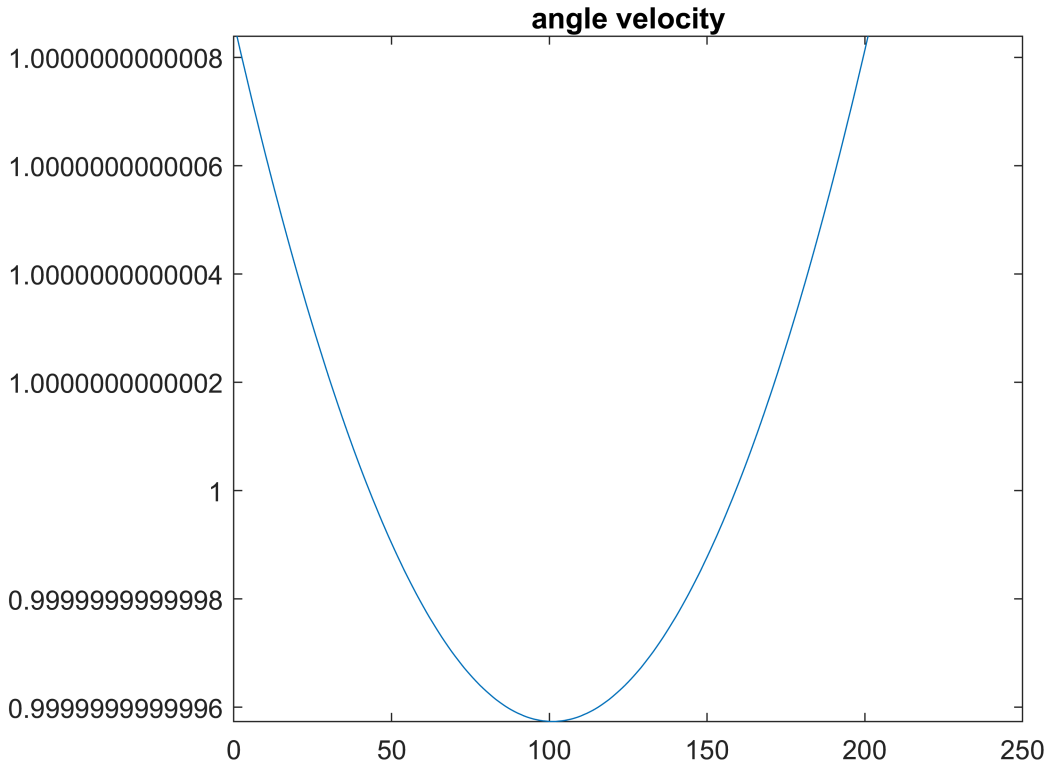
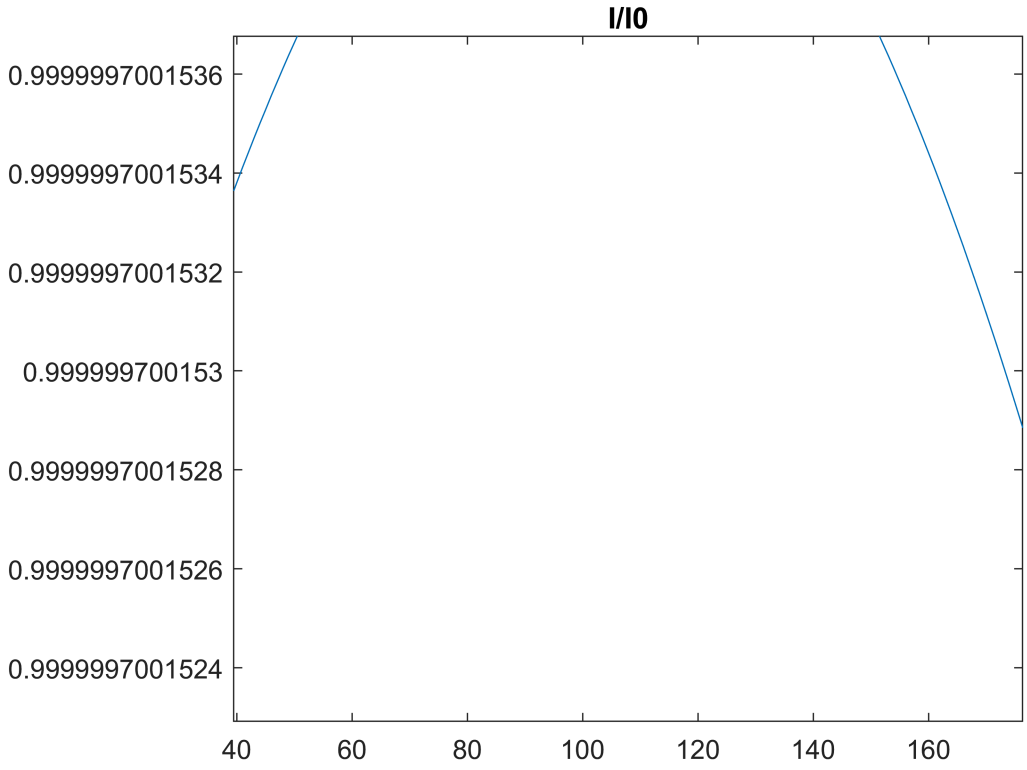
```
% assume refraction number, n = 3
n = 3;
% unit as lambda, optical frequency:411.0420THz
w0 = 2*pi*411.0420;
T = 2*pi/w0;
r0 = 1;
z = -100:100;
% with The Rayleigh distance or Rayleigh range zR(so that the confocal parameter or depth of focus, the
% is determined given a Gaussian beam's waist size(Here λ is the wavelength
% of the light, n is the index of refraction. At a distance from the waist equal to the Rayleigh range z
% beam is √2 larger than it is at the focus where w = w0, the beam waist. That also implies that the on-
% there is one half of the peak intensity (at z = 0). That point along the beam also happens to be where
% (1/R) is greatest.): zR = pi*W0^2*n/lambda;
zR = pi*w0^2*n;
% At position z the Gouy phase of a fundamental Gaussian beam is given by:
phi = atan(z/zR);
% Wavefront curvature radius R
% largest at the Rayleigh distance, z = ±zR,
% on either side of the waist, crossing zero at the waist itself.
% Beyond the Rayleigh distance, |z| > zR, it again decreases in magnitude,
% approaching zero as z -> ±∞. The curvature is often expressed in terms of its reciprocal,
% R, the radius of curvature; for a fundamental(TEM00) Gaussian beam the curvature at position z is give
R = z.*(1+(zR*ones(size(z))/z).^2);%?why.
%R = z*(1+(zR/z)^2);
%evolving beam width
w = w0*sqrt(1+(z/zR).^2);
plot(w/mean(w));
title('angle velocity')
```




```
T = 2*pi./w;
% Gaussian laser beam: I/I0 = (w0/w)^2*exp(-2*r^2/w^2);
IrI0 = (w0./w).^2.*exp(-2.*r0.^2./w.^2);
plot(IrI0);
title('I/I0');
```




```
I = (w0./w).^2.*exp(-2.*r0.^2./w.^2);

%     t = 1:50;
%     y = t+normpdf(t);
%     alpha = ones(size(t));
%     alpha([1 3 end]) = 100;
%     Bout = spap2(1, 2, t, y, alpha);
%     kk = Bout.order;
Delta = z;
Phi = z;
Delta0 = z;
Phi0 = z;
Res = 10^10;
% consider the rabi oscillation, consider a spin-1/2 system with magnetic
% moment mu placed in a classical magnetic field B =
% B0*z+B1*(cos(wt)*x-sin(w*t)*y). Let gamma be the gyromagnetic ratio for
% the system. The magnetic moment is thus mu = h*gamma*sigma/4/pi
for t = 1:(length(z)-1)
    %Hamiltonian of this system is then given by: H = -mu*B =
    %-h/4*w0*sigmaz/pi-h/w1*(sigmax*coswt-sigmay*sinwt),with pi/2 pulse
    w1 = pi/2/t;
    Phi0(t) = 1/w1;
    Delta0(t) = w0;
    k = w(t)*t;
    %Rabi frequency, Phi and laser phase, phi varies with time
    %laser wave vector k(t) projected onto the transport axis
    % at position z(t) and wL, the laser frequency
    % The spatial variation of kz(z(t))
```

```
    % accounts for the curvature of the wavefronts of
    % the Gaussian laser beam:
    h = 6.62607015*10^(-34);
    phi = k*z(t);%k = abs(k)*cos(theta);
    %dephi = (k(2:end)-k(1:end-1))./(z(2:end)-z(1:end-1))*z+k;
    dephi = (w(t+1)*(t+1)-k)/(z(t+1)-z(t))*z(t)+k;
    Phi(t) = phi - w(t)*t;
    deltaL = w(t) - w0;
    Delta(t) = deltaL - dephi; %detuning
    H(t,:) = h/4/pi*(-Phi(t)*PX+Delta(t)*PZ);
    if t == length(z)-1
        Phi(t+1) = phi*(t+1);
        deltaL = w(t+1) - w0;
        Delta(t+1) = deltaL - dephi; %detuning
        H(t+1,:) = h/4/pi*(-Phi(t+1)*PX+Delta(t+1)*PZ);
    end
end
```

```
c = 0;
% find best knots
for kn = 2:length(Phi0)
    BPhi = spap2(augknt([Phi0(1),Phi0(1)+(Phi0(end)-Phi0(1))/(kn-1):(Phi0(end)-Phi0(1))/(kn-1):Phi0(end)
%    BDelta = spap2(augknt([Delta0(1),Delta0(1)+(Delta0(end)-Delta0(1))/(kn-1):(Delta0(end)-Delta0(1))/(
%    BDelta = spap2(kn+1,1,Delta0,Delta);
    if sum(isnan(BPhi.knots))+sum(isnan(BPhi.coefs))>0
        break
    else
        if length(unique(BPhi.knots)) == BPhi.number/2 + 1
            BPhi.knots = unique(BPhi.knots);
        end
            Phifit0 = BPhi.knots(1:BPhi.order:end).*BPhi.coefs(1:BPhi.order/2:end);
%        Phifit1 = interp1(Phifit0,1:0.5:length(Phifit0))./BPhi.coefs;
        Phiref = Phi(floor(length(Phi0)/BPhi.number):floor(length(Phi0)/BPhi.number):length(Phi0));
        Phiref =  Phiref(1:length(BPhi.coefs))
        %         Deltafit0 = BDelta.knots(1:BDelta.order:end).*BDelta.coefs(1:BDelta.order/2:end);
% %        Phifit1 = interp1(Phifit0,1:0.5:length(Phifit0))./BPhi.coefs;
%         Deltaref = Delta(floor(length(Delta0)/BDelta.number):floor(length(Delta0)/BDelta.number):lengt
        if length(Phifit0)==BPhi.number
            Phifit = abs(Phifit0).*(sign(Phiref))
        else
            if BPhi.number == length(1:(length(Phifit0)-0.5)/BPhi.number:length(Phifit0))
                Phifit =abs(interp1(Phifit0,1:(length(Phifit0)-0.5)/BPhi.number:length(Phifit0))./sqrt(a
            elseif BPhi.number == length(interp1(Phifit0,1:length(Phifit0)/(BPhi.number+0.5):length(Phif
                Phifit =abs(interp1(Phifit0,1:length(Phifit0)/(BPhi.number+0.5):length(Phifit0))./sqrt(a
            elseif BPhi.number == length(interp1(Phifit0,1:length(Phifit0)/(BPhi.number+1):length(Phifit
                Phifit =abs(interp1(Phifit0,1:length(Phifit0)/(BPhi.number+1):length(Phifit0))./sqrt(abs
            elseif BPhi.number == length(interp1(Phifit0,1:(length(Phifit0)-0.5)/(BPhi.number+0.5):lengt
                Phifit =abs(interp1(Phifit0,1:(length(Phifit0)-0.5)/(BPhi.number+0.5):length(Phifit0))./
            elseif BPhi.number == length(interp1(Phifit0,1:(length(Phifit0)-1)/BPhi.number:length(Phifit
                Phifit =abs(interp1(Phifit0,1:(length(Phifit0)-1)/BPhi.number:length(Phifit0))./sqrt(abs
            else
                InterpT = interp1(Phifit0,1:(length(Phifit0)-1)/BPhi.number:length(Phifit0));
```

```
                Phifit = abs(InterpT(1:length(Phiref))./sqrt(abs(BPhi.coefs/Phi0(end)^(length(Phifit0)-B
            end
        end
%         if length(Deltafit0)==BDelta.number
%             Deltafit = abs(Deltafit0).*(sign(Deltaref))
%         else
%             if BDelta.number == length(1:(length(Deltafit0)-0.5)/BDelta.number:length(Deltafit0))
%                 Deltafit =abs(interp1(Deltafit0,1:(length(Deltafit0)-0.5)/BDelta.number:length(Deltafi
%             elseif BDelta.number == length(interp1(Deltafit0,1:(length(Deltafit0)-0.5)/(BDelta.number+
%                 Deltafit =abs(interp1(Deltafit0,1:(length(Deltafit0)-0.5)/(BDelta.number+0.5):length(D
%             elseif BDelta.number == length(interp1(Deltafit0,1:(length(Deltafit0)-1)/BDelta.number:len
%                 Deltafit =abs(interp1(Deltafit0,1:(length(Deltafit0)-1)/BDelta.number:length(Deltafit0
%             end
%         end
        res = mean(abs(Phifit) - abs(Phiref)) %+ mean(abs(Deltafit)-abs(Deltaref));
    end
    if abs(Res) > abs(res)
       c = c +1;
       Res = res;
       RES(c) = Res;
       PHI(c) = mean(Phifit);
       PHIREF(c) = mean(Phiref);
%        DELTA(c) = Deltafit;
%        DELTAREF(c) = Deltaref;
       dt(c) = length(Delta)/length(Deltafit);
%        Hs(c,:) = h/4/pi*(-PHI(c)*PX+DELTA(c)*PZ);
%        Hsref(c,:) = h/4/pi*(-PHIREF(c)*PX+DELTAREF(c)*PZ);
        Hs(c,:) = h/4/pi*(-PHI(c)*PX + Delta0(c)*PZ);
        Hsref(c,:) = h/4/pi*(-PHIREF(c)*PX+Delta(c)*PZ);
    end
end
```

```
Phiref = 1×2
10^7 ×
   -0.0517    5.0620
Phifit = 1×2
10^8 ×
   -0.8658    1.6870
res = 1.0207e+08
Warning: Integer operands are required for colon operator when used as index.
Phiref = 1×4
10^7 ×
   -0.6715   -0.0517    1.8595    5.0620
res = -1.9111e+07
Phiref = 1×6
10^7 ×
   -0.5881   -0.6136   -0.0767    1.0227    2.6847    4.9091
res = -1.6492e+07
Warning: Integer operands are required for colon operator when used as index.
Phiref = 1×8
10^7 ×
   -0.4972   -0.6715   -0.5230   -0.0517    0.7425    1.8595    3.2993    5.0620
res = -1.5883e+07
Phiref = 1×10
10^7 ×
   -0.4236   -0.6405   -0.6508   -0.4545   -0.0517    0.5579    1.3740    2.3967 ···
```

```
res = -1.5238e+07
Warning: Integer operands are required for colon operator when used as index.
Phiref = 1×12
10^7 ×
   -0.3554   -0.5785   -0.6694   -0.6281   -0.4545   -0.1488    0.2893    0.8595 ···
res = -1.3141e+07
Phiref = 1×14
10^7 ×
   -0.3182   -0.5351   -0.6508   -0.6653   -0.5785   -0.3905   -0.1012    0.2893 ···
res = -1.3667e+07
Warning: Integer operands are required for colon operator when used as index.
Phiref = 1×16
10^7 ×
   -0.2789   -0.4835   -0.6136   -0.6694   -0.6508   -0.5579   -0.3905   -0.1488 ···
res = -1.2645e+07
Phiref = 1×18
10^7 ×
   -0.2585   -0.4545   -0.5881   -0.6591   -0.6676   -0.6136   -0.4972   -0.3182 ···
res = -1.3679e+07
Warning: Integer operands are required for colon operator when used as index.
Phiref = 1×20
10^7 ×
   -0.2376   -0.4236   -0.5579   -0.6405   -0.6715   -0.6508   -0.5785   -0.4545 ···
res = -1.3946e+07
Phiref = 1×22
10^7 ×
   -0.2162   -0.3905   -0.5230   -0.6136   -0.6625   -0.6694   -0.6346   -0.5579 ···
res = -1.3423e+07
Warning: Integer operands are required for colon operator when used as index.
Phiref = 1×24
10^7 ×
   -0.1942   -0.3554   -0.4835   -0.5785   -0.6405   -0.6694   -0.6653   -0.6281 ···
res = -1.2149e+07
Phiref = 1×26
10^7 ×
   -0.1717   -0.3182   -0.4393   -0.5351   -0.6056   -0.6508   -0.6707   -0.6653 ···
res = -1.0301e+07
Warning: Integer operands are required for colon operator when used as index.
Phiref = 1×28
10^7 ×
   -0.1717   -0.3182   -0.4393   -0.5351   -0.6056   -0.6508   -0.6707   -0.6653 ···
res = -1.2782e+07
Phiref = 1×30
10^7 ×
   -0.1488   -0.2789   -0.3905   -0.4835   -0.5579   -0.6136   -0.6508   -0.6694 ···
res = -9.8616e+06
Warning: Integer operands are required for colon operator when used as index.
Phiref = 1×32
10^7 ×
   -0.1488   -0.2789   -0.3905   -0.4835   -0.5579   -0.6136   -0.6508   -0.6694 ···
res = -1.1901e+07
Phiref = 1×34
10^7 ×
   -0.1253   -0.2376   -0.3370   -0.4236   -0.4972   -0.5579   -0.6056   -0.6405 ···
res = -8.3082e+06
Warning: Integer operands are required for colon operator when used as index.
Phiref = 1×36
10^7 ×
   -0.1253   -0.2376   -0.3370   -0.4236   -0.4972   -0.5579   -0.6056   -0.6405 ···
res = -9.7703e+06
```

```
Phiref = 1×38
10^7 ×
   -0.1253   -0.2376   -0.3370   -0.4236   -0.4972   -0.5579   -0.6056   -0.6405 ···
res = -1.1436e+07
Warning: Integer operands are required for colon operator when used as index.
Phiref = 1×40
10^7 ×
   -0.1253   -0.2376   -0.3370   -0.4236   -0.4972   -0.5579   -0.6056   -0.6405 ···
res = -1.3301e+07
Phiref = 1×42
10^7 ×
   -0.1012   -0.1942   -0.2789   -0.3554   -0.4236   -0.4835   -0.5351   -0.5785 ···
res = -7.9531e+06
Warning: Integer operands are required for colon operator when used as index.
Phiref = 1×44
10^7 ×
   -0.1012   -0.1942   -0.2789   -0.3554   -0.4236   -0.4835   -0.5351   -0.5785 ···
res = -9.0628e+06
Phiref = 1×46
10^7 ×
   -0.1012   -0.1942   -0.2789   -0.3554   -0.4236   -0.4835   -0.5351   -0.5785 ···
res = -1.0304e+07
Warning: Integer operands are required for colon operator when used as index.
Phiref = 1×48
10^7 ×
   -0.1012   -0.1942   -0.2789   -0.3554   -0.4236   -0.4835   -0.5351   -0.5785 ···
res = -1.1674e+07
Phiref = 1×50
10^7 ×
   -0.1012   -0.1942   -0.2789   -0.3554   -0.4236   -0.4835   -0.5351   -0.5785 ···
res = -1.3172e+07
Warning: Integer operands are required for colon operator when used as index.
Phiref = 1×52
10^7 ×
   -0.0767   -0.1488   -0.2162   -0.2789   -0.3370   -0.3905   -0.4393   -0.4835 ···
res = -6.4672e+06
Phiref = 1×54
10^7 ×
   -0.0767   -0.1488   -0.2162   -0.2789   -0.3370   -0.3905   -0.4393   -0.4835 ···
res = -7.1260e+06
Warning: Integer operands are required for colon operator when used as index.
Phiref = 1×56
10^7 ×
   -0.0767   -0.1488   -0.2162   -0.2789   -0.3370   -0.3905   -0.4393   -0.4835 ···
res = -7.8622e+06
Phiref = 1×58
10^7 ×
   -0.0767   -0.1488   -0.2162   -0.2789   -0.3370   -0.3905   -0.4393   -0.4835 ···
res = -8.6744e+06
Warning: Integer operands are required for colon operator when used as index.
Phiref = 1×60
10^7 ×
   -0.0767   -0.1488   -0.2162   -0.2789   -0.3370   -0.3905   -0.4393   -0.4835 ···
res = -9.5610e+06
Phiref = 1×62
10^7 ×
   -0.0767   -0.1488   -0.2162   -0.2789   -0.3370   -0.3905   -0.4393   -0.4835 ···
res = -1.0521e+07
Warning: Integer operands are required for colon operator when used as index.
Phiref = 1×64
```

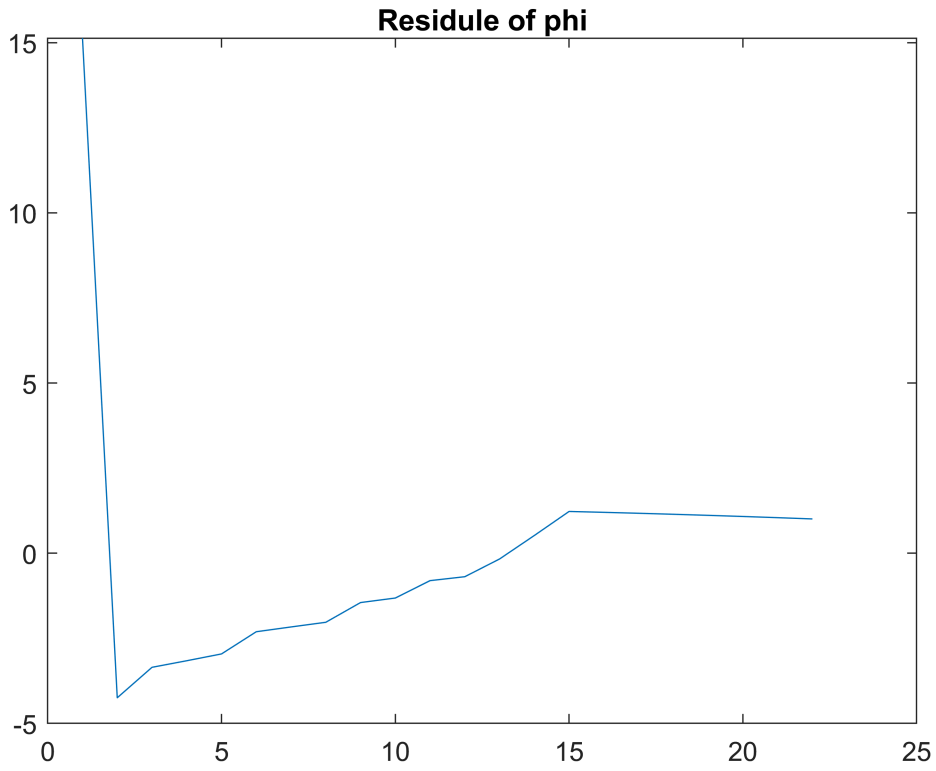
```
10^7 ×
   -0.0767   -0.1488   -0.2162   -0.2789   -0.3370   -0.3905   -0.4393   -0.4835 ···
res = -1.1553e+07
Phiref = 1×66
10^7 ×
   -0.0767   -0.1488   -0.2162   -0.2789   -0.3370   -0.3905   -0.4393   -0.4835 ···
res = -1.2656e+07
Warning: Integer operands are required for colon operator when used as index.
Phiref = 1×68
10^7 ×
   -0.0517   -0.1012   -0.1488   -0.1942   -0.2376   -0.2789   -0.3182   -0.3554 ···
res = -4.8141e+06
Phiref = 1×70
10^7 ×
   -0.0517   -0.1012   -0.1488   -0.1942   -0.2376   -0.2789   -0.3182   -0.3554 ···
res = -5.0561e+06
Warning: Integer operands are required for colon operator when used as index.
Phiref = 1×72
10^7 ×
   -0.0517   -0.1012   -0.1488   -0.1942   -0.2376   -0.2789   -0.3182   -0.3554 ···
res = -5.3363e+06
Phiref = 1×74
10^7 ×
   -0.0517   -0.1012   -0.1488   -0.1942   -0.2376   -0.2789   -0.3182   -0.3554 ···
res = -5.6539e+06
Warning: Integer operands are required for colon operator when used as index.
Phiref = 1×76
10^7 ×
   -0.0517   -0.1012   -0.1488   -0.1942   -0.2376   -0.2789   -0.3182   -0.3554 ···
res = -6.0081e+06
Phiref = 1×78
10^7 ×
   -0.0517   -0.1012   -0.1488   -0.1942   -0.2376   -0.2789   -0.3182   -0.3554 ···
res = -6.3981e+06
Warning: Integer operands are required for colon operator when used as index.
Phiref = 1×80
10^7 ×
   -0.0517   -0.1012   -0.1488   -0.1942   -0.2376   -0.2789   -0.3182   -0.3554 ···
res = -6.8234e+06
Phiref = 1×82
10^7 ×
   -0.0517   -0.1012   -0.1488   -0.1942   -0.2376   -0.2789   -0.3182   -0.3554 ···
res = -7.2833e+06
Warning: Integer operands are required for colon operator when used as index.
Phiref = 1×84
10^7 ×
   -0.0517   -0.1012   -0.1488   -0.1942   -0.2376   -0.2789   -0.3182   -0.3554 ···
res = -7.7775e+06
Phiref = 1×86
10^7 ×
   -0.0517   -0.1012   -0.1488   -0.1942   -0.2376   -0.2789   -0.3182   -0.3554 ···
res = -8.3053e+06
Warning: Integer operands are required for colon operator when used as index.
Phiref = 1×88
10^7 ×
   -0.0517   -0.1012   -0.1488   -0.1942   -0.2376   -0.2789   -0.3182   -0.3554 ···
res = -8.8665e+06
Phiref = 1×90
10^7 ×
```

```
   -0.0517   -0.1012   -0.1488   -0.1942   -0.2376   -0.2789   -0.3182   -0.3554 ···
res = -9.4605e+06
Warning: Integer operands are required for colon operator when used as index.
Phiref = 1×92
10^7 ×
   -0.0517   -0.1012   -0.1488   -0.1942   -0.2376   -0.2789   -0.3182   -0.3554 ···
res = -1.0087e+07
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  4.224756e-17.
Phiref = 1×94
10^7 ×
   -0.0517   -0.1012   -0.1488   -0.1942   -0.2376   -0.2789   -0.3182   -0.3554 ···
res = -1.0746e+07
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  9.333547e-18.
Warning: Integer operands are required for colon operator when used as index.
Phiref = 1×96
10^7 ×
   -0.0517   -0.1012   -0.1488   -0.1942   -0.2376   -0.2789   -0.3182   -0.3554 ···
res = -1.1437e+07
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  2.315900e-17.
Phiref = 1×98
10^7 ×
   -0.0517   -0.1012   -0.1488   -0.1942   -0.2376   -0.2789   -0.3182   -0.3554 ···
res = -1.2159e+07
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  1.525949e-18.
Warning: Integer operands are required for colon operator when used as index.
Phiref = 1×100
10^7 ×
   -0.0517   -0.1012   -0.1488   -0.1942   -0.2376   -0.2789   -0.3182   -0.3554 ···
res = -1.2913e+07
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  8.780450e-18.
res = -4.4779e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  3.597052e-18.
Warning: Integer operands are required for colon operator when used as index.
res = -4.3995e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  2.040862e-18.
res = -4.3345e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  9.034509e-19.
Warning: Integer operands are required for colon operator when used as index.
res = -4.2825e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  2.559382e-18.
res = -4.2432e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  2.187019e-18.
Warning: Integer operands are required for colon operator when used as index.
res = -4.2163e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  5.173382e-19.
res = -4.2015e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  4.579427e-19.
Warning: Integer operands are required for colon operator when used as index.
res = -4.1985e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  1.102663e-18.
res = -4.2071e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  2.035596e-18.
Warning: Integer operands are required for colon operator when used as index.
res = -4.2270e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  5.676834e-19.
res = -4.2580e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  3.422089e-19.
Warning: Integer operands are required for colon operator when used as index.
res = -4.3000e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  5.452935e-19.
res = -4.3526e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  5.650950e-19.
Warning: Integer operands are required for colon operator when used as index.
```

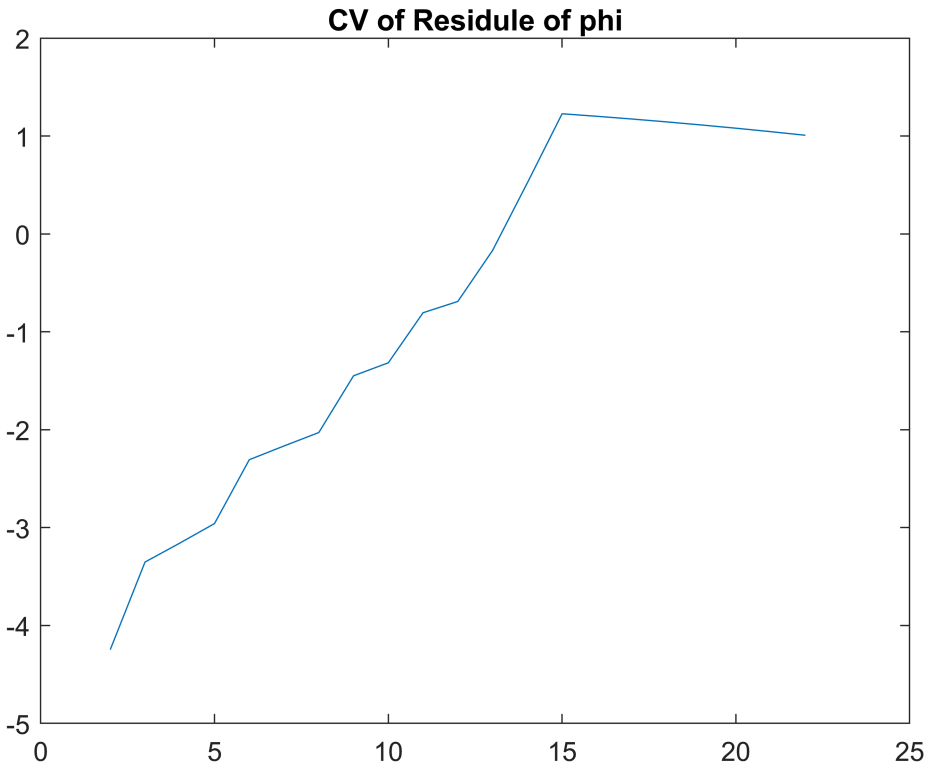
```
res = -4.4158e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  5.886181e-19.
res = -4.4894e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  1.462840e-19.
Warning: Integer operands are required for colon operator when used as index.
res = -4.5732e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  3.007967e-19.
res = -4.6670e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  9.883382e-19.
Warning: Integer operands are required for colon operator when used as index.
res = -4.7708e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  2.916918e-19.
res = -4.8844e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  7.761898e-20.
Warning: Integer operands are required for colon operator when used as index.
res = -5.0076e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  4.171431e-19.
res = -5.1404e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  3.691285e-19.
Warning: Integer operands are required for colon operator when used as index.
res = -5.2826e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  5.177746e-19.
res = -5.4342e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  3.410444e-19.
Warning: Integer operands are required for colon operator when used as index.
res = -5.5950e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  9.396507e-20.
res = -5.7649e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  7.219852e-20.
Warning: Integer operands are required for colon operator when used as index.
res = -5.9439e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  1.917986e-19.
res = -6.1319e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  1.424105e-19.
Warning: Integer operands are required for colon operator when used as index.
res = -6.3288e+06
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  1.947948e-21.
res = -6.5344e+06
Warning: Matrix is singular, close to singular or badly scaled. Results may be inaccurate. RCOND = NaN.
```

```
PHI = PHI/mean(PHI);
PHIREF = PHIREF/mean(PHIREF);
meanPHI = PHI;
meanPHIREF = PHIREF;
CVPHI = PHI;
CVPHIREF = PHIREF;

for ti = 1: length(c)
    meanPHI(ti) = mean(PHI(1:ti));
    stdPHI(ti) = std(PHI(1:ti));
    CVPHI(ti) = meanPHI(ti)/stdPHI(ti);

    meanPHIREF(ti) = mean(PHIREF(1:ti));
    stdPHIREF(ti) = std(PHIREF(1:ti));
    CVPHIREF(ti) = meanPHIREF(ti)/stdPHIREF(ti);
end
meanRES = meanPHI - meanPHIREF;
stdRES = stdPHI - stdPHIREF;
CVRES = CVPHI - CVPHIREF;

plot(meanRES)
```

```
title('Residule of phi')
```




```
plot(CVRES)
title('CV of Residule of phi')
```




```
[h1,p1,ci1,stats1] = ttest(meanPHI, meanPHIREF)
```

```
h1 = 0
p1 = 1.0000
stats1 = struct with fields:
    tstat: -4.7081e-16
       df: 21
       sd: 3.8209
```

```
[h2,p2,ci2,stats2] = ttest(Hs, Hsref)
```

```
stats2 = struct with fields:
    tstat: [-27.8091 1.0975 1.0975 27.8091]
       df: [21 21 21 21]
       sd: [1.7686e-30 4.0167e-28 4.0167e-28 1.7686e-30]
```

```
%imagesc(Hs./Hsref);
```