Partiview
Nearby Galaxies

November 3, 2005

1 Introduction

Partiview is a software package for 3-D interactive data visualization of the universe from the American Museum of Natural History and the Hayden Planetarium

`http://www.haydenplanetarium.org/hp/vo/du/partiview.html`

Its standard databases scaled to render the neighborhood of the Milky Way include the Hipparcos star catalog, and comprehensive catalogs of clusters, nebulae, supernova remnants, and the Local Group galaxies. We have augmented it with other nearby galaxies to extend the range out to most of those in the NGC catalog. Another standard database specifically for extragalactic visualization includes the 2df survey and the Sloan Digital Sky Survey.

Information on objects in all of the basic catalogs are accessible directly from

`http://cdsweb.u-strasbg.fr/CDS.html`

and from the Sloan Survey at

`http://www.sdss.org/`

Partiview uses a Cartesian coordinate system, with the origin placed at the Sun and XY the plane of the galaxy. X is along the line from the Sun to the Milky Way center, and Z points to the North Galactic Pole. Database distances are measured in parsecs. Distances for nearby stars are derived

from parallax, and for galaxies usually from radial velocities and the Hubble Law.

Run the script `partiview_mw` to start partiview with the Milky Way database. It will load star and object catalogs for the Milky Way, including the Hipparcos catalog of nearby stars and the NGC catalog of nebulae and clusters, the Local Group Galaxies, and the Tully catalog of nearby galaxies. For navigating far outside our galaxy, use the command line `partiview_extragalactic`. This will not load the full stellar catalogs and will add the Sloan Survey and other distant galaxies.

A local copy of the User's Guide for Partiview is available online through our help index:

`http://www.physics.louisville.edu/help/`

Navigate through the help directories to the Partiview User's Guide. It is available off-site directly from the Partiview web site.

To really learn how to use this program's many features you may want to experiment while you keep the Guide up on the screen to try some of its examples. However, for a start, try following the instructions below to for an introduction to Partiview and to answer some simple questions about the large scale structure in the distribution of galaxies.

2 Navigating the Milky Way Galaxy

With `partiview_mw` running, grab the lower right corner of the window and expand it to a comfortable size. *Do not* make it full size. It helps to be able to see the original terminal window as well as the visual display. The stellar database is quite large, and on some computers the display may not be as responsive as you are accustomed to. The larger the window, the slower the display can update when it is running this process.

You navigate through the 3-D space using the mouse and an occasional keystroke in one of three modes: orbit, translate, and rotate. By default, the program will start in orbit mode with you at the Sun looking toward Orion. Orbit allows you to "orbit" around the reference point, and to move logarithmically in and out of the screen. However, it does not allow you to move off the reference point initially. Try this:

1. Hold the left mouse button down and move the mouse over the image. This moves you around the Sun, but since you are also on the Sun,

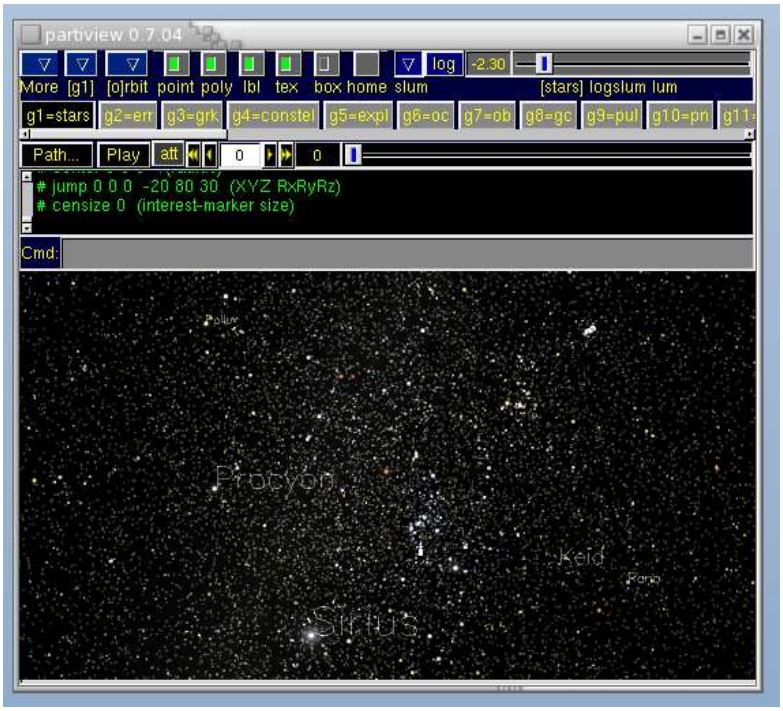

Figure 1: The Partiview window with its Milky Way database.

the effect is let you look around the universe as seen from the center of our solar system. Direct your view above and to the right of Orion toward Taurus and you will see the red giant Aldebaran and the galactic star cluster the Pleiades. Try pressing on the buttons "g4=constell" to toggle on and off the constellation maps, "g15=radec" to toggle the right ascension and declination grid, and "g16=eclip" to toggle the ecliptic coordinate grid.

2. Select the `translate` mode either using the third arrow button on the top of the interface window, or by pressing "t" on the keyboard while the window is active (if necessary, left click on the top of the window bar to make it active). The navigation mode will be displayed under the arrow on the bar, and should show `[t]tran` for "translate" or `[o]rbit` for "orbit".

3. Hold the right mouse button down and move the mouse up over the image. This will move you away from Orion. If you release the button while you are moving the mouse, you will continue to move (you have "inertia"). Left click anywhere on the image to stop the motion.

4. Now that you are no longer at the Sun (it should have receded into the distance in front of you) you can switch back to "orbit" mode. This has the advantage of using logarithmic scaling which will allow you to make a fast journey out of the Milky Way.

5. Since we are interested in galaxies now, let's select the objects that are useful for us. Groups are turned on or off with the buttons along the top of the window. Click off everything (it comes up with "g1=stars" and some others on). If you need to see all 32 groups, use the slider underneath the group list to scroll it left or right. Now click on

   - "g6=oc" open clusters
   - "g8=gc" globular clusters
   - "g9=pul" pulsars
   - "g12=snr" supernova remnants
   - "g27=mwpoly" milky way spiral structure
   - "g28=bar" milky way central bar
   - "g30=lgrp" local group

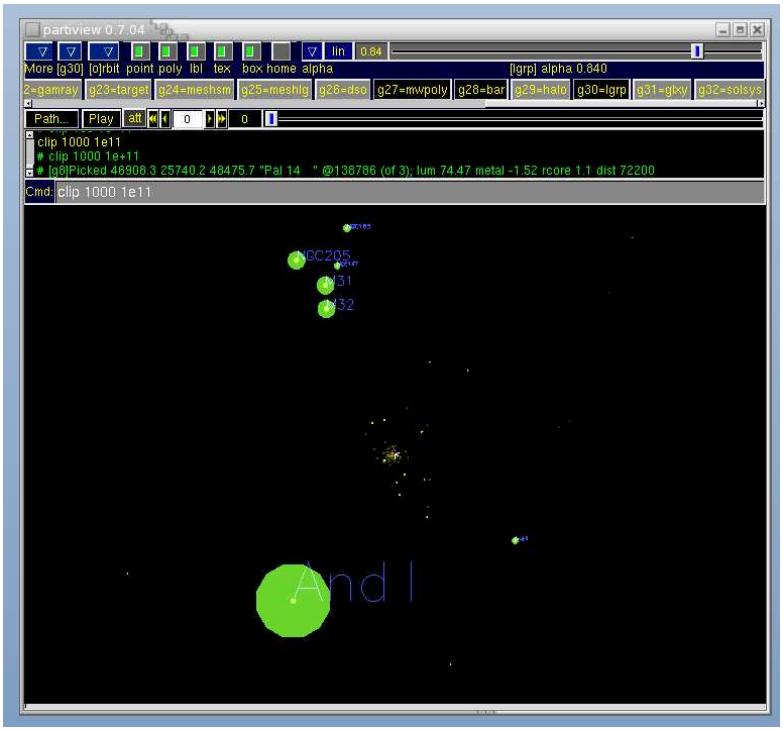

Figure 2: Stars are off, clusters on.

6. Set the clipping planes so that they will be able to include both near and far objects. Usually the command `clip 100 1e11` entered in the "Cmd:" field of the window will do it. You may need to change the clipping at some point if objects of interest disappear, but for now this will do.

7. Add axes centered on the Sun with lengths of 10000 parsecs with the command `censize 10000`

8. In "orbit" mode move the mouse *down* over the image with the right button depressed, and while moving it release the button. Inertia will carry you out of the Milky Way. As it recedes in front of you, left click on the image when it is obviously far in front of you. By holding the left button down and moving the mouse you can orbit around the Sun and see the Milky Way from different directions.

9. Notice that the open clusters, globular clusters, pulsars, and supernova remnants are color coded. You can identify which is which by clicking off/on each group. It might help now to turn off g9 and g12, leaving just the open and globular clusters.

10. Move out farther to see the Local Group galaxies. They will appear in green with blue labels.

11. If you center click on any object, its (x,y,z) coordinates and other information will be displayed both in the information box on the display, and on the terminal window from which you started Partiview. Explore the Local Group and see if you can find the Andromeda galaxy, M31.

12. A shift and right click on any active group button will select it so that you can control some the display parameters specific to that group. Try this on the local group. Now left click on the small arrowhead labeled "slum" near center at the top of the window. This will provide a list of things that can be connected to the slider on the right. Select "alpha" and you will see a label under the slider that says "[lgrp] alpha". As you move the slider you will have control on the brightness of the local group galaxies in the display. "[lgrp] polysize" will make the marker for the object change size logarithmically as you move the slider.

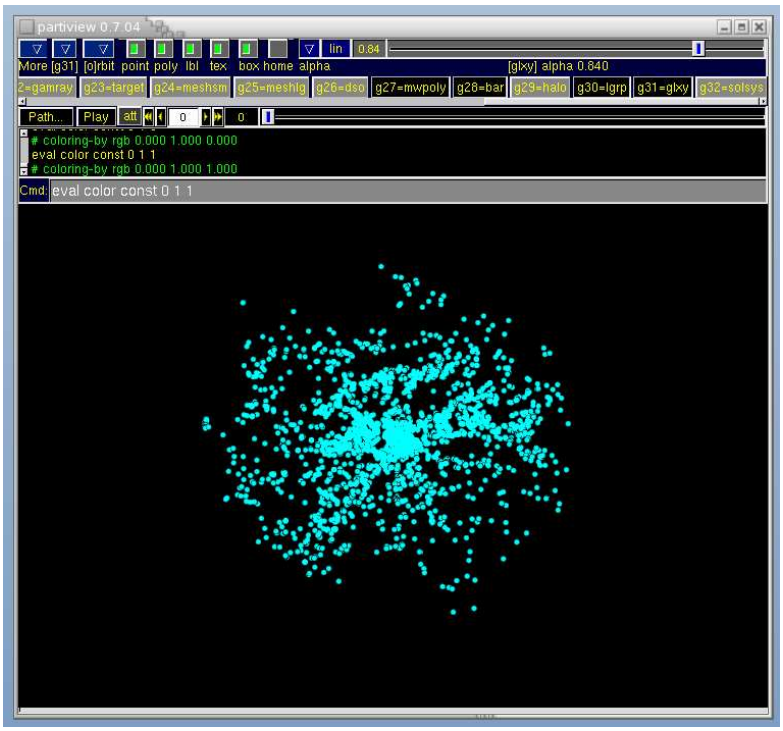

Figure 3: The Tully Nearby Galaxies Catalog.

13. Return to the center of the Milkyway and look for labels that mark the Hyades and Pleiades. Turn the stars back on. It may help to turn on the "Box" feature that is set to bound these clusters. Set the clipping planes to limit the display; something like "clip .1 1000" may work once you are close to the Pleiades. Hold the shift key down and center click in orbit mode to move the center of the orbit to the selected object. For example, select the bright star Atlas in the Pleiades in this way and the motion will be around a point within the cluster. Change to "censize 1" to see a 1 parsec distance scale within the Pleiades. What is the separation between Atlas and Merope?

3 Navigating the Universe

A nearby galaxy database can be seen by starting partiview with the command `partiview_mw`, moving out of the Milky Way, and turning off the stars. Leave the Milky Way representation with "mwpoly" on. It may also help to turn on the coordinate axes with a distance scale using the command "censize 100000" for 100,000 parsecs (or another scale of your choosing. The origin of the scale will be at the Earth. and the x-axis will extend from the Sun back through the center of the Milky Way about 8000 parsecs away.

14. Turn on "g31=nbglxy", turn off the stars, and move out to see the nearby galaxies. There is some duplication between the catalog of nearby galaxies and the local group galaxies, so you may toggle between them as needed. It may help to turn their luminosity up. Shift and right click on "g31=nbglxy", select "alpha", and move the slider to the right. Go out far enough that the complete catalog of galaxies looks like a large ball centered in the display window. With this group selected (right click), if you type `eval color const 0 1 1` in the command field it will set the color of all the galaxies to cyan (red=0, green=1, blue=1) which might also help to make them more visible.

4 Homework Questions

Use Partiview to answer these questions:

1. What is the distance out to which the Tully Nearby Galaxies Catalog includes galaxies? Use the center click function to find the (x,y,z) coordinates of selected galaxies at the limit, and then calculate the distance from
$$r = \sqrt{x^2 + y^2 + z^2}$$
What is the lookback time corresponding to this distance? What would be the redshift if the Hubble Constant is 72 km/s mpc?

2. Orbit around the Tully galaxy distribution. Look for what seems to be a missing strip cut on a great circle right through the center. Line up on this cut, and then move all the way back in to the Milky Way. How does the plane of the Milky Way compare to this strip with no galaxies? Why would this happen in an optical catalog of galaxies?

3. Move back out again. Issue the command "censize 15000000" to increase the reference coordinates to 15 Mpc. The Virgo cluster is a little farther than this. Explore the data to identify clusters of galaxies not far from the North Galactic pole (the blue axis). One of these is the Virgo cluster. The catalog assigns nearly the same distance to all members of the cluster, so they show up as a flat patch of galaxies, while in reality they would be spread over different distances from us. You can identify each galaxy either by its label (which appears when it is close enough), or by a center click on the galaxy which then causes its coordinates and name to appear in the control panel window. There is a text version of the Tully Catalog of Nearby Galaxies on the computer system in `/home/data/tully_galaxies/catalog.txt`. You may scroll through the list using `less catalog.txt` . The entries include Right Ascension, Declination, V, and R. With some help from XEphem you can find which part of the sky these would appear in, and probably even find the galaxy as it shows in our sky. Where in the sky is the other cluster similar in size and distance to Virgo?

4. How many galaxies are in the Virgo cluster and the other one noted above? Compare these clusters to the Local Group. From the coordinates of selected galaxies in these clusters measure the linear extent of these clusters perpendicular to the line of sight to them. Compare both the number of galaxies, and the size of the space these clusters occupy to one another, and to the local group. Is it reasonable to assume that these clusters are not gravitationally bound to the Local Group?

5. Use the data in `catalog.txt` to plot a Hubble law diagram for the Tully catalog. The last two columns of the data file are V and R. What is a best linear fit for the Hubble constant to these data?

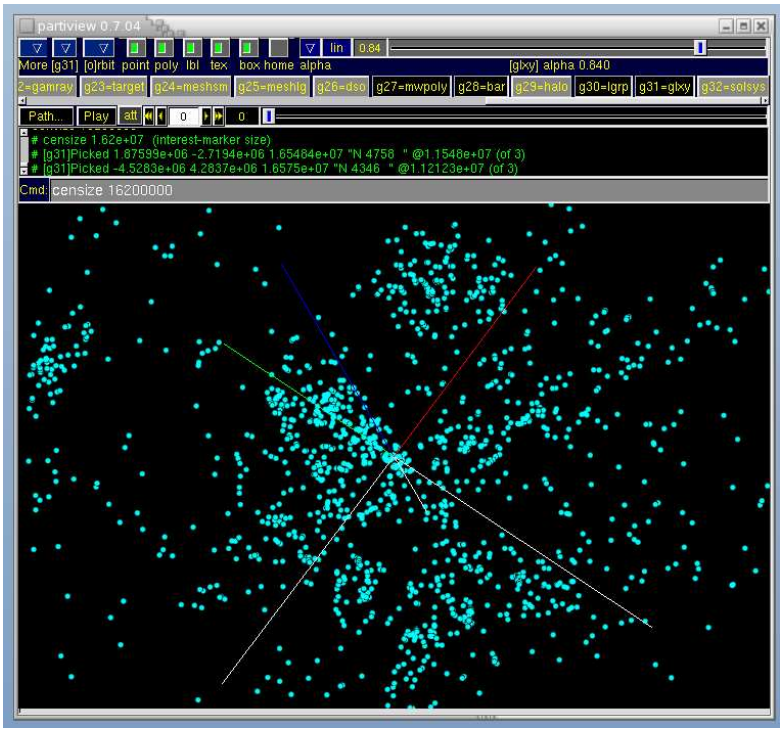

Figure 4: Coordinate axes and the region around the Virgo Cluster.