Rplot:
A Data visualization program for the Riod Simulation

User Guide and Description
Updated: May 15, 2023

This document is the User Guide and Description of the Rplot.exe visualization program to be used in conjunction with Riod Gravitational Simulation. The author uses this document as a living reference which is updated along with any new features, behaviors or methodology. Its primary use is to provide an accurate reference for the author after extended periods of development inactivity. If this document should its way to others and there are questions regarding its content, I can be reached at the email below.

I apologize to any reader in advance in that MS Word keeps messing up this document with false entries in the table of contents and arbitrarily making fonts bold and I have no idea why. Ugh!

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1 Introduction

This document describes the usage and operations of the Rplot.exe data visualization program that was designed to be used the output from the Riod many-body gravitational simulation. The primary purpose for writing this user manual is for the author to track changes to the code and to have a source to refer to after long periods of development inactivity. Of course, if this program makes its way to others for use, the manual provides a base for the use and understanding of what is going on.

Rplot.exe replaces the old Animate.exe program. Rplot was created using the AppGraphics additions to the SimplyFortran development environment and thus has a Windows GUI interface. It provides all the "features" of its predecessor but is much easier to use and minus (most of) its quirks.

Note too that this document is a living one, meaning that it is updated regularly (check out the Change History section) as the author has time to work on the code and make changes.

Note, that if there are references in the document that need further explanation, please see the Riod.exe documentation as it will probably be discussed therein.

2 Plotting Data with Rplot.exe

Rplot is intended to provide the user of the Riod simulation a way of visualizing what is happening with a running or completed simulation's output data. It has many features allowing for many different viewpoints to understand the evolution of the simulation data.

Figure 1 below is a current screen shot (during normal use, it will change slightly during screen capture mode) of the program interface:

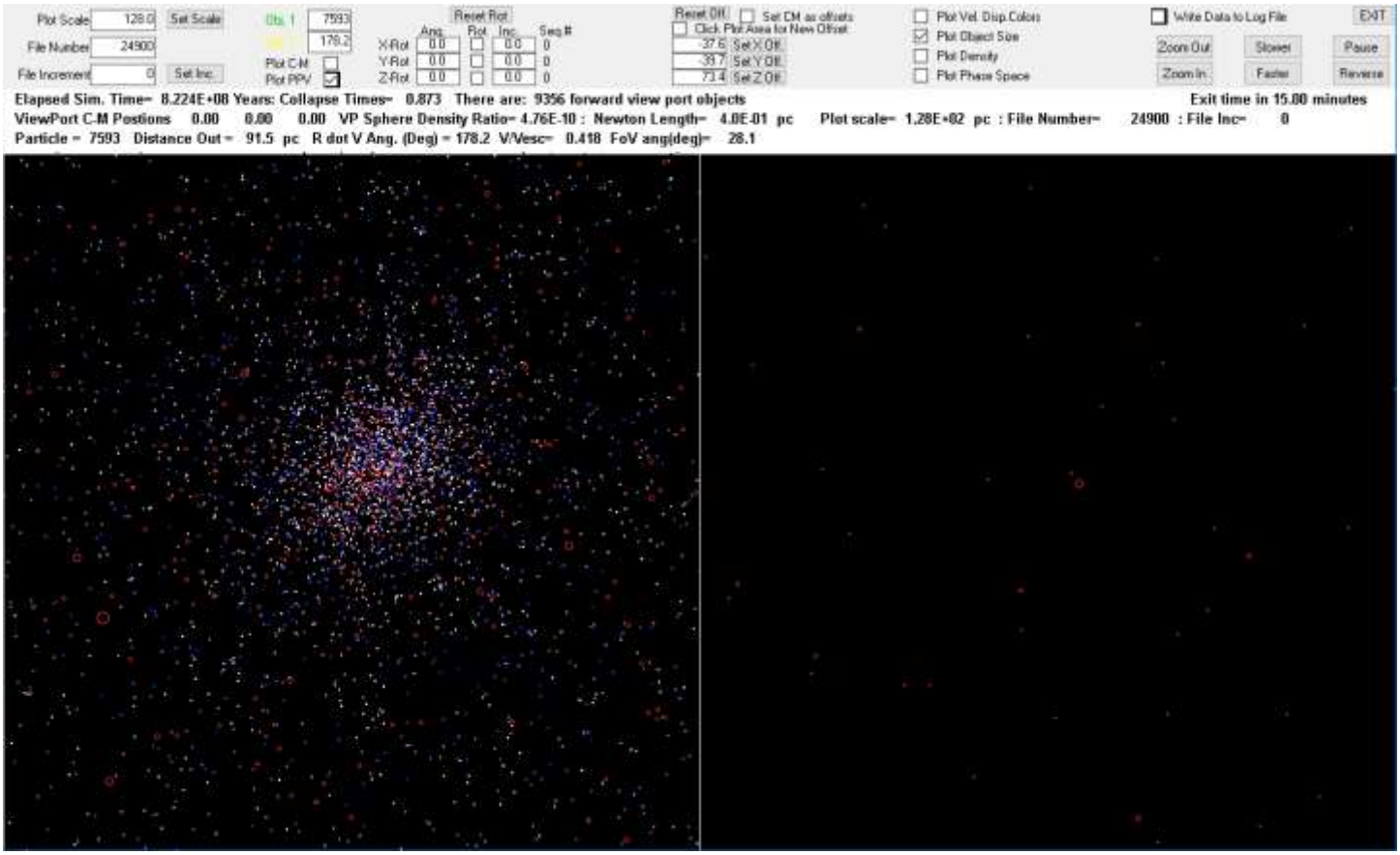


Figure 1: Current Rplot.exe output display showing PPV plotting capabilities as 9/1/2021.

Note on simulation compatibility. As of 7/26/2020, I have modified Rplot.exe to be compatible with simulations that were created before 1/13/2019. These older simulations saved position data as single precision floating point numbers. There was

also no velocity data saved in these simulations, so if Rplot.exe encounters these older simulations, it will turn off the phase space plotting option. Additionally, these older simulations had no RunStrings saved, so that is unavailable.

Further notes on using the action buttons and check boxes:

- New actions are executed once the current action is completed. Since plotting thousands of positions on the screen takes time, an action or actions initiated while plotting will be deferred until the next plotting cycle.
- It is now possible that the user can initiate up to 10 actions before the plotting cycle completes. Those actions will be initiated once the new plotting cycle begins and are completed in the order they were initiated. Note that some user actions will result in program weirdness and Rplot will just shut down. Actions like scaling, changing time directions, pausing, offset and rotation resets are fine but some of the others are at risk use.

Here is the current feature list:

- Zoom in and out, changing the scale. Zooming in far enough will cause the objects to be plotted as a circle with its object size as the circle radius. A zoom in will reduce the plotting scale by $2^{1/2}$ of its current value and zoom out will increase the plotting scale by $2^{1/2}$ its current value. In screen capture mode, the scaling factor is $2^{0.2}$.
- One click can cause a change in the direction of time, going forward or backward in time.
- A pause button freezes the plot animation at the current spot. Cycling the pause button will start and stop the animation.
- Increase or decrease the file increment, essentially speeding up or slowing down the object animation speed. Slowing down will reduce the file increment to $2^{-1/2}$ of its current value and zoom out will increase the file increment $2^{1/2}$ its current value.
- Ability to have X-Y-Z offsets as a way to shift the apparent origin of the plotting areas to be able to shift the view perspective to follow individual objects better. Enter a new offset in the text box and push the Set Offset button for a new offset.
- Ability to shift focus to one or two objects and plot data in their center-of-mass coordinates. Entering the object numbers into text boxed and checking the appropriate check box will cause this to happen. If only one object number is entered into the first text box, that objects coordinates are used for the origin for all other objects.
- The program will use an initialization text file Rplot.ini to read in some initial settings if needed. If Rplot.ini does not exist when it first starts, the program will create it automatically for the user.
- Currently I am trialing a new method for plotting color of objects out of the plane. I am using blue and red to help indicate how far an object is out of the plane. The bluer or redder an object is will indicate it is farther from the plane being plotted. Thus, as an object in the plotting plane zone will appear white but if it moves in a positive Z direction, it will become redder; becoming dark red as it gets to the boundary. If an object in the plane moves in a negative Z direction, it will get bluer. The same color actions happen in the Y-Z plane for objects moving towards or away from the plotting plane. One can see some of different colors in the screen capture above.
- Print status to the text window. Currently the elapsed simulation time and the number of objects in the view port are displayed. If in screen capture mode, a second line of text includes the plot scale, the plotted file number and the current file increment.
- The ability to do a sequence of screen captures to facilitate video creation. The Rplot.ini file now has as its final input a flag to generate screen captures. A screen capture file will be generated for every complete paint in the application window.
- Ability to rotate any of the three axes, one at a time in a sequence of rotations. Any order of rotation can be achieved and a rotation within the sequence and be altered until a satisfactory rotation is achieved.
- A new check box allows the center-of-mass coordinates for the plotting windows to be used as offsets.
- The upper right hand corned now has an" EXIT" button to cleanly exit the program. Use this one rather than the window kill button.
- A check box will toggle the right-hand view port between the position data in the Y-Z plane to a density profile plot. This plot is also available in the screen capture mode so that videos can include an evolution of the density profile. The plot also includes the force softening length plotted as vertical line and the particle density plotted as a red-dashed horizontal line. Both these lines are labeled with text.
- A check box will toggle the Y-Z position plot with a phase space plot. The phase space velocity is ratio of the particle speed divided by the speed of light and the escape speed scaled by c. The escape speed is calculated from a distance of 5 times the final expected virial radius and all the mass in the current simulation. The speed of light scaled escape speed the number presented in the plot header. The phase space plot is available in screen capture mode.

- A check box will plot the particle size if larger than a single pixel based on the scale size.
- The ability to mouse click into the plot areas and update the plot offsets with that new position.
- Ability to change the scale size from the text box. Enter a new scale and click the button to the right.
- Ability to change the file increment from the text box. Enter a new increment and click the button to the right to update to a new increment.
- Ability to toggle particle colors between the standard and a velocity direction color. Blue for aligned with position vector and read for anti-aligned. There is a new check box to toggle this behavior in the plot control section of the control.
- A checkbox above the "Zoom Out" button now allows the user to output data from the plotted file to a text file, RplotData.txt. The file is created/replaced when first checked. Unchecking the box retains the file should it be rechecked.

2.1 Starting and Stopping Rplot.exe

Starting this program is as simple as double clicking the Rplot.exe executable from Windows explorer. One can easily create a desktop shortcut to start it as well. Stopping the program can be achieved by clicking the "Exit" button it the upper-right corner, do so will end the program in a respectable way by releasing arrays and closing open files. Of course, closing the window in the usual way, by clicking the "X" button in the window's top right corner will also stop Rplot. The Rplot.exe program should be placed in the same directory as the "Riod.exe" file. All data that it needs is found relative to that directory folder. The program will also now stop after a 15-minute interval if no buttons are clicked or checked.

2.2 Rplot.exe Output or "What am I seeing?"

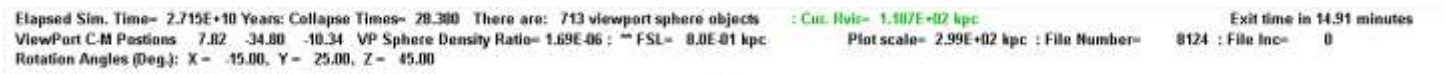
Looking at the screen shot above, one can see that the program has three segments defined, the control area at the top, a small area devoted to text status output and the plotting area in the lower area of the window. Each of these will be discussed below.When the program starts, it will immediately start plotting data files from the simulation directory that it is placed in. It expects to have two files "Riod3.dat" and Riod.ini that must be read and get preliminary information on the simulation and then a "pos" directory (with the usual position directory structure) that it can read the usual "Riod" data files. The program uses a default method for determining the plot scale, and file increment. It begins plotting from the last/newest data file and increments backwards in simulation time towards the beginning of the simulation. Using the controls, one can manipulate the plotting details in real time to change the viewing attributes.

Objects are plotting the appropriate viewports within the constraints of the viewport scale. For example, if an object has its X-Y positions within the viewport scale, but the Z-Y position is outside the scaling, then that object is not plotted in either viewport. Also, a new feature is a check box to determine if object size is to be plotted. If that check box is checked and the scaling is small enough to show the object size, that object is plotted with a circle using its calculated size as the circle radius.

Note that if the program detects that this is a halo type simulation, where there is a large mass with an extended halo radius as given by CON(16), then the radius plotted circle is determined by CON(16)*1.3205. Note that the scaling of CON(16) gives the only current halo M(R) 90% radius. If future halo M(R) become available, then Rplot will have to accommodate different 90% scaling.

2.3 Rplot Text Information View Port

The viewport between the plotting area and control areas is the information viewport and it looks like the following:



The information displayed in this viewport conveys current plotting view port status. The information here is only updated every plotting interval unless in screen capture mode when it will l update every 5 file reads. The information is fairly well described in the accompanying text. At the top, the simulation elapsed time in years, and the number of objects in the view port inscribed sphere are displayed on the left. In the middle is the estimate of the virial radius for this plot data. If this number is green, the estimate is valid and will change as the simulation plotting moves forward or backward in time. If the text is red, then this number is the expected final virial radius and will not change. The right portion shows the exit timer, should no other control buttons be used; this timer is reset for any change in the control options.

The bottom line is less obvious but has the viewport center-of-mass positions, x, y, and z displayed following with a density ratio which is the viewport density divided by the particle density. This ratio becomes interesting for interior mass densities

once it approaches the value of 1. Now there is more information in this line. Next to the density ratio is the Force Softening Length (FSL) in real units; here in kiloparsecs. Farther to the right, is the plot scale in units the same as FSL. Finally, the file number and increment are displayed.

Note that in screen capture mode, the output will is formatted differently. In addition, if there are rotations active, there is a third line of output that will display the three rotation angles in degrees.

2.4 Rplot Controls

This section discusses the Rplot controls. Starting from the far right, the sections below will describe the functions and output in the control area of the program GUI.

2.4.1 Reverse Button

One click can cause a change in the direction of time, going forward or backward in time. Clicking this button will change the sign of the file increment, effectively changing the "direction" of time flow of the plotted data.

2.4.2 Pause Button

Clicking the pause button will freeze the animation at the current spot. While the animation has stopped, the operator can use the offset and zooming function buttons to change the plotting viewpoint. Cycling the pause button will stop and restart the plot animation. Pausing in screen capture mode will cause screen captures to be made while paused, since the screen is being refreshed while paused.

2.4.3 Zoom In and Zoom Out Buttons

Zoom in and out, changing the scale. A zoom in will reduce the plotting scale to $2^{-0.5}$ of its current value and zoom out will increase the plotting scale by $2^{0.5}$ its current value. Zooming in far enough will cause the objects to be plotted as a circle with its object size as the circle radius.

2.4.4 Slow Down and Speed Up Buttons

Pushing the "Speed Up" or "Slow Down" buttons will increase or decrease the file increment between plotting changes, essentially speeding up or slowing down the object animation speed. Slowing down will reduce the file increment to $2^{-0.5}$ of its current value and zoom out will increase the file increment $2^{0.5}$ its current value.

2.4.5 X-Y-Z Offset

Pushing any one of these six buttons in the middle of the control area gives the user the ability to have X-Y-Z offsets as a way to shift the apparent origin of the plotting areas. This allows the user to be able to shift the view perspective to follow individual objects better. Enter a number into the appropriate axis offset and push the adjacent button to create the offset on that axis.

2.4.6 Two Particle Center-Of-Mass Viewport Check Button and Input Boxes

The checkbox and text boxes allow the user to have the ability to shift focus to one or two objects and plot data in their center-of-mass coordinates. Entering the object numbers into text boxes and checking the appropriate check box will cause this to happen. If only one object number is entered into the first text box, that object's coordinates are used as the origin for all other objects.

To use this feature, first enter an object identifier in the top text box and/or a second object identifier in the lower text box. Then click the check box above the text boxes to begin plotting in the COM of those two identified objects. The program will plot these objects as different colors, object 1 as green and object 2 as yellow.

For a specific type of particle collision simulations, where ICN(18) = -2 or -3, and if CON(30) cross-section is being used to create collisions, then when the particle size option is activated, the program will estimate the two particle's relative velocity and get an interaction radius using CON(30). The interaction radius is plotted for both of the chosen particles as their radial size. No other particles in the viewports will have this size plotted. Note that these interaction radii are generally much larger than the standard particle radii. Also note that because the interaction cross-section is relative velocity dependent, the radial sizes will decrease as the relative velocity increases.

2.4.7 Left Most Text Boxes

The text boxes on the left show the current plot scale, the current file number being plotted and the current file increment number. These text outputs may change as the various buttons to the right are pushed. A new plot scale and increment can now be entered into the text box and changed to that value entered when the "Set Scale" or "Set Inc." buttons are pressed.

2.4.8 Rplot Text Output

The text area in the middle in white is used to output text strings while the data is being plotted. This version prints out the elapsed simulation time in years and the number of objects in the view port sphere for the current plot data. In addition to the above, when in screen capture mode, the plot scale, file number and file increment are printed in a second line below the above information. Additional information may be added in the future.

2.4.9 Data Plotting

The plotting area is divided into two equal squares. The left most plot area plots X-positions on the horizontal and Y-positions on the vertical. The right most plot area plots Z-positions on the horizontal and again the Y-positions on the vertical. The scale of each square is 2 times the scale as shown as information above, indicating that from the middle of the area, it is one scale factor to the plotting edge.

2.4.10 Object Size plotting

The check box to the right of the offset controls now determines if object size is plotted. The size circles are only plotted if the check box is checked and if the object size is large enough to make a circle on the current plot scale. Checking and unchecking the box will cause a screen refresh.

2.4.11 Plot Rotation Sequences

The user can now begin a rotation sequence about any of the three axes. The use can simply enter a rotation angle into the angle box next to the desired rotation axis or enter and/or enter an angle increment to the right of the check box. Hitting the check box will begin the rotation for that particular axis. To stop the rotation and leave the rotation angle in place for further plotting, uncheck the check box for that rotation. When the check box is initially checked and this is the first rotation of the sequence, a number "1" will appear next to the Increment text box indicating it is the first of the sequence. IF the user wants to modify this rotation, an new increment can be entered into the increment text box and checking the axis rotation check box.

In this way as sequence of three rotations about three different axes can be created. All three rotations will remain after the last rotation is complete and the viewport plotting will use those three rotations for all succeeding plots.

A rotation sequence can be reset by clicking the "Reset Rot." button and all rotation angles will be set to zero.

Note that an initial rotation sequence can be initiated at startup using the "Riod.in" file. See below.

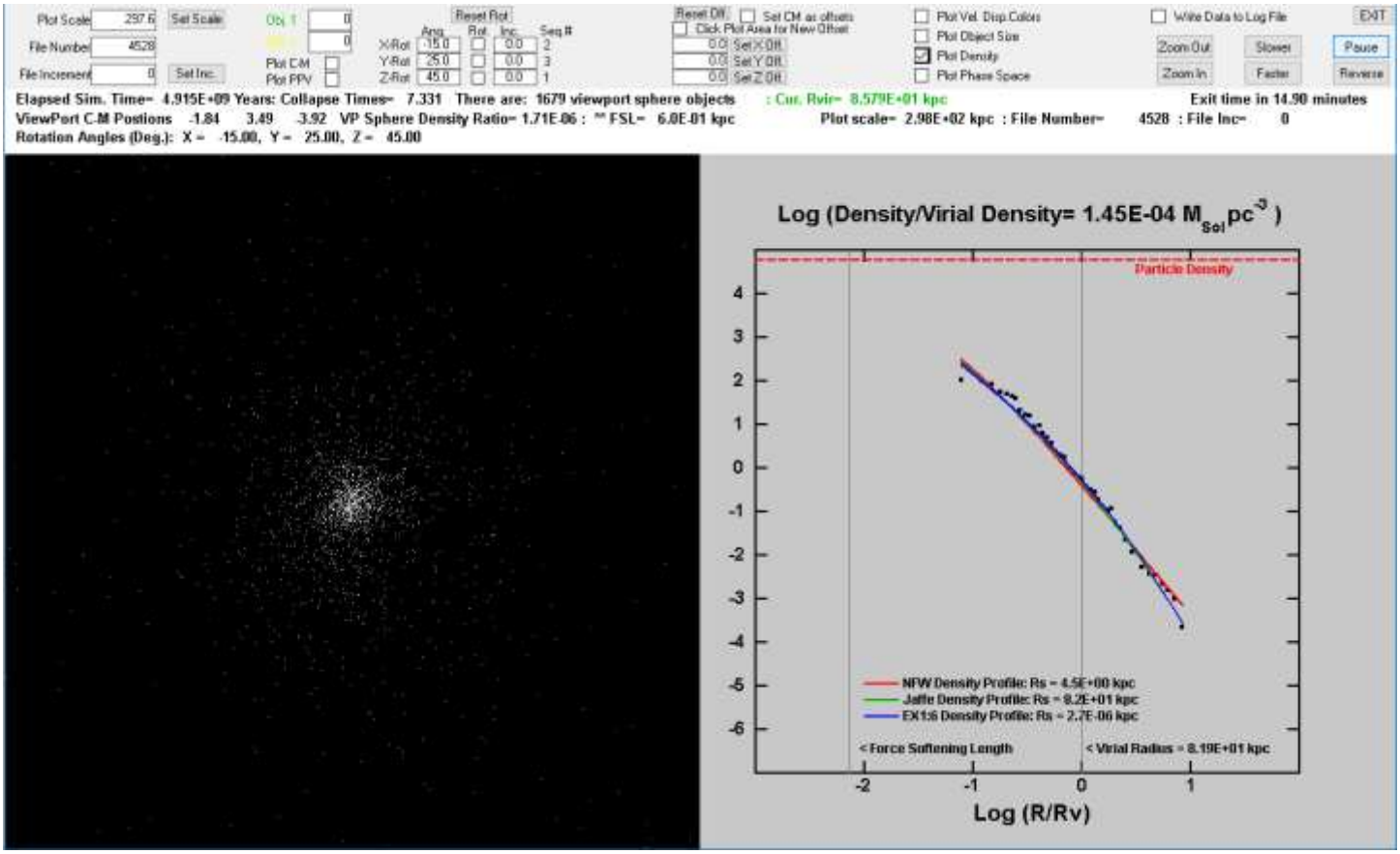
2.4.12 Plot CM as Offsets

There is now a check box to the right of the offset buttons that when checked, will use the center-of-mass coordinates within the plot windows and set those as the current offset. If an offset already exists, the CM coordinates are added to the current offsets. Now, once checked it will stay on until unchecked. This way density plots can be created with the current offset which may be useful in creating screen captures of the density plots. In addition, when this check box is unchecked by the user, the offsets in all three directions are reset to zero.

2.4.13 Density Plots

The check box beneath the C-M offset box will toggle the right-hand plot window between the position view of the Y-Z plane and a density plot. There currently are no options associated with this action, the user gets what is plotted. The density plot will work also in the screen capture mode. The program will not allow the user to check this box if the Phase Space plot is active. The density plot now includes NFW, Jaffe and EX1:6 profiles added to the plot. This helps with some of the comparisons for the data in the cases where the simulation is doing collapse scenarios. Below is a current screen capture of the density plot.

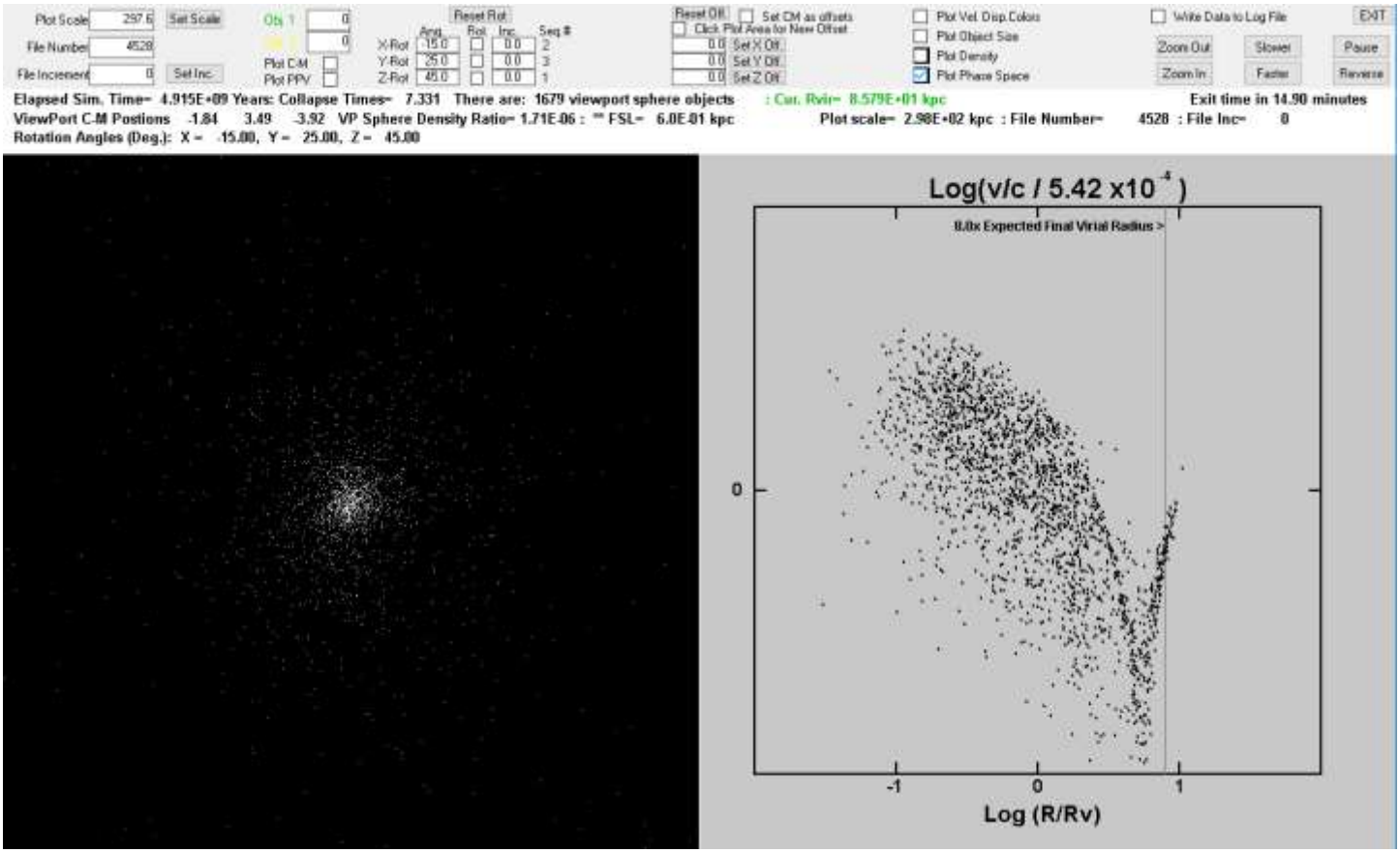
Note now the density in this plot is scaled to the initial virial density and the range scale is scaled to the expected final virial radius. These changes help solidify the plot characteristics across simulation types which may vary by many orders of magnitude.



2.4.14 Phase Space Plots

The check box beneath the density plot check box will toggle the Y-Z plotting window and a phase space plot. The phase space velocity is ratio of the particle speed divided by the speed of light and the escape speed scaled by c. The escape speed is calculated from a distance of 8 times the final expected virial radius and all the mass in the current simulation. The speed of light scaled escape speed the number presented in the plot header; in the example plot above, that number is 3.62×10^{-4}. The program will not allow the user to check this box if the Density plot is active.

Note now the range scale is scaled to the expected final virial radius. These changes help solidify the plot characteristics across simulation types which may vary by many orders of magnitude.



2.4.15 Create New Plot Offsets with Mouse Click

The usage and controls are still being considered but the feature does what is intended. The intent is to be able to mouse click into the plot area and use that position as a new plotting offset. If the user clicks into the left plotting plane, that is X-Y plane and then the x and y offsets would be changed. For clicking in the Y-Z plot, only the y and z offsets are updated. When used in combination, first in one then the other, a new X-Y-Z offset will be created. This can be very useful in isolating groups of SO for further observation.

New offsets can be operationally changed in two ways. One can first click into the plot area, then click the check box or invert that order, clicking the check box and then clicking a spot in the plot areas. The new offsets will be shown in the offset text boxes.

2.4.16 Set a New Plot Scale

A button in the upper left of the control area allows an input into the text box to be read in as the new plotting scale. Note that this new scale is then set as the original scale size and the number of zoon clicks is set to zero.

2.4.17 Set a New File Increment

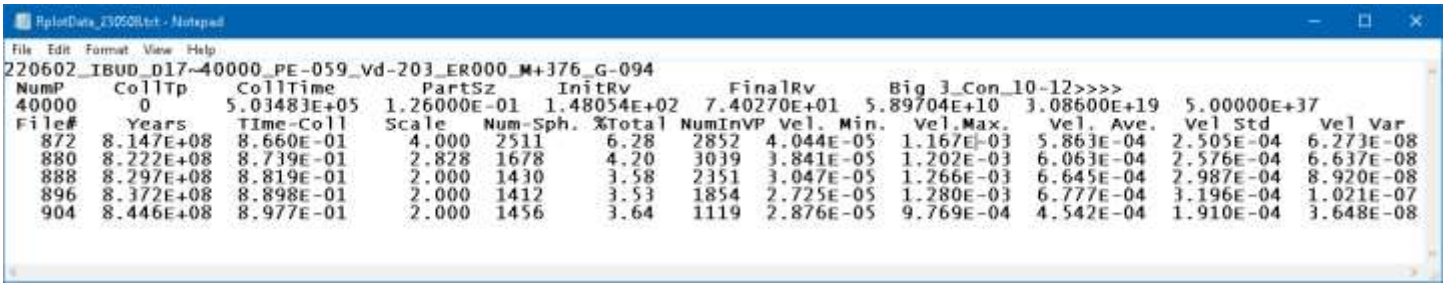
A new button in the left portion of the control window allows the user to change the file increment. Enter a new value in the text box and push the update button to set a new file increment.

2.4.18 Plot Velocity Dispersion Colors

Checking the “Plot Vel. Disp. Col” check box particle colors now take the spectrum of blue to red as being moving inward to moving outward. This is done sort of as an estimate of the particle velocity by using its previous position as a indication of speed and direction. Then the cosine of the R-V dot-product angle is used to determine the particle color. This feature is a bit weird using a continuous offset and rotations for now.

2.4.19 Write Data to Log File

Clicking this check box will output selected data from the file being plotted to a text file in the POS directory. The filename is of the following format: RplotData_YYMMDD.txt, where YYMMDD is the year month and day format the file was created. Note that each time the box is checked in that day, data is appended to the existing file.



RplotData_230508.txt - Notepad

File Edit Format View Help

220602_IBUD_D17~40000_PE-059_Vd-203_ER000_M+376_G-094

NumP	CollTp	CollTime	PartSz	InitRv	FinalRv	Big 3_Con_10-12>>>>			
40000	0	5.03483E+05	1.26000E-01	1.48054E+02	7.40270E+01	5.89704E+10	3.08600E+19	5.00000E+37	
File#	Years	TIme-Coll	Scale	Num-Sph.	%Total	NumInVP	Vel. Min.	Vel.Max.	Vel. Ave.	Vel Std	Vel Var
872	8.147E+08	8.660E-01	4.000	2511	6.28	2852	4.044E-05	1.167E-03	5.863E-04	2.505E-04	6.273E-08
880	8.222E+08	8.739E-01	2.828	1678	4.20	3039	3.841E-05	1.202E-03	6.063E-04	2.576E-04	6.637E-08
888	8.297E+08	8.819E-01	2.000	1430	3.58	2351	3.047E-05	1.266E-03	6.645E-04	2.987E-04	8.920E-08
896	8.372E+08	8.898E-01	2.000	1412	3.53	1854	2.725E-05	1.280E-03	6.777E-04	3.196E-04	1.021E-07
904	8.446E+08	8.977E-01	2.000	1456	3.64	1119	2.876E-05	9.769E-04	4.542E-04	1.910E-04	3.648E-08

The first line of output is the run string followed by more two lines simulation specific data, number of particles, collision type, collision time, particle size, initial virial radius, time delta, distance and mass units. Then lines follow with specific data from the plotted position files. Included in each output line are the file number, time in years, collapse times, plot scale and number and percent of total in the plot scale sphere. Newly added to the end of this string are the extracted speed components inside the viewport. The data is the number used for the speed calculations, the minimum and maximum speeds, the average speed and its standard deviation, and finally followed by the speed variance. The variance is added in case that it a negative quantity as can happen in the calculation of the standard deviation. If negative, this will indicate that the standard deviation calculation is incorrect.

2.4.20 Particle-Point-Of-View Option

I have created a new view point plotting perspective that I call the particle-point-of-view (PPV). PPV gives the Rplot user the perspective of riding a specified particle with the forward direction being the particle direction, like riding in a car and looking forward. In addition, the viewpoint is imaged like a pinhole camera with a specified focal length. Particles are given size as to their apparent size given their distance from the chosen particle and are given color based on whether they are moving toward or away from the particle. Colors are based on a red-shift like model where red is moving away and blue is moving toward the particle. Colors also transition red-to-white-to-blue with white colors orthogonal to the particle direction of motion.

This feature and be activated by checking the new check-box, labeled “Plot PPV” under the particle input boxes on the left portion of the control pane. If a particle number is entering the “Obj. 1” text box, then the program will use that particle for the observation particle. If no particle is entered and the PPV box is checked, then the program will pick a random particle for the viewing particle.

There is an addition line to the output text window that has the following information:

- The particle number of the particle of reference.
- The distance of that particle from the original coordinate system origin (this becomes the offset distance based on the particle coordinates),
- R Dot V of the particle, which is the angle (in degrees) between the coordinate vector and the velocity vector. Note that a particle heading directly toward the coordinate origin will have an angle of 180 degrees and opposite the origin will have an angle of 0 degrees.
- The particle speed as referenced to the escape speed. The escape speed is estimated from the distance out from the origin and total mass of the system. Note for particles in the interior of the mass distribution, this number will be an over-estimate.
- Field of view in degrees.

Also note that if the apparent size of a particle is smaller than the single pixel size, it will not be plotted. Doing this has the effect of limiting the camera resolution to a single pixel in the viewing/imaging plane.

When this feature is active, only a few of the other controls will work. Here is what will work and is tested so far:

- Slower and Faster buttons will continue to decrease or increase the number of files (and hence time) between screen plots
- The Pause and Reverse buttons will continue to work as implemented.
- Zoom In and Zoom Out now work by increasing/decreasing the focal length of the pinhole camera.

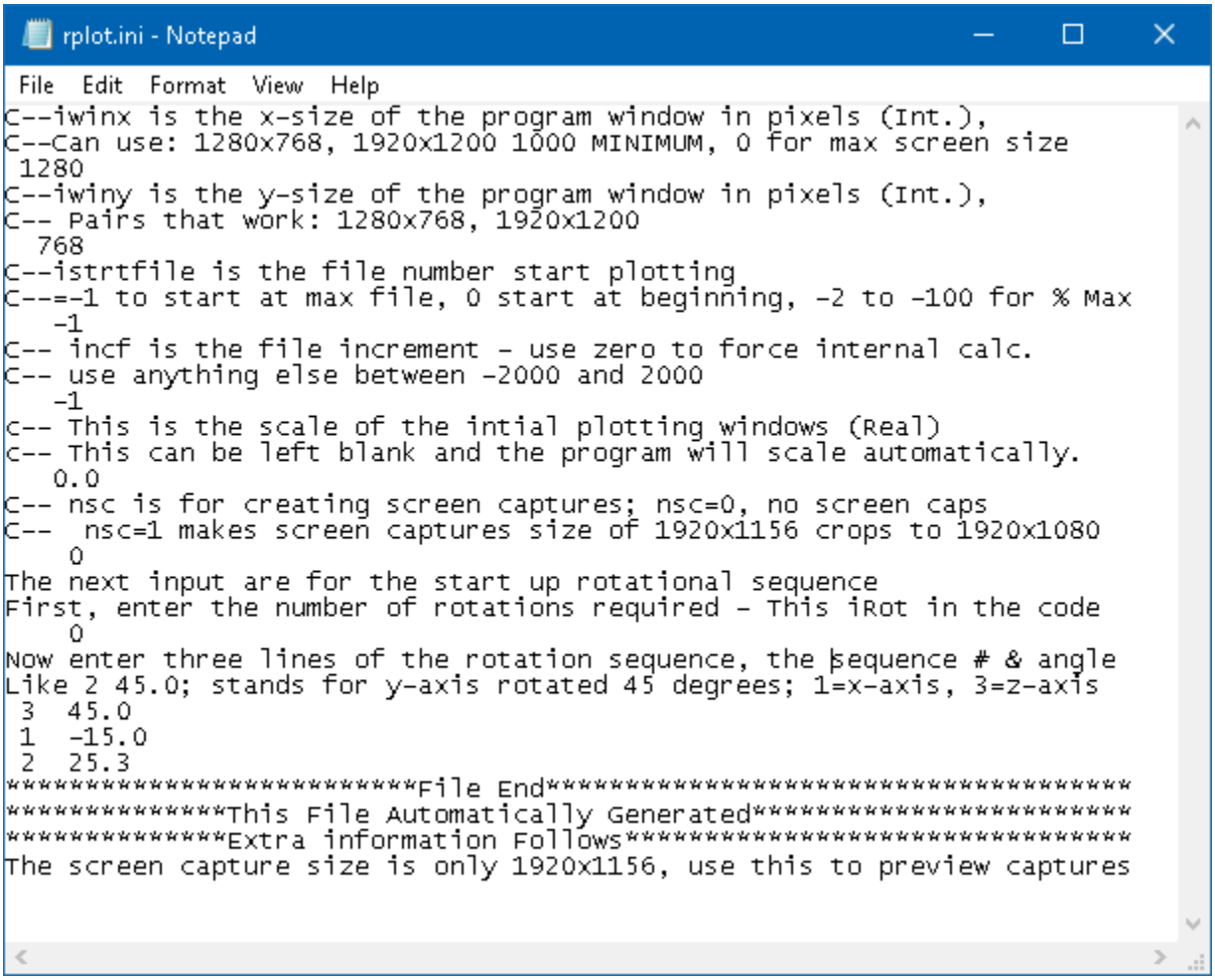
- The Density and Phase-Space plots will continue to work. Note that for these plots, there is a new offset so that the density plot will use that offset for some interesting density variants.
- The "Set Inc." button will allow the user to set a file increment.
- The "Exit" button will cause the program to exit.
- Screen capture mode works in this mode too.

2.5 Rplot.ini File

The program will use an initialization text file Rplot.ini to read in some initial settings if needed. If Rplot.ini does not exist when it first starts, the program will create it automatically for the user. Currently, this file allows the user to change a few of the default parameters. Note that the file has the strict structure that there are two comment lines followed by the input number. The comment lines are used to describe usage. Specifically, here is what can be changed:

- The window size dimensions in pixels can be input as the first two entries in the file. The file gives the user suggestions for these two parameters. For the X dimension, please do not use anything smaller than 1000. Tested pairs are 1280x768 (which is the program default) and 1920x1200. Note that these inputs expect an integer number. In addition to the above, if the x-dimension is left zero, the program will use the current display's maximum value and begin plotting in an essentially full screen mode.
- This file allows one to pick the starting plot point in time via a file number. If the user sets this value as zero, it starts plotting from the first file. If you set it equal to -1, it will begin at the last available file and begin plotting with the time order reversed. I also can now be set to start a percentage of the maximum current file by using a negative integer less than -1 to represent the percentage. For example, if there are 1000 files available to plot and this parameter is set to -50, then 505 of the maximum file will be the starting point, or the 500^{th} file.
- One can also pick the beginning file increment, which has the effect of controlling the time interval between the animated motions of the objects. Inputs can be between -2000 and 2000 to start but can be modified once in the program. If this is set to zero, the program will calculate an increment for the user.
- The initial plot scale. If set to zero, the program will scale the plots in its default method. Currently, the default scale is twice the expected final virial radius. Note this input expects a real number.
- The next input is the screen capture flag. If set to 1, Rplot.exe will generate screen captures and save them as BMP files.
- What follows is the initial rotational sequence. First is the number of rotations followed by two numbers for up to three rotations, 1 for rotations about the x-axis, 2 and 3 for the y- and z-axes, respectively. The second number is the angle of the rotation in degrees, either positive or negative.

Below is a screen capture of the current automatically generated file.



2.6 Screen Capture Mode

As discussed above, when the screen capture flag is set to 1 in the Rplot.ini file, a series of screen captures will be initiated as the program starts. A Windows BMP file will created for each screen capture and placed in a unique directory created for this instance of Rplot.exe. When the program starts, the captures will have the plotting properties derived from the Rplot.ini file. Each file will have the following naming format: xxxxxx_yyyyyyyy.bmp. The xxxxxx is a 6 digit sequence number that increases for every capture that is created. The yyyyyyyy is the 8 digit number representing the file number from the data position files.

Files are created in a unique directory that has the structure relative the directory where the program is run such that we have “pos\cap\YRMODY-HRMNSC”. The directory name is made of the year-month-day-hour-minute-second identifier for when the screen captures where created. If the “cap” directory does not exist at the time the program is run, it will be created automatically.

Screen capture will now stop once the last file position is captured. The created screen captures are set internally to be of the size 1920x1176 to accommodate HD video sizes. These files need to be cropped to the standard 1920x1080 which will remove the control area from the top of the screen leaving the text and plot regions of the screen capture.

One last change for this mode is that the text will have two information lines of output, the first is what is seen as standard during non-capture mode. The second now contains the additional information for plot scale, file number and file increment.

3 Rplot.exe Change History

Below is a table listing the Riod change history and possible future fixes and features. This history table was begun in February of 2007 and is fairly accurate since that date. The entries before that are reconstructed as best that can be determined from my logbook. There are many other changes that have happened over the years but there was almost a 10-year gap between entries in the logbook.

To do	

5/15/2023	Yesterday I created some changes to the two particle CM plotting sequence. Now, for simulations with ICN(18)<-2 and ICN(19)=1 for collisions using the velocity dependent cross-section, the pair of particles are drawn using the cross-section radius. These are the only two particles with that radius because to calculate the radius, the relative velocity is needed. The relative velocity is estimated using particle positions between the last two plotted time. A third line is added to the information window showing separation distance interaction radius and relative speed.
5/8/2023	Yesterday I added some code to output information on velocities inside the viewport sphere radius. I calculated the average speed and speed variance. I also extract the maximum and minimum speeds from the viewport sphere. This is all output to the RplotData.txt file as addition information addended to the line output. This new information will only be calculated if there are no other special plot options set, like PPV, Density and Phase Space plots. There is a problem with as the number of objects in the viewport as calculated live for the plots, it different (less) than what the new code calculates. Not sure why that is but may look into it.
4/24/2023	I changed the formatting on the X, Y, Z offsets to f7.1 from f6.1 as one simulation was overflowing. The program crashes with any larger format for some reason but there seems to be enough room in the text box accommodate at least one more digit.
4/23/2023	I added a conversion from iterations to years parameter into the code. It changes nothing really but added as I debugged an issue that was not really and issue, just improper input to “Rplot.ini” file. Ugh!
4/11/2023	Yesterday I rewrote some of the density calculations so that when the “Write Data to Log File” box is checked while in density plot mode, the range and density parameters printed to the file are in MKS units. I did this primarily so that comparisons between differing simulation data was not confused by using the simulation units. Doing this mess up a number of things that had to change to support this view. In the end, the changes made output data that was consistent with the RSU system, so nothing was gained (but plenty learned) for all that effort. I also cleaned up some of this computational code to be more efficient but results are imperceptible for now. I also changed the default plot scale to be twice the expected final virial radius. Before this change the default value was twice the initial virial radius.
4/3/2023	I fixed the display of the current virial radius output in the text display area. It was not being corrected by the distance conversion factor. The fix then broke the displayed number for nanometer distance conversions, so I hack a fix for that specific case for tiny dimensions. Seems to be correct now for all cases that I am running.
2/6/2023	I had to fix the virial radius output number on the density plot as it was not scaled properly to the correct display units. I checked some of the output and they seem to be scaled correctly.
2/5/2023	Over the last two days, I modified the density and phase space plots. The range scale used to be in determined units based on input. Now the range is scaled with the final expected virial radius. In addition, the density plot density numbers are scaled with the initial virial density. Making these changes reduces the churn and understandability/look of these plots across many simulation types which may span many different orders of magnitude. I also changed from of the weirdness associated with the density plot top label. I repositioned somethings and created a relative pixel offset for the smaller characters. The end seems to be okay across all the running simulations. One last change for today (I hope), I went down a rabbit hole and wasted over an hour thinking I had broke the screen capture feature. What I discovered was the I had set the screen capture option in the INI file but didn’t change the start file to something other than the last file number. Rplot closes itself if that is the case because only forward in time going screen captures are allowed. Now, I trap for this case and if NSC=1 and iStrtfile ≤ 0, then iSrtfile is set to 0. Dumb bunny!
1/26/2023	Modified the output to the RplotData_YYMMDD.txt file to make it more compatible to pasting into Excel. The content has not changed.

1/25/2023	I completely rewrote the feature from 1/20/203. This time I made the logic less spaghetti-like. I start by reading all the DAT files that exist and create an array of these virial radii. I then reference this array with the appropriate values to estimate the current virial radius. This implementation is cleaner and does not go back a reread DAT files as needed. I also fixed a behavior for determining the maximum plot distance decade. There was a single instance that highlighted this oversight. What was changed was the integer value being greater than zero when it should have been greater or equal to zero for MaxIntR.
1/21/2023	I fixed some logic errors in the feature below regarding the virial radius calculation. The new logic was required for DAT files near the maximum value and as this value was approached. This was all internal and does not affect the visuals or virial radius calculation.
1/20/2023	In the last several days I added a new feature to the output screen to display a running virial radius as captured in the DAT file sequences. So as the plotting progresses, the program gets accompanying data from the two nearest DAT files (if they exist) and does a linear interpolation of the virial radius. This is then displayed in the display window as green text if the operation succeeds in getting the DAT file data or red if it is using a static virial radius. I also modified the phase space plotting method for determining the horizontal maximum decade as described below for the density plots. This is a better solution for simulations using varying scaling. SO far this works for kpc, pc and nm scaling.
1/16/2023	I changed/fixed how the write data to file check box worked. For some reason, it was creating a second file rather than just appending to the current file. Now the file is written to POS directory and appended with the current date string. There were some other modifications in this time period but not remembering now just what they were.
12/29/2022	I modified the way the density plot picks the maximum decade for plotting. I added what amount to multiplying the final Virial radius estimate by another 1.25 factor. This seems to put an extra decade in for higher density simulations and will still collect the far-out spillover. I will use this for now as it seems to work for the running sims now.
11/2/2022	I fixed a couple of unwanted behaviors today. First was that the file increment change action for reading the input box was crashing the program when I just click on the box with no changes in the text box and if it was a negative number. This one vexed me for a while until I noticed that the text message was 7 characters and the text string was set to 8. The other issue was the program would crash occasionally when changes were made to the file increment. If the increment needed to reverse direction at the same time as a new increment was specified, the program would crash. I noted that I had code to cover this case but it should be implemented just before the new file read. So I moved those lines of code to a more appropriate place and things seem to be better now.
11/1/2022	I added diagnostic text to the program to track the button/check box actions in the Rpinit.txt file. There are currently 26 actions in the program and I was just outputting the action number but since that is not particularly obvious to the programmer, I added a text array and text strings to identify the action happening. Unfortunately, every time I add an action in the future, a new entry into the string array but be made and the number of elements must be updated.
10/27/2022	I fixed some annoying issues with the phase space and density plots features. The title of the phase space plot was too high in the frame so I moved it down a bit and we will check this position out for now. The density plot was not really picking the number of horizontal decades properly so I modified the code to use the final virial radius as the measure to determine the number of decades and the maximum decade. I multiply the final virial radius by 1.5 then use that number to have 2 decades about it. This seems to work for now. Tested this change with nanometer and kiloparsec scale simulations.
10/25/2022	Today I inserted code to allow more than one action at a time during the plot cycle. This means, for example one can press the “Zoom Out” button many times in during the plot cycle and the plot scale will change by the number of times it was pressed, as per the change rate. This all seems to work fine

	for plotting changes and will work for single askes for Density or Phase Space plots. It will not accept more than one rotation at a time though and will unselect the check box of an additional rotation request if another request is asked. The mostly works well and is a nice thing to have when plotting times are large, like for large numbers of plotting SO.
10/22/2022	Over the last several days, I have added several new plot items to the density plot feature. First, I added two other profiles (Jaffe and EX1:6) to the density plot. The intension is the make all three profile graphs as independently activated features but they all appear together at the current time. Finally, I added a vertical line to represent the current (or if there is no current value the expected final) virial radius.
10/20/2022	I fixed a problem with the program just stopping after changed made to the RIOD.EXE program for the big mass changes. I needed to create and internal variable to hold the number of SO (NumOP) because the spaghetti nature of the code was getting confused and so numbers were not initialized properly.
10/8/2022	I fixed a bug (still testing) where if the simulation changes the total number of particles from one time stamp to the next, Rplot would crash. The fix was simple (I hope) in that the program was taking the number of particles from the current DAT file which might have fewer particles that when the simulation started. The fix was simply to read the original DAT file then allocate the arrays from the original number, since there is no way any simulation currently can have more particles that the original provisioned number but there can be fewer particles.
9/10/2022	I added a new feature to the density plot to add the NFW profile on the plot to compare to the data. The program uses the known viral radius or the calculated expected final virial radius from the total energy. The NFW plot uses the empirical result that the NFW scaling radius is the virial radius divided by 19.56 and needed for the NFW integral to complete when Rmax=200*Rs.
9/7/2022	I made a small modification to now open the Rplot.exe window in the center of the display. Before it was letting the system place the position of the window.
9/3/2022	I changed the format to include another decimal point for rotation and offset output to the information viewport. The rotation didn't need it but they both use the same string variable which now needed to be 8 characters.
7/18/2022	I fixed the rotational sequence reporting in the main control window. The initial rotation sequence that I put in on 5/5/2022 was not showing up and then then there was the reset which was placing the text for the sequence out of the control window. The font for that sequence numbers was also wrong so that needed addressing. Seems to work properly now.
6/20/2022	I added more output to the information window. I added the current X-Y-Z offset values when the offset check button is checked. I added it both cases for normal and screen capture mode.
6/5/2022	I fixed the screen capture output where there were spurious characters at the end of the information window.
5/5/2022	I added the ability to create rotation sequence at start up new inputs in the Rplot.ini file. See that section for more details.
2/16/2022	I made a small change to Rplot.exe to change how often the information window updates. Previously, it was updated every 5 file reads. Now it is updated for every file read, except when in screen capture mode.
9/28/2021	I made some changes to Rplot.exe. I added an option to the Rplot.ini input file to all a percentage of the maximum file number to be input by entering a negative integer to represent the percentage. I also tried account for all the cases for input so that there won't be any inputs that are not handled properly. I also modified the PPV focal length change for the zoom in and out buttons to be 2 to the ¼ power, so it takes four zoom clicks to change the focal length by 2.
9/19/2021	I made a small change to Rplot.exe to make the particle colors more easily discernable. Specifically, the dark blue colors in the color palette were hard to see. I increased the initial level of blue and red and changed the incremental color rate and this appears to be better.

9/18/2021	I made some changes in Rplot.exe today to improve the display of particle color in the PPV feature. I now use the Cosine angle of the difference of the particle of interest and the other particles and the SO of interest direction. This seems to represent the particles in the field of correctly with their observed motion. There is still some odd behavior where particles falling into a distribution show way more coming toward the SO of interest. However, in some ways this makes sense since many of the particles are also falling into the COM from the far end of the origin. I will use this for a while to see if it looks right for other scenarios.
9/1/2021	I improved the PPV feature in Rplot.exe. Now one can zoom in or out of the field-of-view. I am now using the plot transformation using the number of pixels across the plot view port as the default focal length, so now plotting scale is just the number of pixels. Then zooming in or out changes the focal length by the square root of 2 (two clicks doubles or halves the focal length of the pin hole camera. In addition, I have added more information to the information view port string to print out the field-of-view in degrees. I have also removed the minimum z distance check to plotting a point in the view port, only X and Y positions limit plotting.
8/26/2021	I cleaned up some of the code for the PPV feature in Rplot.exe. I needed to space the text a bit better in the text window. I changed the text portion of the information window that reports the number of objects in the window to reflect the count is for the forward direction. I also fixed a case where the window was odd pixel sized as determined from the Rplot.ini file. In some cases there was not enough room to print the third line of text as used in the PPV feature.
8/22/2021	For the last two weeks I have been working on a new feature for Rplot.exe. Rplot now has the ability to plot a specified particle's journey through the simulation evolution with the field of view being the forward direction of motion. It is like driving a car looking forward as you drive but, in this case, you are just a passenger. Particles in the field of view are given size and color, size is the apparent size based on its distance from the observer and color is based on a red-shift concept where red is going away from the observer and blue is toward the observer. Colors gradually are transition between red and blue with white being a perpendicular direction to the observer. See the Rplot.exe description in Section2.
7/7/2021	I added a new feature to Rplot.exe where a check box when clicked will output information from the current file being plotted to a file, PlotData.txt. Currently the data being output is the file number, time in years, collapse times, plot scale and number of particles in the sphere of plot scale radius. As a result, the way numbers are counted inside the viewport has changed from the entire viewport cube to the viewport sphere inscribed inside the viewport scale and is now noted as such in the output text to the screen.
3/25/2021	Rplot.exe changes to update yesterday's feature and improve usability by adding some addition checks on the click buttons to be sure their status aligns with set flags. Now all check boxes should have correct status despite errant clicking.
3/24/2021	I added a new feature to Rplot.exe where the velocity dispersion direction is plotted as color. Particles moving inward relative to their position vector are blue and gradually going through white for velocity directions at 90 degrees and then turning red for outward moving particles. I am trialing this feature as it could be useful. It can be toggled on and off with a check box. Behavior is a bit unpredictable with using offsets and rotations, although the latter seems okay for now.
3/8/2021	Fixed the two particle CM plot option in Rplot.exe. When in screen capture mode, the green and yellow colors supposed to identify the two particles were not being enabled. I moved the order of particle fill and changed some of the logic in the XY and YZ plane viewports to make this work as intended.
2/16/2021	In Rplot.exe the multiplier of the final virial radius was not correct, so I fix that and cleaned up some of the ambiguity in the code on how that is determined.
2/15/2021	Rplot.exe changes: I "improved" the density plot for cases where the particle density is off the plot scale. I changed the scale so that it would include the particle density, which can cause shoving all the halo density way down in the plot. There seems to still be about 6-7 decades to plot the data but it isn't an ideal solution.

	I also now force the number of decades in the density plot to be 5 and scale the maximum to be 10000 RSU, since all simulation runs are scaled to be much less than that. I am not sure that the scaling length line that is plotted will be within the plot scale now for all simulation types though. We'll see if this needs to change in the future.
2/2/2021	Changed Rplot.exe to include the expanded viewport size (from 1/30/2021) in the density ratio calculation. I also expanded the total mass comparisons to now include masses of 10^{24} and greater to use M_{sol}/pc^3 on the density plots.
2/1/2021	One more Plot enhancement today. I now output the particle density to the plot it is outside the bounds of the plot scale.
1/31/2021	I added the central mass into the escape velocity calculation used in the Rplot.exe phase space plot. This gives a better looking, more realistic plot but still bothers me that the values plotted are over one.. Should be less than one.
1/30/2021	I improved the Rplot.exe viewport plotting option when plotting particle sizes. I added the maximum particle size to the plot edge extremes so that if part of the arc would appear in the viewport, then it is plotted. The maximum size is based on CON(14) and ICN(24). I suppose I could change this to be actual size as it could be per particle. This will only matter if there are inelastic collisions allowed for the simulation.
1/29/2021	I fixed the Rplot.exe density plot from underflowing the density scale. Now if density points are out of bounds for the plot scale, they are not plotted.
1/28/2021	Made changes to Rplot.exe to include the density plot to use solar mass per parsec cubed units for masses down to 10^{27} kg. I also had to make a change in the plot distance scale because it was not generic enough for some cases.
1/12/2021	I added to Rplot.exe the text option for elastic collisions. In this case, I changed the text and density plot line output to the Newtonian length based on the power of the elastic repulsive core, CON(17). This makes more sense than the softening length since there is only force modifications for EC.
12/4/2020	I made more changes to Rplot.exe in the last two days. I completely rearranged the offset control and made them more useable, I hope. Since Rplot.exe is a living tool, these changes are perhaps temporary as need dictates. Here is what I have done from a usability/feature perspective. • I removed the offset action buttons that shift the offset a set amount. There are only three buttons now, for X, Y or Z control, whose actions read in an offset set by the user. These can be with positive or negative numbers. • I added a offset reset but to force all offsets bac to zero. • The "Use ViewPort CM positions as Offset" and "Click ViewPort for offset" actions are unchanged but the check boxes are moved into the offset control poertion of the control view ports. • The other plot controls check boxes were moved to the right and grouped together. • I added a feature to change the plot scale directly in addition to the Zoom In/Out feature. There is now a button that will read the contents of the scale TextBox and use it as the new original scale factor that will be used for plotting. Note that the number of zoom clicks is reset to zero. • I added a feature to enter a file increment using the existing file increment text box. Enter an increment value in the text box and push the adjacent button to update the plotting sequence with a new file increment.
11/8/2020	I added a new feature to Rplot.exe this week. The usage and controls are still being considered but the feature does what is intended. The intent is to be able to mouse click into the plot area and use that position as a new plotting offset. If the user clicks into the left plotting plane, that is X-Y plane and then the x and y offsets would be changed. For clicking in the Y-Z plot, only the y and z offsets are updated. When used in combination, first in one then the other, a new X-Y-Z offset will be created. This can be very useful in isolating groups of SO for further observation.
10/31/2020	I changed the way Rplot.exe determines the maximum decade for the density plots. Now I use 8 times the expected final virial radius as benchmark to the largest distances. I set the maximum decade to be

	two more than that value for positive decade numbers and one more for negative numbers. This seems to be a good compromise for now.
10/11/2020	Over the last week I have been adding some operational improvements to the Rplot.exe program. I have tried to eliminate some of the wonky check box issues and the ordering of the user actions. For example, if one checks the plot CM action and then immediately checks the Plot Density box, both would stay checked but only the last action would be done. The changes now make the first action as the only action. In addition, check boxes are now reset if their status flags are not in alignment with the check box. One action change is that when the "Plot CM as offsets" is unchecked, the offset are reset to zero for all three directions.
9/30/2020	I have made some cosmetic changes to Rplot.exe in the last week. I modified the phase-space plot to now show a vertical line at 2.5 times the initial virial radius and then calculate the escape velocity from that distance. The escape velocity assumes all mass is interior to that position for a single particle. I also changed the particle density label in the density plot to now be output below the particle density line.
9/8/2020	I fixed the previous update to Rplot.exe so that the plot title will change the v/c scaling number should the number particles change in the plot. This is this the case for inelastic and vanishing collision cases.
9/6/2020	I changed the way Rplot.exe does the phase space plots. The velocity is now scaled to the speed of light and the escape velocity from 5 times the expected final virial radius, scaled to the speed of light too. I have also then changed the velocity scale to be log(v/c). This velocity scale is really log(v/c/v_{esc}/c) and the fraction v_{esc}/c is shown in the window title.
8/16/2020	I added an output text to Rplot.exe when in screen capture mode to display the current rotation angles. This output was added below the current two lines of output where there as space to accommodate this added text.
7/27/2020	I tweaked the Rplot.exe plot scale display to now include a decimal point in the scale number. For some reason I had it converted to an integer.
7/26/2020	I made changes today to Rplot.exe to be compatible with simulations that predate the change in R2 to the position files that have extensions. These older simulation's position data was saved as single precision. I have also disabled the phase space option as there is no velocity data in those older position files. Rplot calls these older position file as release 1, which I think is technically true as the position files structure has not changed since the very early days. This change (I think) will accommodate simulations before about 1/13/2019.
7/8/2020	I have added a new feature in the last couple of days to Rplot.exe to plot the phase space of the particles. Currently, it is technically not the traditional phase space but one that plots the ratio of the velocity to the particle's current escape velocity. That escape velocity is the determined by the current particle position and assuming all the mass is inside that position. There is a new check box to initiate this plot and not other input is required. I am still flushing out this feature so there may be some changes coming depending on usability and accuracy. This feature will also work in the screen capture mode.
6/29/2020	I changed the way Rplot.exe operates when the "Set CM as Offsets" button is clicked. Before the button would turn itself off after setting the flag to use the offsets. Now the action will continuously update the offsets as long as the button is checked. This makes sense for creating screen captures using the plot density action.
6/1/2020	Made some fixes in Rplot.exe today to correct the density plot when using units not in the kpc range. For all other cases, density will be k/m^3 and distance will be in meters.
4/16/2020	I have been working on a new feature for the Rplot.exe program which replaces the right had view with a plot of the density profile. This is now mostly complete but there are still some tweaks and modifications that will be added as I examine the utility and the cosmetics. This new feature has a toggle check box that turns it on and off. See Section 2

4/5/2020	I added an exit button to the Rplot.exe program today. This was needed to cleanly exit from the program rather than killing the program window. I also cleaned up some behavior with the rotation sequencing behavior. Now when a single rotation is entered for any of the rotation options, the check box will uncheck itself if there is no incremental rotational input.
3/5/2020	I changed Rplot.exe to now have a more consistent scale factor. The scale will always be and integer value and based on the number of clicks in or out. The scale for non-screen cap usage will be one half every two clicks.
3/2/2020	I added some new output to the Rplot.EXE program to use proper units with the Scale factor. There are now unit ranges from nanometers to kiloparsecs and hopefully the program will use the correct units based on the RSU length parameter in CON(11). This was added so that for screen captures and the eventual video, the scale will be in understandable units. I added this feature back into the R2 version so that older simulations will be able to create videos with the units correct for the scale factor.
10/30/2019	I have made some changes to Rplot.exe over the last couple of days. Mostly the changes are tied to what happens during screen captures. I changed back to 1 two-pixel radius and changed object colors to the standard colors in the non-screen capture mode. I did this to make resulting videos more YouTube friendly. I also added axis labels to the plots. These labels are not what I intended but will do for now. I also changed the method for up and down scaling of the plots. Now in the no-screen cap mode, the plot scale will double every two clicks and in screen cap mode it will double every five clicks.
10/4/2019	I fixed the Rplot.exe screen cap option when printing to the information viewport. Earlier changes had not allowed enough space for the text. I also changed the plot radius for screen cap particles to 1 hoping that videos would not smear out the dots. We'll try that and change it back if it is a problem.
8/24/2019	I added to the output of Rplot.exe a string that relates the ration of the viewport density to the particle density. These are calculated in RSU but since the number is unitless it is an interesting measure.
7/23/2019	For the last couple of weeks, I have been adding features to Rplot.exe. The biggest feature was to create a viewport rotation sequence where the sequence can have rotations about the three axes. The other feature was to add check box that will take the CM coordinates of the particles in the viewport and use that as the viewport offsets for the three coordinates. See section 2 for more details.
7/9/2019	I have made changes to Rplot.exe over the last couple of days as I try to make videos from screen captures. The only operation change is that now the screen captures will stop and program will exit once the last file capture is completed. The rest of the changes were mostly clean up of some problems that I didn't handle properly. For example, the initial file captures had the wrong sequence numbers. I also made new case plotting for the screen capture mode as the particle size in HD movies was not big enough to make smooth video playback on streaming sites like Youtube, so all particles now have a radius of 2 pixels.
5/28/2019	I added a feature to Rplot.exe that created a check box to enable or disable object size plotting. Plotting object size has always depended on whether the current plot scale and the object size allow a circle size to represent the object to be plotted. Now there is added control to force plotting or not plotting. See Section 2.4.10 for more details.
5/15/2019	I fixed an issue with my changes to Rplot.exe from the day before. I forgot that I had a newer version of the code on my old workstation. So I had to remake the changes from yesterday on that code which had been updated for unlimited particles.
3/7/2019	I made a modest change to Rplot.exe today to read the Run String I created and put in the riod2.dat file. Now it displays the run string on the window banner to identify the simulation being plotted.
8/27/2018	In anticipation of future simulation runs that will require more than the old position file directory function, I have now changed the directories to have to top level go up to 999. I intentionally programed this so that older auxiliary programs like Rplot.exe and Hist.exe will still work with the older structure but new structure will require changes in those codes eventually when and only if the highest directory goes over 99. I have tested this out beyond 100 and seems to work ok.

12/7/2017	I have made a couple of changes to Rplot.exe. First, I extended file increment in the in the rplot.ini file to now be up to ±2000. I also noted that for the screen capture option, the size of the window size was not correct. I made the initial size now as 1920x1156, which forces the standard 1080p size when cropped.
10/27/2017	I found a bug with how I deal with the large integer iteration number. I seems I need to convert all other integer instances using int8 when using the Iter8 variable. This is across all programs and I need to check all of them. I have fixed Riod.exe, Rplot.exe, Hist.exe, and Stats.exe.
7/25/2017	I changed Rplot.exe to allow the Rplot.ini file to have increments between -2000 and +2000. This accommodates some for creating screen caps of larger file increments. See Section 2.5 for more details.
2/22/2017	This morning I added a way to plot a halo radius to Rplot.exe. The code now when getting the object size, it checks to see if the current mass is equal to CON(13) and if CON(16) is greater than 0.0. then the returned size is 1.3205*con(16). This new scaling is the 90% mass size for the only halo type currently available.
9/24/2016	Rplot changes were begun a bit sooner that the date noted here. SimplyFortran update caused problems and while looking at the code to see if it was my issue, I made some behavioral changes and some cosmetic changes. I modified the offset functions to only make a 2% change rather than a 10% change. I also changed the color of the C-M pairs, one is still green but the other is now yellow, hoping to contrast the other colors used.
9/17/2016	Rplot.exe had a bug that did not use the extended iteration number correctly. Since I have the reference iteration number as 1,000,000,000 is hard coded for Riod, it also appears the same in Rplot. However, in one of the subroutines, the number is changed by some old code that had it coded to be somewhat smaller to test with. I removed that code and it seems to work properly now. Rplot is a work in progress as I updated my SimplyFortran package and now there are unwanted behaviors.
10/17/2015	I made a change in the “Rplot.exe” program. I am trying out using colors to indicate which objects are out of plane of the plotting viewport. I use variants of blue and red to indicate which particles are out of the plane. White is still used are the color when in the plane of the viewport. I am actually trialing this to see if it helps or hinders understanding of that is happening in the plots. See Section 2 for more details.
7/4/2015	I modified “Rplot.exe” to now include a pause button which will pause the plot animation until the pause button is pushed again. In making this addition, the position and size of the other buttons were changes to make sure everything fit in the smallest sized window that the program allows, which is 1000 horizontal pixels. See Section 2 for details.
6/9/2015	More Rplot.exe changes in the last week. I added the ability to do screen captures however a bug in the AppGraphics package will not allow screen captures of the control area of the application. After some thought, I decided to expand the text area during screen captures and then print out the plot scale, file number and file increment in the text area. See Section 2 for details.
5/25/2015	I made some cosmetic changes to the control area of the Rplot.exe program today. This was done to facilitate making videos at 1920x1080 resolution and thus being able to do screen captures at that window size. Buttons are a bit smaller and some of the text is changed. Functionally, there are no changes.
5/24/2015	I have added some options to the Rplot.ini file to allow control of the starting file number and file increment on start up. See Section 2 for details.
4/6/2015	I have updated Rplot.exe with an added feature where now I also output the number of objects plotted in the plot windows. I also fixed a bug where the text color in was picking up the last color used in plotting, which caused the text to become very light or even disappear.
4/3/2015	I have put the finishing touches on the Rplot.exe program. Mostly this was clean up and making it more visually appealing. One functional change was to plot the objects with a different intensity depending on the distance of that object from the viewing plane. Read more about this in Section 2.

3/21/2015	Created a new data plotting program using the AppGraphics extensions to SimplyFortran. The program is call Rplot.exe and provides the use with a Windows GUI to augment the plotting of data files. There is much work yet to be done but at this point it completely replaces the Animate.exe program. Section 2 now describes the capabilities of the new program.

4 Acknowledgments

The work documented here was spawned by my working in a vacuum for years/decades, using stuff I learned from my Physics training and extensions of that knowledge. Literature references that helped with certain concepts are captured in footnotes throughout the document. This section acknowledges others who have contributed in some way to the software development that I would like to thank.

4.1 Julie Zhu (12/1/2012)

During one of our many discussions about things over the years, the subject of this simulation would come up. After expressing unhappiness with the FORTRAN package I was using and the lack of affordable options, Julie suggested I look into the free GNU FORTRAN. This suggestion (something I should have thought of myself, D'oh!) started a chain of events that led me to the Simply FORTRAN product. Changing to this new development environment spurred a burst of activity that led me to develop multithreaded code, the creation of the new RPLOT.EXE data viewing program, and the creation of many other tools and features. Thanks Julie!

4.2 Joe Henson (8/8/2016)

Joe helped me with a solution to a mystifying problem with MS Word. For some reason, Word will inexplicably change the header/footer spacing but the worst was the spacing increases for footnotes. The fix for this (so I will remember the next time this happens as it has happened more than once) is the following:

- Go into the "View" tab and click the "Draft" mode button.
- Then go to the "References" tab and click the "Show Footnotes".
- At the bottom of the page, there is a drop-down box labeled "All Footnotes". Enter each option of that drop-down list and remove all the unwanted spacing.

Thanks Joe!

4.3 Sean Emer (3/19/2020)

As a videographer, Sean provided video expertise as I could not get my videos to play properly on Youtube. His solution was to create the video in 4K resolution, which forces Youtube to treat the video with higher quality. This did work for me as now the videos have a much better viewing experience on Youtube. Thanks again Sean!

4.4 Ed Rojek (8/12/2021)

I have known and been friends with Ed since graduated school days. He is a go-to source of knowledge on many subjects and is always willing to help. I consulted with Ed regarding the particle-point-of-view feature now included in Rplot.exe. I was struggling with how to display the data for this feature but at the time, I was just trying to figure out why the output looked wrong. The discussion with Ed helped crystalize some concepts but also helped me rethink what I was doing and find the bugs in the code, which were dumb (interchanged the names of the Z and Y rotation subroutines) and an ill-conceived coordinate system model.

However, the most important aspect of our conversation was that he reminded me that I needed a reference imaging method. I had considered creating a camera perspective but was originally thinking that the transformation math would be

prohibitive. After fixing the above bugs, I dug into the imaging aspect and found a simple camera obscura (pin hole camera) transformation which suited my needs perfectly[1]. See section 2.4.20 for details on how this Rplot.exe feature works.

Thanks for your help, Ed and your continued friendship.

[1] Pin hole camera transformation link: http://www.cs.toronto.edu/~jepson/csc420/notes/imageProjection.pdf