for ii=1:5

```
clearvars -except ii
rrbar=[0.25 0.6 0.75 1.5 10];
ttbar=[0 0 0.3 0.3 0.6];
rbar=rrbar(5);
tbar=ttbar(5);
a=0.1;
b=1;
i0=1;
kap=3;
n=80;
h=(b-a)/(n-1);
k=pi/2/(n-1);
beta=h^2/k^2;
a_mat=zeros((n-1)^2);
b_ary=zeros((n-1)^2,1);
b_ary_1=zeros((n-1)^2,1);
b_ary_2=zeros((n-1)^2,1);
count=0;
for i=1:n-1
    for j=1:n-1
        count=count+1;
        theta=(i-1)*k;
        r=(j-1)*h+a;
        r_ray(count)=r;
        theta=(i-1)*((pi/2)/(n-1));
        theta_ray(count)=theta;
        a_mat((i-1)*(n-1)+j,(i-1)*(n-1)+j)=-2*(1+beta/r^2);
        if i==1 %boundry C
            if j==1 %corner BC
                a_mat((i-1)*(n-1)+j,(i-1)*(n-1)+j+1)=2;
                a_mat((i-1)*(n-1)+j,i*(n-1)+j)=2*beta/r^2;
            elseif j==(n-1) % corner CD
                a_mat((i-1)*(n-1)+j,i*(n-1)+j)=2*beta/r^2;
                a_mat((i-1)*(n-1)+j,(i-1)*(n-1)+j-1)=(1-h/(2*r));
            else
                a_mat((i-1)*(n-1)+j,i*(n-1)+j)=2*beta/r^2;
                a_mat((i-1)*(n-1)+j,(i-1)*(n-1)+j-1)=(1-h/(2*r));
                a_mat((i-1)*(n-1)+j,(i-1)*(n-1)+j+1)=(1+h/(2*r));
            end
        end
        if j==(n-1) %boundry D
            if i==1 %corner CD
                a_mat((i-1)*(n-1)+j,i*(n-1)+j)=2*beta/r^2;
                a_mat((i-1)*(n-1)+j,(i-1)*(n-1)+j-1)=(1-h/(2*r));
            elseif i==(n-1) %corner AD
                a_mat((i-1)*(n-1)+j,(i-2)*(n-1)+j)=beta/r^2;
                a_mat((i-1)*(n-1)+j,(i-1)*(n-1)+j-1)=(1-h/(2*r));
            else
                a_mat((i-1)*(n-1)+j,i*(n-1)+j)=beta/r^2;
                a_mat((i-1)*(n-1)+j,(i-2)*(n-1)+j)=beta/r^2;
```

```
                    a_mat((i-1)*(n-1)+j,(i-1)*(n-1)+j-1)=(1-h/(2*r));
                end
            end
            if j==1 %boundry B
                if i==1 %corner BC
                    a_mat((i-1)*(n-1)+j,(i-1)*(n-1)+j+1)=2;
                    a_mat((i-1)*(n-1)+j,i*(n-1)+j)=2*beta/r^2;
                elseif i==(n-1) %corner AB
                    a_mat((i-1)*(n-1)+j,(i-1)*(n-1)+j+1)=2;
                    a_mat((i-1)*(n-1)+j,(i-2)*(n-1)+j)=beta/r^2;
                else
                    a_mat((i-1)*(n-1)+j,(i-1)*(n-1)+j+1)=2;
                    a_mat((i-1)*(n-1)+j,(i-2)*(n-1)+j)=beta/r^2;
                    a_mat((i-1)*(n-1)+j,(i)*(n-1)+j)=beta/r^2;
                end
            end
            if i==(n-1) %boundry A
                if j==1 %corner AB
                    a_mat((i-1)*(n-1)+j,(i-1)*(n-1)+j+1)=2;
                    a_mat((i-1)*(n-1)+j,(i-2)*(n-1)+j)=beta/r^2;
                elseif j==(n-1) %corner AD
                    a_mat((i-1)*(n-1)+j,(i-2)*(n-1)+j)=beta/r^2;
                    a_mat((i-1)*(n-1)+j,(i-1)*(n-1)+j-1)=(1-h/(2*r));
                else
                    a_mat((i-1)*(n-1)+j,(i-1)*(n-1)+j+1)=(1+h/(2*r));
                    a_mat((i-1)*(n-1)+j,(i-1)*(n-1)+j-1)=(1-h/(2*r));
                    a_mat((i-1)*(n-1)+j,(i-2)*(n-1)+j)=beta/r^2;
                end
            end
            if i~=1 && i~=(n-1) && j~=1 && j~=(n-1)
                a_mat((i-1)*(n-1)+j,(i-1)*(n-1)+j+1)=(1+h/(2*r));
                a_mat((i-1)*(n-1)+j,(i-1)*(n-1)+j-1)=(1-h/(2*r));
                a_mat((i-1)*(n-1)+j,(i-2)*(n-1)+j)=beta/r^2;
                a_mat((i-1)*(n-1)+j,(i)*(n-1)+j)=beta/r^2;
            end
            if j==(n-1)
                b_ary_1((i-1)*(n-1)+j,1)=(1+h/(2*r))*(-
i0*b*cos(3.*theta));
            end
            if i==(n-1)
                b_ary_2((i-1)*(n-1)+j,1)=0;
            end
            b_ary=(b_ary_1+b_ary_2);
        end
    end
    amat=diag(ones((n-1)*(n-1),1))-rbar*tbar*a_mat;
    bmat=diag(ones((n-1)*(n-1),1))+(1-tbar)*rbar*a_mat;
    aray=b_ary*(-rbar)*tbar;
    bray=b_ary*(1-tbar)*rbar;
    u_0=zeros((n-1)^2,1);
    temp=0;
    for i= 1:150
        temp=temp+1;
        u_1=amat\(bmat*u_0+bray-aray);
```

```
        u_i_1(temp)=u_0(30,1);
        u_i_2(temp)=u_0(1500,1);
        u_i_3(temp)=u_0(2200,1);
        u_i_4(temp)=u_0(3400,1);
        u_i_5(temp)=u_0(6000,1);
        u_0=u_1;
    end
    u_mat=reshape(u_1,[(n-1),(n-1)]);
    [x_ray,y_ray]=pol2cart(theta_ray,r_ray);
    x_mat=reshape(x_ray,[(n-1),(n-1)]);
    y_mat=reshape(y_ray,[(n-1),(n-1)]);
    figure()
    pcolor(x_mat,y_mat,u_mat)
    title(['solution map, r=',num2str(rbar),'theta=',num2str(tbar)])
    figure()
    plot(u_i_1)
    title(['transient timeseries 1, r=',num2str(rbar),'
 theta=',num2str(tbar)])
    xlabel('time as iteration #')
    ylabel('U(i)')
    figure()
    plot(u_i_2)
    title(['transient timeseries 2, r=',num2str(rbar),'
 theta=',num2str(tbar)])
    xlabel('time as iteration #')
    ylabel('U(i)')
    figure()
    plot(u_i_3)
    title(['transient timeseries 3, r=',num2str(rbar),'
 theta=',num2str(tbar)])
    xlabel('time as iteration #')
    ylabel('U(i)')
    figure()
    plot(u_i_4)
    title(['transient timeseries 4, r=',num2str(rbar),'
 theta=',num2str(tbar)])
    xlabel('time as iteration #')
    ylabel('U(i)')
    figure()
    plot(u_i_5)
    title(['transient timeseries 5, r=',num2str(rbar),'
 theta=',num2str(tbar)])
    xlabel('time as iteration #')
    ylabel('U(i)')

    t_c(1)=max(find(abs(u_i_1-u_i_1(end))>=0.37*u_i_1(end)));
    t_c(2)=max(find(abs(u_i_2-u_i_2(end))>=0.37*u_i_2(end)));
    t_c(3)=max(find(abs(u_i_3-u_i_3(end))>=0.37*u_i_3(end)));
    t_c(4)=max(find(abs(u_i_4-u_i_4(end))>=0.37*u_i_4(end)));
    t_c(5)=max(find(abs(u_i_5-u_i_5(end))>=0.37*u_i_5(end)));
%end
```

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