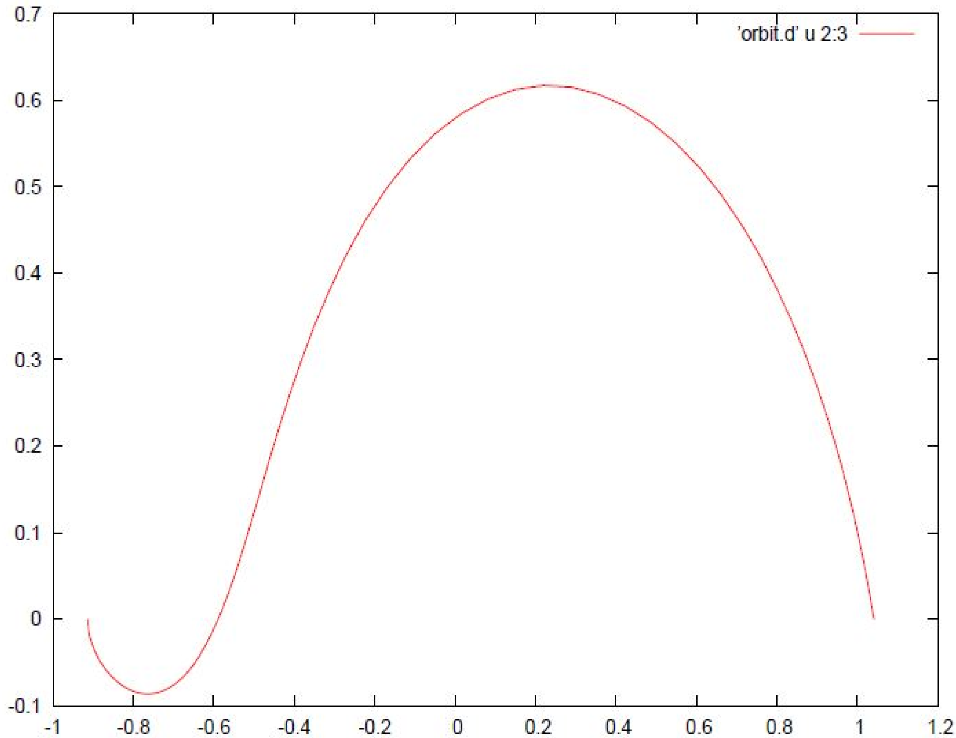
2.3 Plots idir=1

2.3.1 Plots idir=1 and iregion=1

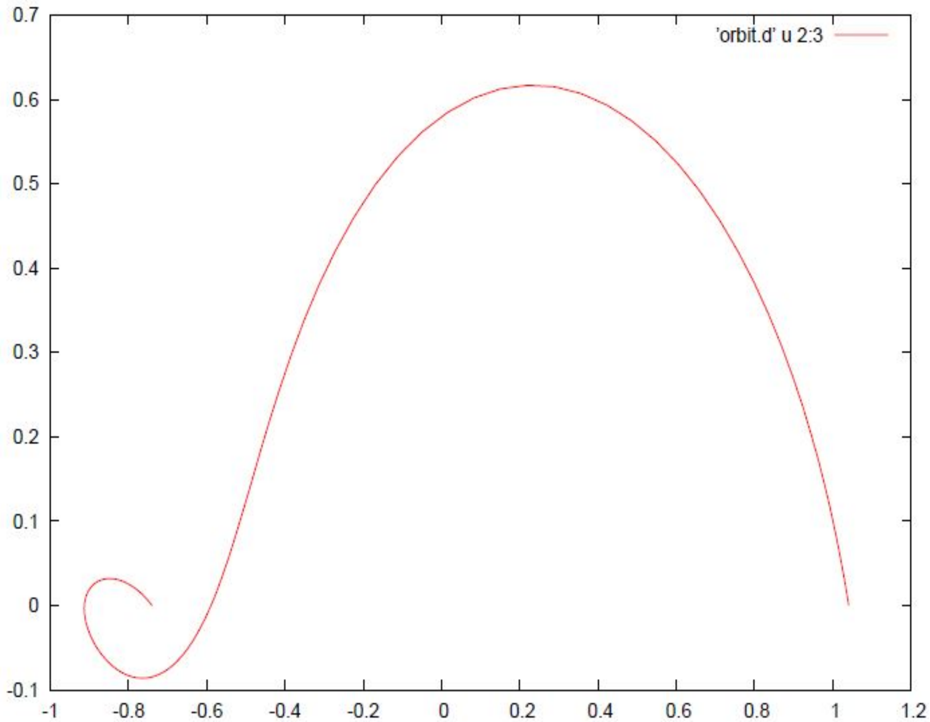
number of crossings=1



number of crossings=2

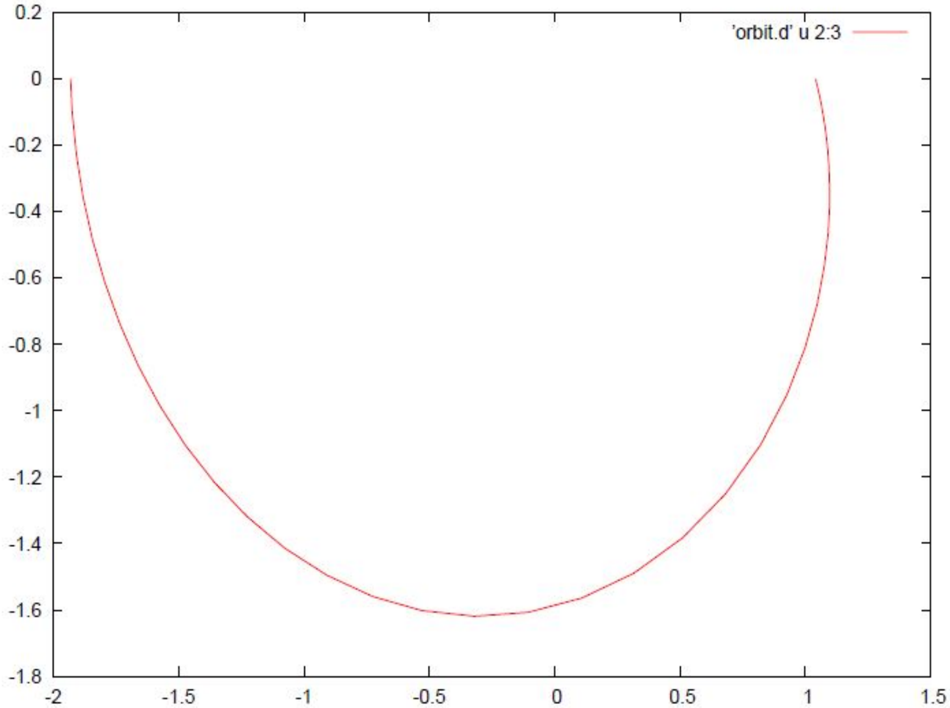


number of crossings=3

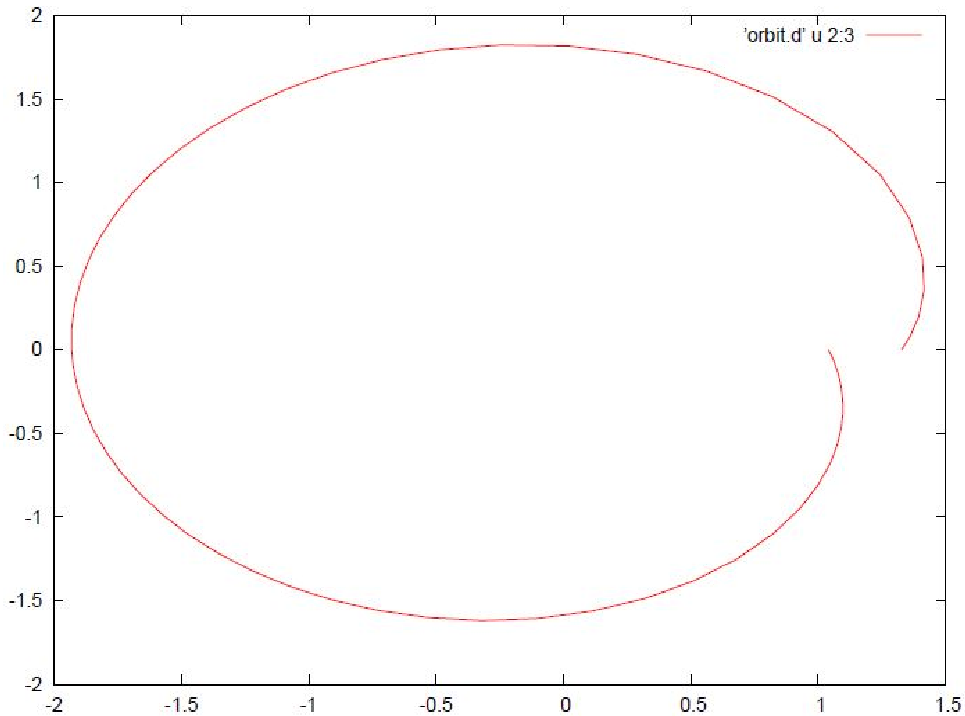


2.3.2 Plots idir=1 and iregion=-1

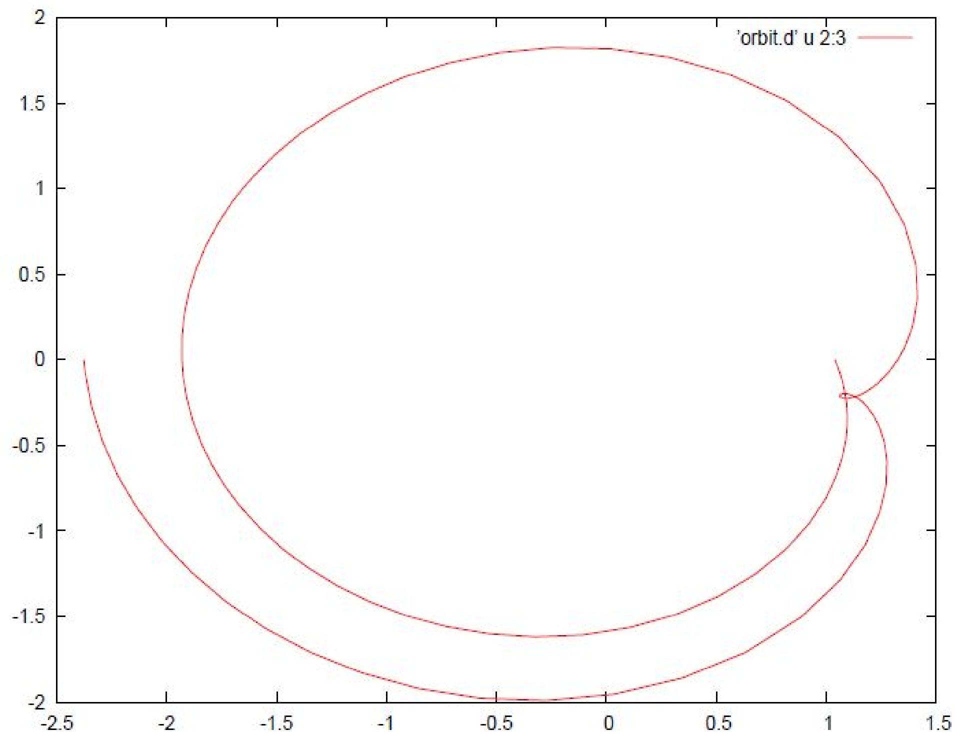
number of crossings=1



number of crossings=2



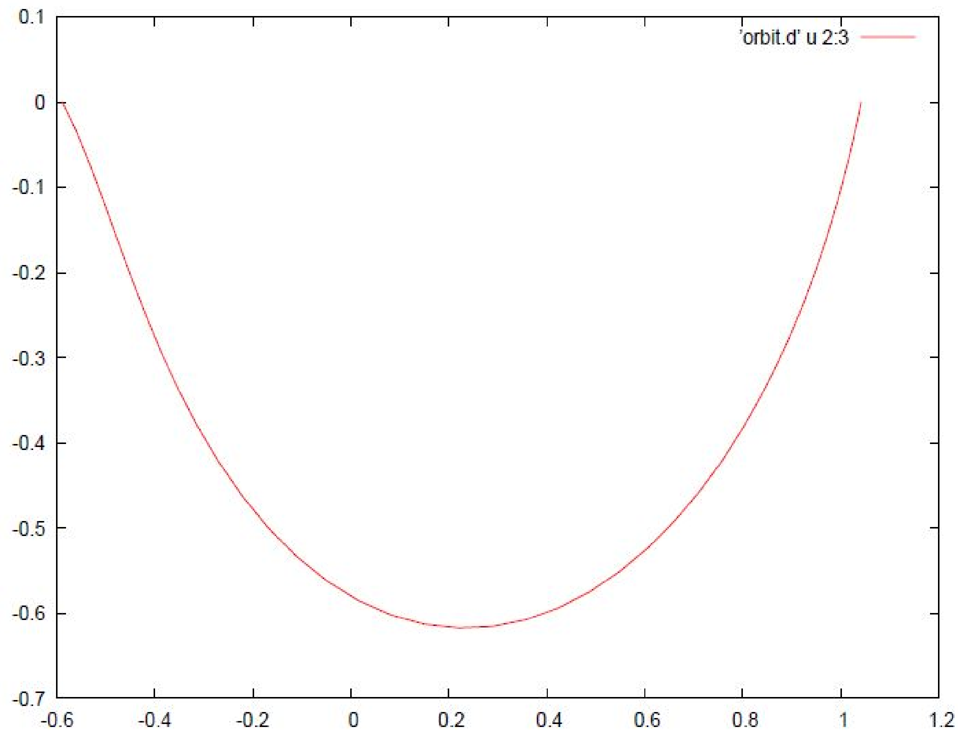
number of crossings=3



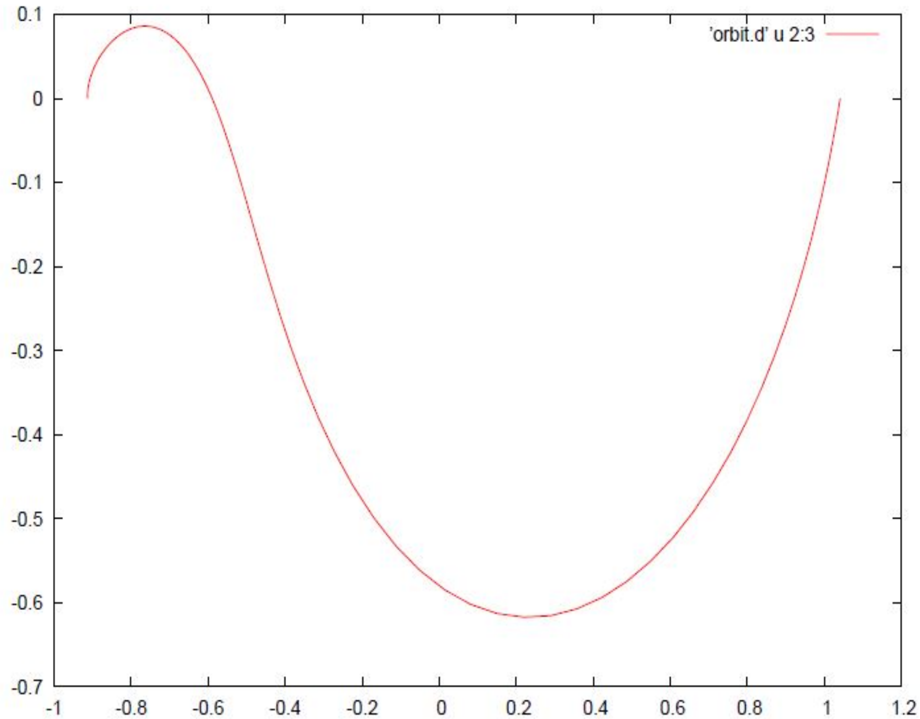
2.4 Plots idir=-1

2.4.1 Plots idir=-1 and iregion=1

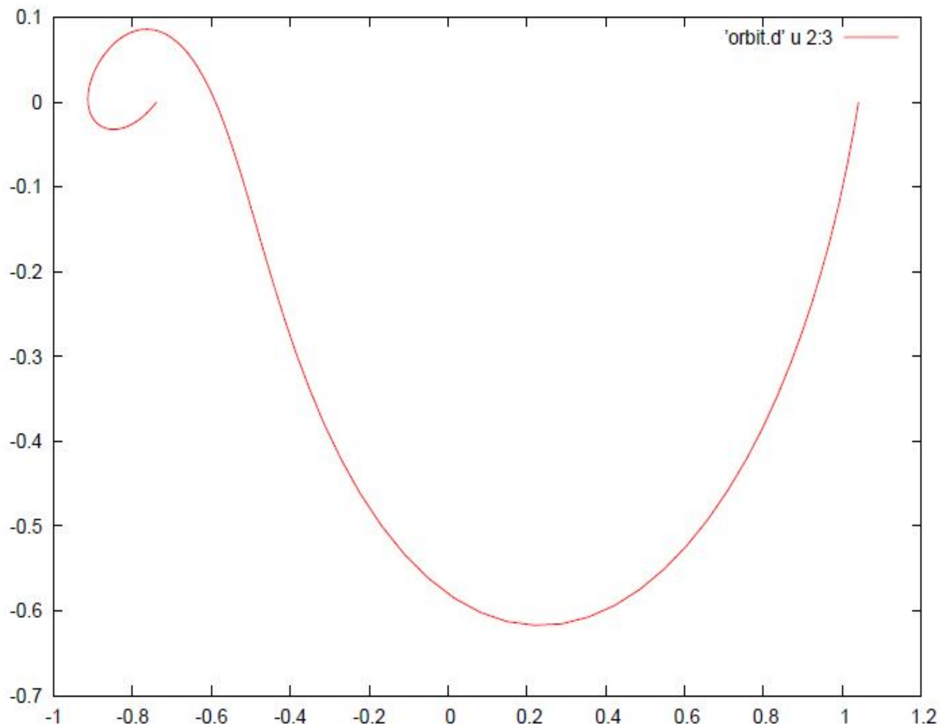
number of crossings=1



number of crossings=2

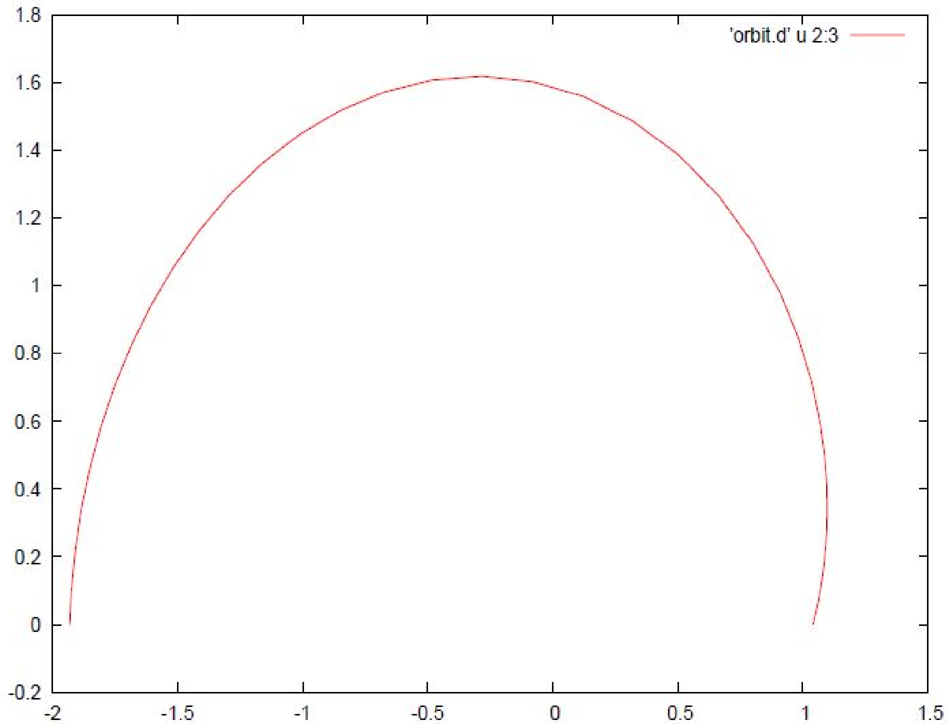


number of crossings=3

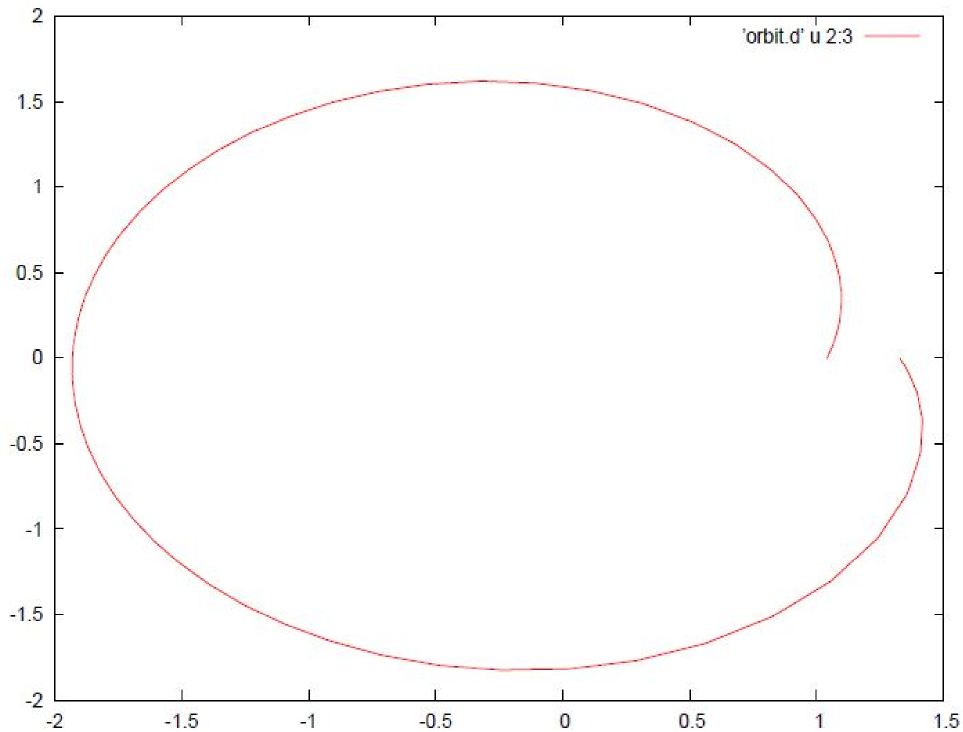


2.4.2 Plots idir=-1 and iregion=-1

number of crossings=1



number of crossings=2



number of crossings=3