**Cluster Velocity Dispersion[[1]](#footnote-1)**

The nearest large cluster of galaxies is the Virgo Cluster, approximately 18 million parsecs (Mpc) away. At the center of the Virgo Cluster is the giant elliptical galaxy M87. Even further away is the dense, massive Coma Cluster (100 Mpc distant).

Galaxies within clusters are bound together by their mutual gravitational pull. Unlike the rest of the Universe, which expands with the cosmic expansion since the Big Bang, galaxies in clusters do not expand away from each other, but rather orbit around the cluster center on timescales of billions of years.

The Coma Cluster of galaxies (Credit: The

National Optical Astronomy Observatory

**Measuring the Mass of Coma** – Just as the velocities of stars orbiting a galaxy tell us the mass of the galaxy, so do the motions of galaxies in a cluster tell us the mass of the cluster. Since there is no central massive core to a galaxy cluster, however, galaxies in a cluster move more like a swarm of bees than the stately rotation of a spiral galaxy.

To measure the mass of a cluster of galaxies, astronomers must measure the radial velocity of many galaxies in the cluster to determine the cluster's velocity dispersion. The velocities of individual galaxies are measured from spectra using the Doppler Effect. Remember, however, that the cluster of galaxies is itself receding from us. The width of the histogram tells us the spread in velocities, or the velocity dispersion, while the average velocity tells us about how fast the cluster as a whole is moving away from us due to the cosmological expansion of the universe.

**The Coma Velocity Dispersion** – Log onto the computer, open a browser, and load the JavaLab at http://burro.astr.cwru.edu/JavaLab/clusters/ClustersApplet.html.

In this Java Lab, we will use the velocities and spatial distribution of galaxies in clusters to get an estimate of the dynamical mass of clusters.

Select the Coma Cluster from the pull-down menu at the upper right of the window.

An image of the Coma Cluster will appear in the pane. If the image is too large to be viewed in the pane, you can use the scroll bars to view the hidden portions of the image.

When you move your mouse over a galaxy in the image, information regarding that galaxy will appear in the small window to the right.

When you click on a galaxy, a circle will be drawn around it, indicating that it has been added to the data set for analysis. Clicking the galaxy again will toggle its selection off. Holding down CONTROL while clicking will deselect all of the galaxies.

Histogram of radial velocities in a cluster of galaxies. (Chris Mihos)

Almost all of the objects visible in the image are galaxies in the Coma Cluster. A handful of Milky Way stars are also visible – the objects with points, such as the bright star near the right edge of the frame. Select about 50 galaxies. You can switch back and forth between the Analyze and the Select frame to see how your histogram is building up.

When you have selected a good sample of galaxies, click the "analyze" button to switch to the analysis screen, where you can analyze the cluster based upon the galaxies you have chosen.

You may wish to set lower and upper limits for the radial velocities to be included in the calculation to eliminate outlying velocities. Some few galaxies are either foreground or background objects that are not members of the Coma Cluster.

Also enter a value for the Hubble Constant (use Ho=72 km s-1 Mpc-1, which will be used to calculate the distance to Coma.

Click the “Calculate” button to display the cluster distance, luminosity, size (half-light radius), gravitational mass, and mass to light ratio.

Cluster distance \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Cluster Luminosity \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Gravitational Mass \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Mass/Light ratio \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. From Chris Mihos at Case Western Reserve [↑](#footnote-ref-1)