
Subject: need to speed up Runge-Kutta section
Posted by [pdeyoung](#) on Wed, 04 May 2005 22:45:04 GMT
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The code below basically tracks particles through a magnetic field using 4th order RK. We are still running validation checks to find the typos but we know now that it is too slow. As currently written it does 1000 trajectories in about 0.5 second but ultimately we will need to generate about 10^6 for the project. The current speed is doable but I wonder if anyone can see a way to speed up the RK section (search for SYSTIME to find the beginning and end of the slow RK section). I know there is an RK4 built-in but worried that all the function calls would be even slower. Thankyou in advance for any suggestions. I am using IDL6.1

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```
pro rk_fullfield_v5
```

```
; I feel the need for speed!
```

```
common keep_track,x,y,z,vx,vy,vz  
common
```

```
keep_data,datax,datay,dataz,x_data,y_data,z_data,number_of_channels_x,  
number_of_channels_y,number_of_channels_z  
common constants,mass,gamma  
;start map stuff
```

```
number_of_channels_x = 150  
number_of_channels_y = 5  
number_of_channels_z = 200 ;150 by 200 grid  
x_bin_width = 0.0050336 ;(-550 to +200 in 149 steps)  
y_bin_width = 0.22098;  
z_bin_width = 0.0072864 ;(-300 to +1150 in 199 steps)  
min_x_value = -0.550  
max_x_value = (number_of_channels_x - 1) * x_bin_width + min_x_value  
min_y_value = -2*.22098  
max_y_value = (number_of_channels_y - 1) * y_bin_width + min_y_value  
min_z_value = -0.300  
max_z_value = (number_of_channels_z - 1) * z_bin_width + min_z_value  
;print,max_z_value
```

```
;file = dialog_pickfile() ;generic way to pick the data file that need  
to be preprocessed  
file2 = "c:\user\map_tracking\map2.txt"  
openr, lun2, file2, /get_lun ;opens data file for reading
```

```
file3 = "c:\user\map_tracking\map3.txt"
openr, lun3, file3, /get_lun ;opens data file for reading
file4 = "c:\user\map_tracking\map4.txt"
openr, lun4, file4, /get_lun ;opens data file for reading
file5 = "c:\user\map_tracking\map5.txt"
openr, lun5, file5, /get_lun ;opens data file for reading
file6 = "c:\user\map_tracking\map6.txt"
openr, lun6, file6, /get_lun ;opens data file for reading
```

```
data2=fltarr(number_of_channels_x,number_of_channels_z)
data3=fltarr(number_of_channels_x,number_of_channels_z)
data4=fltarr(number_of_channels_x,number_of_channels_z)
data5=fltarr(number_of_channels_x,number_of_channels_z)
data6=fltarr(number_of_channels_x,number_of_channels_z)
```

```
x_data = fltarr(number_of_channels_x)
y_data = fltarr(number_of_channels_y)
z_data = fltarr(number_of_channels_z)
```

```
readf, lun2, data2,FORMAT='(150F0)'
readf, lun3, data3,FORMAT='(150F0)'
readf, lun4, data4,FORMAT='(150F0)'
readf, lun5, data5,FORMAT='(150F0)'
readf, lun6, data6,FORMAT='(150F0)'
```

```
free_lun,lun2
free_lun,lun3
free_lun,lun4
free_lun,lun5
free_lun,lun6
```

```
for i = 0,number_of_channels_x-1, 1 do begin
x_data(i) = float(i) * x_bin_width + min_x_value
endfor
```

```
for i = 0,number_of_channels_y-1, 1 do begin
y_data(i) = float(i) * y_bin_width + min_y_value
endfor
```

```
for i = 0,number_of_channels_z-1, 1 do begin
z_data(i) = float(i) * z_bin_width + min_z_value
endfor
```

```
;end map stuff
```

```
;make three d arrays
```

```
datax =  
  fltarr(number_of_channels_x,number_of_channels_y,number_of_channels_z)  
datay =  
  fltarr(number_of_channels_x,number_of_channels_y,number_of_channels_z)  
dataz =  
  fltarr(number_of_channels_x,number_of_channels_y,number_of_channels_z)
```

```
;fill the datay array
```

```
datay(*,0,*) = data2(*,*)  
datay(*,1,*) = data3(*,*)  
datay(*,2,*) = data4(*,*)  
datay(*,3,*) = data5(*,*)  
datay(*,4,*) = data6(*,*)
```

```
;ISURFACE, data2(*,*),x_data,z_data  
;ISURFACE, data3(*,*),x_data,z_data  
;ISURFACE, data4(*,*),x_data,z_data  
;ISURFACE, data5(*,*),x_data,z_data  
;ISURFACE, data6(*,*),x_data,z_data
```

```
;generate the other components of the field
```

```
call_procedure, 'build_field',x_bin_width, y_bin_width, z_bin_width
```

```
;data_plot =  
  fltarr(number_of_channels_x,number_of_channels_y,number_of_channels_z)  
;data_plot =  
  reform(datax(*,0,*),number_of_channels_x,number_of_channels_z)  
;ISURFACE,data_plot,x_data,z_data,ZRANGE=[-10,10],TITLE="x2 "  
;data_plot =  
  reform(datax(*,1,*),number_of_channels_x,number_of_channels_z)  
;ISURFACE,data_plot,x_data,z_data,ZRANGE=[-10,10],TITLE="x3 "  
;data_plot =  
  reform(datax(*,2,*),number_of_channels_x,number_of_channels_z)  
;ISURFACE,data_plot,x_data,z_data,ZRANGE=[-10,10],TITLE="x4 "  
;data_plot =  
  reform(datax(*,3,*),number_of_channels_x,number_of_channels_z)  
;ISURFACE,data_plot,x_data,z_data,ZRANGE=[-10,10],TITLE="x5 "  
;data_plot =  
  reform(datax(*,4,*),number_of_channels_x,number_of_channels_z)  
;ISURFACE,data_plot,x_data,z_data,ZRANGE=[-10,10],TITLE="x6 "  
;data_plot =
```

```

reform(datay(*,0,*),number_of_channels_x,number_of_channels_z)
;ICONTOUR,data_plot,x_data,z_data,N_LEVELS=10,TITLE="y2"
;data_plot =
reform(datay(*,1,*),number_of_channels_x,number_of_channels_z)
;ICONTOUR,data_plot,x_data,z_data,N_LEVELS=10,TITLE="y3"
;data_plot =
reform(datay(*,2,*),number_of_channels_x,number_of_channels_z)
;ICONTOUR,data_plot,x_data,z_data,N_LEVELS=10,TITLE="y4"
;data_plot =
reform(datay(*,3,*),number_of_channels_x,number_of_channels_z)
;ICONTOUR,data_plot,x_data,z_data,N_LEVELS=10,TITLE="y5"
;data_plot =
reform(datay(*,4,*),number_of_channels_x,number_of_channels_z)
;ICONTOUR,data_plot,x_data,z_data,N_LEVELS=10,TITLE="y6"
;data_plot =
reform(dataz(*,0,*),number_of_channels_x,number_of_channels_z)
;ISURFACE,data_plot,x_data,z_data,ZRANGE=[-10,10],TITLE="z2 "
;data_plot =
reform(dataz(*,1,*),number_of_channels_x,number_of_channels_z)
;ISURFACE,data_plot,x_data,z_data,ZRANGE=[-10,10],TITLE="z3 "
;data_plot =
reform(dataz(*,2,*),number_of_channels_x,number_of_channels_z)
;ISURFACE,data_plot,x_data,z_data,ZRANGE=[-10,10],TITLE="z4 "
;data_plot =
reform(dataz(*,3,*),number_of_channels_x,number_of_channels_z)
;ISURFACE,data_plot,x_data,z_data,ZRANGE=[-10,10],TITLE="z5 "
;data_plot =
reform(dataz(*,4,*),number_of_channels_x,number_of_channels_z)
;ISURFACE,data_plot,x_data,z_data,ZRANGE=[-10,10],TITLE="z6 "

```

```

;start of SLOW rk stuff

```

```

T = SYSTIME(1)

```

```

magic_cos = cos(2.7381*!PI/180.)
magic_sin = sin(2.7381*!PI/180.)

```

```

;initial conditions
x_initial = -0.04805 ;meter - set by map
y_initial = 0.0
z_initial = -0.100 ; set by map

```

```

;generate 1000 tracks

```

```

for ienergy=.9,1.1,.001 do begin
;print,"factor",ienergy

```

```

constant = (10*ienergy*3.2718*300/931.494/26.2114)^2
beta = sqrt(constant/(1+constant))
;fix this for three dimension

theta_inplane = 0.0*PI/180.
theta_outplane = 1.0*PI/180.
tan_theta_inplane = tan(theta_inplane)
tan_theta_outplane = tan(theta_outplane)

beta_inplane_squared =
  (tan_theta_inplane)^2*beta^2/(1+(tan_theta_outplane)^2+(tan_theta_inplane)^2)
beta_inplane = sqrt(beta_inplane_squared)
beta_outplane_squared =
  (tan_theta_outplane)^2*beta^2/(1+(tan_theta_outplane)^2+(tan_theta_inplane)^2)
beta_outplane = sqrt(beta_outplane_squared)
beta_z = sqrt(beta^2-beta_inplane_squared-beta_outplane_squared)
;print,tan(theta_inplane),tan(theta_outplane)
;print,beta,beta_inplane,beta_outplane,beta_z

vx_initial = (magic_cos*beta_inplane-magic_sin*beta_z)*3e8
vy_initial = beta_outplane*3e8
vz_initial = (beta_inplane*magic_sin+magic_cos*beta_z)*3e8
;meter/second
;print,vx_initial,vy_initial,vz_initial
;By = 1 ; Tesla
mass = 26.2114*(931.494e6)*(1.6e-19)/(3e8)^2 ;kilograms

q = 10*1.6e-19 ; coulombs

gamma = 1/sqrt(1-(beta)^2) ; unitless

;print,gamma,mass

x = fltarr(1001)
y = fltarr(1001)
z = fltarr(1001)

vx = fltarr(1001)
vy = fltarr(1001)
vz = fltarr(1001)

```

```

x(0) = x_initial
y(0) = y_initial
z(0) = z_initial
vx(0) = vx_initial
vy(0) = vy_initial
vz(0) = vz_initial

step = 2e-11 ; seconds
times = findgen(1001) * step

;do the r-k here
for i = 0, 999, 1 do begin

;get field value

x_index = ((x(i) - min_x_value) / x_bin_width)
y_index = ((y(i) - min_y_value) / y_bin_width)
z_index = ((z(i) - min_z_value) / z_bin_width)

Bx = INTERPOLATE(datax, x_index, y_index, z_index, MISSING = 0)
By = INTERPOLATE(datay, x_index, y_index, z_index, MISSING = 0)
Bz = INTERPOLATE(dataz, x_index, y_index, z_index, MISSING = 0)

if (Bx+By+Bz EQ 0) then begin
    step = step*500
    times(i+1) = times(i)+step
endif

vx_temp = vx(i)
vy_temp = vy(i)
vz_temp = vz(i) ;this was faster than replacing the *_temp below

k1x = step*(vx_temp)
k2x = step*(vx_temp+k1x/2.)
k3x = step*(vx_temp+k2x/2.)
k4x = step*(vx_temp+k3x/2.)

k1y = step*(vy_temp)
k2y = step*(vy_temp+k1y/2.)
k3y = step*(vy_temp+k2y/2.)
k4y = step*(vy_temp+k3y/2.)

k1z = step*(vz_temp)
k2z = step*(vz_temp+k1z/2.)
k3z = step*(vz_temp+k2z/2.)
k4z = step*(vz_temp+k3z/2.)

```

```

k1vx = step*q*(vy_temp*Bz-vz_temp*By)/gamma/mass
k1vy = step*q*(vz_temp*Bx-vx_temp*Bz)/gamma/mass
k1vz = step*q*(vx_temp*By-vy_temp*Bx)/gamma/mass

k2vx = step*q*((vy_temp+k1vy/2)*Bz-(vz_temp+k1vz/2)*By)/gamma/mass
k2vy = step*q*((vz_temp+k1vz/2)*Bx-(vx_temp+k1vx/2)*Bz)/gamma/mass
k2vz = step*q*((vx_temp+k1vx/2)*By-(vy_temp+k1vy/2)*Bx)/gamma/mass

k3vx = step*q*((vy_temp+k2vy/2)*Bz-(vz_temp+k2vz/2)*By)/gamma/mass
k3vy = step*q*((vz_temp+k2vz/2)*Bx-(vx_temp+k2vx/2)*Bz)/gamma/mass
k3vz = step*q*((vx_temp+k2vx/2)*By-(vy_temp+k2vy/2)*Bx)/gamma/mass

k4vx = step*q*((vy_temp+k3vy/2)*Bz-(vz_temp+k3vz/2)*By)/gamma/mass
k4vy = step*q*((vz_temp+k3vz/2)*Bx-(vx_temp+k3vx/2)*Bz)/gamma/mass
k4vz = step*q*((vx_temp+k3vx/2)*By-(vy_temp+k3vy/2)*Bx)/gamma/mass

x(i+1) = x(i)+(1/6.)*(k1x+2*k2x+2*k3x+k4x)
y(i+1) = y(i)+(1/6.)*(k1y+2*k2y+2*k3y+k4y)
z(i+1) = z(i)+(1/6.)*(k1z+2*k2z+2*k3z+k4z)
vx(i+1) = vx(i)+(1/6.)*(k1vx+2*k2vx+2*k3vx+k4vx)
vy(i+1) = vy(i)+(1/6.)*(k1vy+2*k2vy+2*k3vy+k4vy)
vz(i+1) = vz(i)+(1/6.)*(k1vz+2*k2vz+2*k3vz+k4vz)

if (step GE 1e-9) then break

endfor

xlast = x(i+1)
xntlast = x(i)
ylast = y(i+1)
yntlast = y(i)
zlast = z(i+1)
zntlast = z(i)

;print,i,z(i),z(i+1),times(i),times(i+1),step

;get the angle and position in CRDC frame

thetarad = atan((xlast-xntlast)/(zlast-zntlast))
theta = thetarad*180/!PI
;print,"x angle, x angle in fp frame",theta,theta+45.7381

;eq of crdc1 is x=.97456*z-1.995
;find B for track
trackb=xlast-tan(thetarad)*zlast
trackz=(-1.995-trackb)/(tan(thetarad)-0.97456)

```

```

trackx = 0.97456*trackz-1.995
crdcx=sqrt((trackx+0.80314)^2+(trackz-1.22304)^2)
if (trackz LT 1.22304) then begin
crdcx = -crdcx
endif
;print,"z,x at crdc1, x dist from crdc center",trackz,trackx,crdcx

;get the angle and position in CRDC frame

;note angle correction for 43 degrees
thetarad = atan((ylast-yntlast)/((zlast-zntlast)/cos(43*!PI/180.)))
theta = thetarad*180/!PI
;print,"y angle in fp frame",theta

;recalc theta in map frame
;find B for track
thetarad = atan((ylast-yntlast)/(zlast-zntlast))
trackb=ylast-tan(thetarad)*zlast
tracky = tan(thetarad)*trackz+trackb
crdcy = tracky
;print,"y dist from crdc center",crdcy

;find the flight time to the crdc1
;find closest index in z array

tof = INTERPOL(times(0:i+1),z(0:i+1),trackz)
;print,"tof to crdc",tof
dist = beta*0.30*tof*1e9
;print,"flight path",dist
endfor

PRINT, SYSTIME(1) - T, 'Seconds'

IPLOT,z(0:i+1),x(0:i+1),COLOR=[255,0,0]
IPLOT,z(0:i+1),y(0:i+1),COLOR=[255,0,0]

;ICONTOUR,data4,x_data,z_data
;IPLOT,x,z,COLOR=[255,0,0],OVERPLOT=1

end

pro interp_B, x_value, y_value, z_value, x_bin_width, min_x_value,

```

```
y_bin_width, min_y_value, z_bin_width, min_z_value, Bx, By, Bz
```

```
common
```

```
keep_data, datax, datay, dataz, x_data, y_data, z_data, number_of_channels_x, number_of_channels_y, number_of_channels_z
```

```
x_index = ((x_value - min_x_value) / x_bin_width)
```

```
y_index = ((y_value - min_y_value) / y_bin_width)
```

```
z_index = ((z_value - min_z_value) / z_bin_width)
```

```
Bx = INTERPOLATE(datax, x_index, y_index, z_index, MISSING = 0)
```

```
By = INTERPOLATE(datay, x_index, y_index, z_index, MISSING = 0)
```

```
Bz = INTERPOLATE(dataz, x_index, y_index, z_index, MISSING = 0)
```

```
end
```

```
pro build_field, x_bin_width, y_bin_width, z_bin_width
```

```
common
```

```
keep_data, datax, datay, dataz, x_data, y_data, z_data, number_of_channels_x, number_of_channels_y, number_of_channels_z
```

```
;above midplane
```

```
for j=2,3,1 do begin
```

```
for i=0,number_of_channels_x-2,1 do begin
```

```
for k=0,number_of_channels_z-1,1 do begin
```

```
datax(i,j+1,k) =
```

```
(datay(i+1,j,k)/x_bin_width-datay(i,j,k)/x_bin_width)*y_bin_width+datax(i,j,k)
```

```
endfor
```

```
endfor
```

```
endfor
```

```
for j=2,3,1 do begin
```

```
for i=0,number_of_channels_x-1,1 do begin
```

```
for k=0,number_of_channels_z-2,1 do begin
```

```
dataz(i,j+1,k) =
```

```
(datay(i,j,k+1)/z_bin_width-datay(i,j,k)/z_bin_width)*y_bin_width+dataz(i,j,k)
```

```
endfor
```

```
endfor
```

```

endifor

;below midplane
for j=2,1,-1 do begin
for i=0,number_of_channels_x-1,1 do begin
for k=0,number_of_channels_z-2,1 do begin

dataz(i,j-1,k) =
(datay(i,j,k)/z_bin_width-datay(i,j,k+1)/z_bin_width)*y_bin_width+dataz(i,j,k)

endifor
endifor
endifor

for j=2,1,-1 do begin
for i=0,number_of_channels_x-2,1 do begin
for k=0,number_of_channels_z-1,1 do begin

datax(i,j-1,k) =
(datay(i,j,k)/x_bin_width-datay(i+1,j,k)/x_bin_width)*y_bin_width+datax(i,j,k)

endifor
endifor
endifor

for j=0,number_of_channels_y-1,1 do begin
for i=0,number_of_channels_x-1,1 do begin
for k=0,number_of_channels_z-1,1 do begin

datax(i,j,k) = datax(i,j,k)>(-10)
datax(i,j,k) = datax(i,j,k)<10
dataz(i,j,k) = dataz(i,j,k)>(-10)
dataz(i,j,k) = dataz(i,j,k)<10

endifor
endifor
endifor

end

```
