Electronic Supplementary Material (ESI) for Nanoscale Advances.

MATLAB Codes for Fig. 2 and Visualization 1.

1. **Matlab Code-Visualization 1-isosurface of Potential Energy from Different Viewpoints:**

```
 % interference of six Gaussian beams
clc
close all
clear
% Constants
================================================================
e0=8.854187817620e-12; % vacuum permittivity
m0=4*pi*1e-7; % free space permeability
y0=sqrt(e0/m0); % intrinsinc admittance
c=299792458; % speed of light (m/s)
KT=4.04e-21; % Thermal energy (ET=KT, T=293 K)
% Surrounding medium parameters
=========================================
nm=1.33; % the refractive index of the Surrounding medium
ym=nm*y0; % Surrounding medium admittance
% Particle parameters
=====================================================
np=1.59; % particle refractive index
a=50e-9; % particle radius
nr=np/nm; % Relative refractive index of the particle
e=(nr^2-1)/(nr^2+2);
A=4*pi*a^3*e; % particle polarizability
% Incident beam parameters
================================================
P=1/6; % the power of each beam
l0=632.8e-9; % free-space wavelength
l=l0/nm;
k0=2*pi/l0; % free-space wavenumber
k=nm*k0; % wavenumber in the surrounding medium
w0=4*l; % waist radius
z0=(1/2)*k*w0^2; % Rayleigh range
S=pi*w0^2; I0=2*P/S;
E0=sqrt(2*I0/ym);
% simulation region
=========================================================
d=350e-9+eps;
s=5e-9;

v=-d:s:d;
[x,y,z]=meshgrid(v);
t=0:3:180;
filename = 'viewpoint_change.gif';
h = light;
for m=1:length(t)
% propagation direction (x)
```

```
rx=sqrt(y.^2+z.^2); % radial distance from the center axis of the beam
Rx=x.*(1+(z0/x).^2);
Sx=atan(x/z0);
wx=w0*sqrt(1+(x/z0).^2);
fx=k*x+0.5*k*rx.^2./Rx-Sx;
Ex=E0*(w0./wx).*exp(-(rx./wx).^2);
% ========================================================
% propagation direction (y)
ry=sqrt(x.^2+z.^2); % radial distance from the center axis of the beam
Ry=y.*(1+(z0/y).^2);
Sy=atan(y/z0);
wy=w0*sqrt(1+(y/z0).^2);
fy=k*y+0.5*k*ry.^2./Ry-Sy;
Ey=E0*(w0./wy).*exp(-(ry./wy).^2);
% ========================================================
% propagation direction (z)
rz=sqrt(x.^2+y.^2); % radial distance from the center axis of the beam
Rz=z.*(1+(z0/z).^2);
Sz=atan(z/z0);
wz=w0*sqrt(1+(z/z0).^2);
fz=k*z+0.5*k*rz.^2./Rz-Sz;
Ez=E0*(w0./wz).*exp(-(rz./wz).^2);
% ========================================================
E1x=Ez.*exp(-1i*fz); E2x=Ez.*exp(+1i*fz);
E1y=Ex.*exp(-1i*fx); E2y=Ex.*exp(+1i*fx);
E1z=Ey.*exp(-1i*fy); E2z=Ey.*exp(+1i*fy);
% ========================================================
E_x=E1x+E2x;

E_y=E1y+E2y;
E_z=E1z+E2z;
I=0.5*ym*(abs(E_x).^2+abs(E_y).^2+abs(E_z).^2);
U=-0.5.*nm.*A.*I/c;
Un=U/KT;
Un=Un-min(min(min(Un)));
hiso = patch(isosurface(x,y,z,Un,10));
isonormals(x,y,z,Un,hiso)
set(hiso,'FaceColor','[0,0.45,0.74]','EdgeColor','none');
hcap = patch(isocaps(x,y,z,Un,10),...
'FaceColor','none',...
'EdgeColor','none');
colormap(hsv(200));
axis tight
box on
% camproj perspective
% camzoom(0.7)
view(t(m),35)
axis equal
% camlight(t(m),20)
lightangle(h,t(m),-20)
set(gcf,'Renderer','zbuffer');
lighting phong
```

```
set(hcap,'AmbientStrength',.6)
drawnow
frame = getframe(1);
im = frame2im(frame);
[B,map] = rgb2ind(im,256);
if m == 1;
imwrite(B,map,filename,'gif','LoopCount',Inf,'DelayTime',0.2);
else
imwrite(B,map,filename,'gif','WriteMode','append','DelayTime',0.2);
end
end
```

2. Matlab Code-Fig. 2-Normalized Potential Energy:

```
 % Fig. 2
clc
close all
clear
% Constants
============================================================
e0=8.854187817620e-12; % vacuum permittivity
m0=4*pi*1e-7; % free space permeability
y0=sqrt(e0/m0); % intrinsinc admittance
c=299792458; % speed of light (m/s)
KT=4.04e-21; % Thermal energy (ET=KT, T=293 K)
% Surrounding medium parameters
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nm=1.33; % the refractive index of the Surrounding medium
ym=nm*y0; % Surrounding medium admittance
% Particle parameters
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np=1.59; % particle refractive index
a=50e-9; % particle radius
nr=np/nm; % Relative refractive index of the particle
e=(nr^2-1)/(nr^2+2);
A=4*pi*a^3*e; % particle polarizability
% Incident beam parameters
=================================================
P=1/6; % the power of each beam
l0=632.8e-9; % free-space wavelength
l=l0/nm; % wavelength
k0=2*pi/l0; % free-space wavenumber
k=nm*k0; % wavenumber in the surrounding medium
w0=4*l; % waist radius
z0=(1/2)*k*w0^2; % Rayleigh range
S=pi*w0^2; I0=2*P/S;
E0=sqrt(2*I0/ym);
```

```
% simulation region
=====================================================
d=350e-9+eps;
s=3.5e-9;
v=-d:s:d;

[x,y,z]=meshgrid(v);
% propagation direction (x)
rx=sqrt(y.^2+z.^2); % radial distance from the center axis of the beam
Rx=x.*(1+(z0./x).^2);
Sx=atan(x/z0);
wx=w0*sqrt(1+(x/z0).^2);
fx=k*x+0.5*k*rx.^2./Rx-Sx;
Ex=E0*(w0./wx).*exp(-(rx./wx).^2);
% propagation direction (y)
ry=sqrt(x.^2+z.^2); % radial distance from the center axis of the beam
Ry=y.*(1+(z0./y).^2);
Sy=atan(y/z0);
wy=w0*sqrt(1+(y/z0).^2);
fy=k*y+0.5*k*ry.^2./Ry-Sy;
Ey=E0*(w0./wy).*exp(-(ry./wy).^2);
% propagation direction (z)
rz=sqrt(x.^2+y.^2); % radial distance from the center axis of the beam
Rz=z.*(1+(z0/z).^2);
Sz=atan(z/z0);
wz=w0*sqrt(1+(z/z0).^2);
fz=k*z+0.5*k*rz.^2./Rz-Sz;
Ez=E0*(w0./wz).*exp(-(rz./wz).^2);
% ============================================================
E1x=Ez.*exp(-1i*fz); E2x=Ez.*exp(+1i*fz);
E1y=Ex.*exp(-1i*fx); E2y=Ex.*exp(+1i*fx);
E1z=Ey.*exp(-1i*fy); E2z=Ey.*exp(+1i*fy);
% ============================================================
E_x=E1x+E2x;
E_y=E1y+E2y;
E_z=E1z+E2z;
I=0.5*ym*(abs(E_x).^2+abs(E_y).^2+abs(E_z).^2);
U=-0.5.*nm.*A.*I/c;
Un=U/KT;
Un=Un-min(min(min(Un)));
[Fx,Fy,Fz]=gradient(-U);
F=sqrt(Fx.^2+Fy.^2+Fz.^2);

%
=========================================================================
%
=========================================================================
positionVector1 = [0, 0.2, 0.6, 0.6];
positionVector2 = [0.44, 0.2, 0.6, 0.6];
figure
subplot('Position',positionVector1)
xslice =[-l/2,0,l/2];
```

```
yslice =[-l/2,0,l/2];
zslice =[-l/2,0,l/2];
cvals = linspace(0,10,80);
contourslice(x,y,z,Un,xslice,yslice,zslice,cvals)
colormap(hsv(350))
hiso = patch(isosurface(x,y,z,Un,10));
hiso.AmbientStrength=0;
isonormals(x,y,z,Un,hiso);
set(hiso,'FaceColor','g','EdgeColor','none');
hcap =
patch(isocaps(x,y,z,Un,10),'FaceColor','none','EdgeColor','none');
alpha(hiso,0.5)
view(60,60)
camlight(50,50)
set(gcf,'Renderer','zbuffer');
lighting phong
ax = gca;
ax.FontSize = 14;
ax.FontWeight='bold';
ax.XTick =[-200 0 200]*1e-9;
ax.YTick = [-200 0 200]*1e-9;
ax.ZTick = [-200 0 200]*1e-9;
ax.XTickLabel = {'200','0','200'};
ax.YTickLabel = {'200','0','200'};
ax.ZTickLabel = {'200','0','200'};
axis tight
axis equal

colorbar
box on
grid on
camzoom(1.2)
xlabel('x (nm)','FontSize',14,'Color','k')
ylabel('y (nm)','FontSize',14,'Color','k')
zlabel('z (nm)','FontSize',14,'Color','k')
title('(a)','FontSize',28,'Color', 'k');
subplot('Position',positionVector2)
h = slice(x,y,z,Un,[0],0,0);
% h.AmbientStrength=0.7;
% alpha('color')
set(h,'EdgeColor','none','FaceColor','interp','AmbientStrength',0.5,
...
'FaceAlpha','interp')
alphamap('rampdown')
alphamap('increase',0.2)
colormap(hsv(300))
alpha(0.8)
view(60,60)
% camlight(50,50)
camlight('headlight')
% camlight(50,50)
set(gcf,'Renderer','zbuffer');
```

```
lighting phong
axis tight
axis equal
colorbar
hold on
box on
camzoom(1.2)
h = streamslice(x,y,z,Fx,Fy,Fz,0,0,0);
set(h,'LineWidth',1.5)
set(h,'Color','m')
D=[-l/2,0,l/2];
x0=D;
y0=D;
for m=1:3

for n=1:3
S=(x-x0(m)).^2+(y-y0(n)).^2+(z).^2-a^2;
hiso = patch(isosurface(x,y,z,S,0));
isonormals(x,y,z,S,hiso)
set(hiso,'FaceColor','[0,0.45,0.74]','EdgeColor','none');
hcap =
patch(isocaps(x,y,z,S,0),'FaceColor','none','EdgeColor','none');
colormap(hsv(300));
end
end
ax = gca;
ax.FontSize = 14;
ax.FontWeight='bold';
ax.XTick =[-200 0 200]*1e-9;
ax.YTick = [-200 0 200]*1e-9;
ax.ZTick = [-200 0 200]*1e-9;
ax.XTickLabel = {'200','0','200'};
ax.YTickLabel = {'200','0','200'};
ax.ZTickLabel = {'200','0','200'};
xlabel('x (nm)','FontSize',14,'Color','k')
ylabel('y (nm)','FontSize',14,'Color','k')
zlabel('z (nm)','FontSize',14,'Color','k')
title('(b)','FontSize',28,'Color', 'k');
```