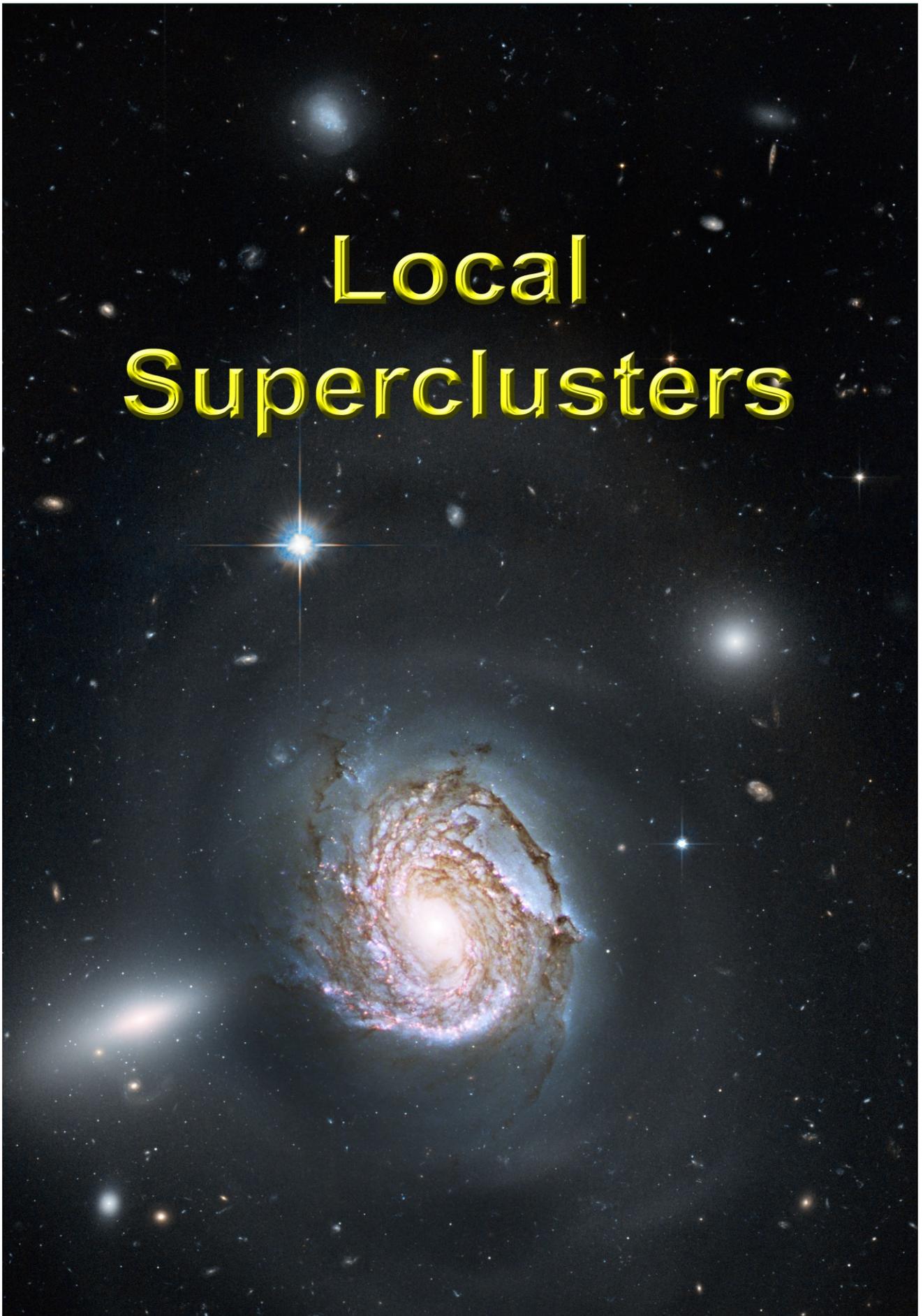


# Local Superclusters





## Local Superclusters

**{Abstract** – In this segment of our “How far away is it” video book, we cover the superclusters closest to our supercluster, Virgo.

First we discuss the overall structure of the nearest 20 superclusters and illustrate the galactic structures of galaxy filaments, walls and voids including: the Sculptor void; the Perseus-Pegasus filament; the Fornax, Centaurus, and Sculptor walls as well as the Great Wall or Coma wall. Then we take a look at several of these superclusters and some of the galaxies in each one we examine.

We start with the Hydra Supercluster with the Hydra Galaxy Cluster at its center. We examine NGC 2314, a rare double aligned pair of galaxies. We then move to the Centaurus Supercluster with the Centaurus Galaxy Cluster at its center. We then take a look at some of the galaxies in this supercluster including NGC 4603, NGC 4622, the unusual NGC 4650A, and NGC 4696. We then move on to the Perseus-Pisces Supercluster and the Perseus galaxy cluster within it and the remarkable galaxy NGC 1275 within it. Then we cover the Coma Supercluster with the Coma galaxy cluster at its center. We then take a look at the beautiful and wispy galaxy NGC 4921 along with NGC 4911.

Next we review the distances to some of the other local superclusters including Hercules, Leo, Shapely, Horologium, and the 1 billion light years distant Corona-Borealis Supercluster. We also cover the unusual peculiar motion superimposed on the normal Hubble flow that all the galaxies within a billion light years have. It appears that they are all moving towards a Great Attractor in the Norma or Shapley Supercluster.

Next we take a look at additional galaxies within a billion light years of us including: ESO 510 – G13; NGC 6782; ESO 243-49 HLX-1 with a supermassive black hole in its disk; Stephan’s Quintet; interacting galaxies NGC 1409 and NGC 1410; interacting galaxies ARP 127 and NGC 5679; galaxy cluster Abell S0740; ESO 325-G004 with its unique gravitational lens arcs called Einstein’s rings; and finish with the very interesting Hoag’s Object.

We end with a map of all the superclusters where we highlight the ones we’ve seen and show the dot that represents our local volume.}

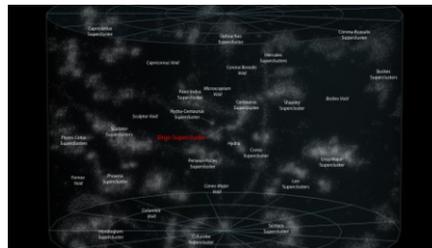
### Introduction

**[Music: Ludwig van Beethoven – “Moonlight Sonata” – Completed in 1801, this is one of Beethoven’s most popular piano compositions. Moonlight is starlight reflecting off the moon. The name Moonlight along with the sound of the music itself is perfect for introducing the galaxies of the Local Superclusters.]**

## How Far Away Is It – Local Superclusters



Here's a map of our local superclusters including the Virgo supercluster. As you can see, galaxies and clusters of galaxies are not uniformly distributed in the Universe. Instead they collect into vast clusters, filaments and walls of galaxies interspersed with large voids in which very few galaxies seem to exist.



A filament is constructed of galaxies and galaxy clusters. The Perseus-Pegasus Filament is an example. Walls are much wider and thicker than filaments. Here we see the Fornax, Centaurus, Sculptor and the Great Wall or Coma wall. The Great Wall is one of the longest known super-structures in the Universe. It is approximately 200 million light-years away and measures over 500 million light-years long, 300 million light-years wide and 16 million light-years thick.

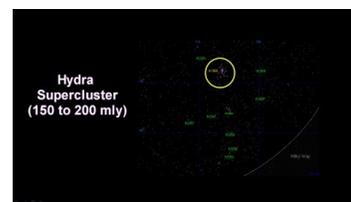


Voids are the vast empty spaces between filaments which contain very few, or no, galaxies at all. There are 25 major voids in our local superclusters. Only a few are marked here. The Sculptor void is the largest in the nearby universe.

Let's take a look at some of these superclusters and some of the galaxies photographed by Hubble that are contained in these superclusters.

### Hydra Supercluster

The Hydra Supercluster is close to the Virgo Supercluster and similar in size and shape to it. It's about 100 million light years long and contains the large Hydra galaxy cluster. This map plots every bright galaxy in the Supercluster. The galaxies in the supercluster range from 150 to 200 million light years away.



### Hydra Cluster



Here is a picture of the Hydra Cluster. The white blobs in this picture are the galaxies in the cluster. The bright orange star at the center is a nearby red giant in the clusters line of sight, not actually in the cluster.

### NGC 3314 – 140 mly

Here's a unique galaxy pair in Hydra. Through an extraordinary chance alignment, a face-on spiral galaxy lies precisely in front of another larger spiral. This line-up provides us with the rare chance to visualize dark matter within the front galaxy, seen only because it is silhouetted against the object behind it.

## How Far Away Is It – Local Superclusters

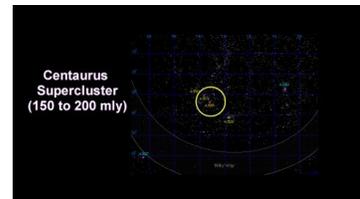


The bright blue stars forming a pinwheel shape near the center of the front galaxy have formed recently from interstellar gas and dust. A small, red patch near the center of the image is the bright nucleus of the background galaxy, NGC 3314b.

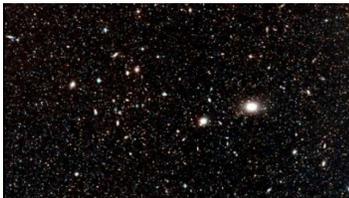
**[Additional info:** It is reddened for the same reason the setting sun looks red. When light passes through a volume containing small particles (molecules in the Earth's atmosphere or interstellar dust particles in galaxies), its color becomes redder.]

### Centaurus Supercluster

The Centaurus Supercluster is the closest neighbor of our Virgo Supercluster. It contains a number of large galaxy clusters including the Centaurus Cluster. The galaxies in the supercluster range from 150 to 200 million light years away. This map plots the brightest galaxies in this area of the sky. The supercluster structure is fairly obvious in the middle of the map.



### Centaurus Cluster



Here is a picture of the Centaurus Cluster. It is one of the most massive assemblages of galaxies in the nearby universe. Note that the plane of our galaxy cuts its way through this region of sky, so any photographs will be contaminated by a large number of foreground Milky Way stars.

**[Music:** *Antonín Leopold Dvořák – “String Serenade” – Composed in 1875, this was one of Dvorak's most popular orchestral works. With the rhythm of a fine waltz, this Sting Serenade makes for beautiful music to accompany the galaxies in the Centaurus Cluster.*]

### NGC 4603 – 108 mly



Here's a magnificent view of the spiral galaxy NGC 4603 in the Centaurus cluster. It is the most distant galaxy in which Cepheid variables have been found. Clusters of young bright blue stars highlight the galaxy's spiral arms. In contrast, red giant stars in the process of dying are also found. Only the very brightest stars in NGC 4603 can be seen individually. Much of the diffuse glow comes from fainter stars that cannot be individually distinguished. [The reddish filaments are regions where clouds of dust obscure blue light from the stars behind them.]



### NGC 4622 – 111 mly

Here is another galaxy in the Centaurus Cluster. The image shows NGC 4622 and its outer pair of winding arms full of new stars, shown in blue. Astronomers are puzzled by its clockwise rotation because of the direction the outer spiral arms are pointing. Most spiral galaxies have arms of gas and stars that trail behind as they turn. But this galaxy has two "leading" outer arms that point toward the direction of the galaxy's clockwise rotation.



### NGC 4650A – 130 mly



Located about 130 million light-years away in the Centaurus cluster, NGC 4650A is one of only 100 known **polar-ring galaxies**. Their unusual disk-ring structure is not yet well understood. One possibility is that polar rings are the remnants of colossal collisions between two galaxies sometime in the distant past, probably at least a billion years ago.

### NGC 4696 Black Hole – 150 mly

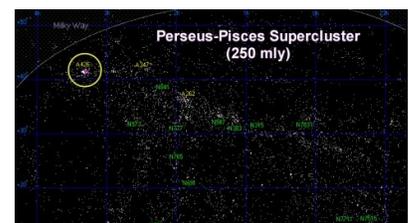
NGC 4696 is an elliptical galaxy in the Centaurus Cluster. In fact, it is the brightest galaxy in the cluster. This composite image was taken in a study of the galaxy's central black hole. It shows a vast cloud of hot gas (in red), surrounding high-energy bubbles 10,000 light years across (in blue). The green dots in the image show infrared radiation from star clusters on the outer edges of the galaxy.



**[Additional info:** An important implication of this work is that the conversion of energy by matter falling toward a black hole is much more efficient than nuclear or fossil fuels. For example, it is estimated that if a car was as fuel-efficient as these black holes, it could theoretically travel more than a billion miles on a gallon of gas!]

### Perseus-Pisces Supercluster

The Perseus-Pisces Supercluster is a long, dense wall of galaxies with a length of almost 300 million light-years that is around 250 million light-years away. It is one of the largest known structures in the universe. This plot of the brightest galaxies in the supercluster show how prominent it is. At the left end of the supercluster is the massive Perseus cluster – one of the most massive clusters of galaxies within 500 million light-years.





### Perseus Cluster



This picture shows the central part of the Perseus cluster. As with the others we've seen, it is crowded with Milky Way stars in the foreground that show up as faint dots.

### NGC 1275 – 230 mly

Here we are zooming into the giant elliptical galaxy NGC 1275 in the Perseus cluster. We see fine, thread-like filamentary structures in the gas surrounding the galaxy. The red filaments are composed of cool gas being suspended by a magnetic field, and are surrounded by the 100-million-degree Fahrenheit hot gas in the center of the Perseus galaxy cluster.



The filaments are dramatic markers of the feedback process through which energy is transferred from the central massive black hole to the surrounding gas. The filaments originate when cool gas is transported from the center of the galaxy by radio bubbles that rise in the hot interstellar gas.

### Coma Supercluster

The Coma Supercluster is a nearby supercluster of galaxies that includes the famous Coma Cluster (Abell 1656). Located 300 million light-years from Earth, it is roughly spherical, about 20 million light-years in diameter and contains more than 3,000 galaxies.



Being one of the first superclusters to be discovered, Coma Supercluster helped astronomers understand the large scale structure of the universe. This map plots the brightest galaxies in Coma Supercluster's region of the sky.

**[Music: Edvard Grieg – “Peer Gynt – Morning” – This was written in 1875 as music for Henrik Ibsen's play of the same name. The piece depicts the rising of the sun, a star in a galaxy that is just a dot in the Virgo Supercluster.]**

### Coma Cluster



The Coma cluster has received a huge amount of scientific research. This is partly because it lays a long way from the plane of our Galaxy and it is largely unobscured by any gas, dust or foreground stars. There is also one obvious foreground star in this image. It's less than one millionth of the distance to the Coma cluster.

## How Far Away Is It – Local Superclusters



### NGC 4921 – 320 mly

Here we are zooming into NGC 4921. It is one of the rare spirals in the Coma cluster, and a rather unusual one — it is an example of an "anemic spiral" where the normal vigorous star formation that creates a spiral galaxy's familiar bright arms is much less intense. As a result there is just a delicate swirl of dust in a ring around the galaxy, accompanied by some bright young blue stars.



### NGC 4911 – 320 mly

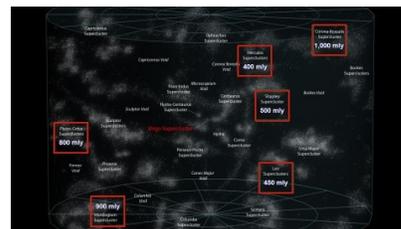


NGC 4911 contains rich lanes of dust and gas near its center. These are silhouetted against glowing newborn star clusters and iridescent pink clouds of hydrogen, the existence of which indicates ongoing star formation.

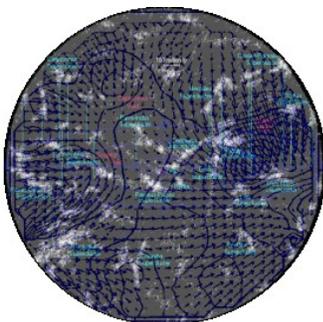
4911 and other spirals near the center of the cluster are being transformed by the gravitational tug of their neighbors. In the case of 4911, wispy arcs of the galaxy's outer spiral arms are being pulled and distorted by forces from a companion galaxy (NGC 4911A) to the upper right. The resultant stripped material will eventually be dispersed throughout the core of the Coma Cluster, where it will fuel the intergalactic populations of stars and star clusters.

Here are the distances to a few additional superclusters in our local group:

**Hercules** is 400 million light years away.  
**Leo** is 450 million light years away.  
**Shapley** is 500 million light years away.  
**Horologium** is 900 million light years away.  
**Corona Borealis** is 1 billion light years away.



### The Great Attractor

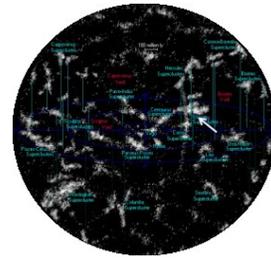


There's one more thing about the galaxies in our local Superclusters – They all have an unusual peculiar motion. Normally, galaxies are expected to have a motion consistent with the Hubble flow. That is, given the Hubble law, and the distance to a galaxy, its velocity is set. But in our local area – within 1 billion light years – there is an additional flow superimposed on the Hubble flow. It appears that our galaxy and a large number of the galaxy superclusters in our area are flowing towards what is called 'the great attractor'.

## How Far Away Is It – Local Superclusters



Initially, it looked like the great attractor was located close to the Norma Cluster – not too far from the Centaurus Supercluster. But Norma is so close to our galactic plane or ‘area of avoidance’ that we cannot see into it very well. More recently, updates to motion vectors indicate that the flow is not so much to the Norma Cluster, but to the much more massive Sharply Supercluster behind it.



Let’s take a look at a few more galaxies found in our local superclusters.

### ESO 510-G13 150 mly



This is an image of an unusual edge-on galaxy, revealing remarkable details of its warped dusty disk. The strong warping of the disk indicates that this galaxy has recently undergone a collision with a nearby galaxy and is in the process of swallowing it. In the outer regions, especially on the right-hand side of the image, we see that the twisted disk contains not only dark dust, but also bright clouds of blue stars. This shows that hot, young stars are being formed in the disk. Astronomers believe that the formation of new stars may be triggered by collisions between galaxies, as their interstellar clouds smash together and are compressed.

*[Music: Claude Debussy – “Clair De Lune” – Debussy published this famous piano suite in 1905. Moon light - starlight reflected off the Moon. Inspired by the lyrics, Debussy created the perfect music to accompany the galaxies in our nearby galaxy superclusters.]*

### NGC 6782 – 183 mly



The appearance of a galaxy can depend strongly on the color of the light with which it is viewed. This galaxy, when seen in visible light, exhibits tightly wound spiral arms that give it a pinwheel shape similar to that of many other spirals. However, when the galaxy is viewed in ultraviolet light, its shape is startlingly different.



Ultraviolet light has a shorter wavelength than ordinary visible light, and is emitted from stars that are much hotter than the Sun. At ultraviolet wavelengths, which are rendered as blue in this Hubble image, we see a spectacular, nearly circular bright ring surrounding its nucleus. The ring marks the presence of many recently formed hot stars.



### ESO 243-49 HLX-1 – 290 mly

This spectacular edge-on galaxy is believed to be home to an intermediate-mass black hole that may have been stripped off of a cannibalized dwarf galaxy. The estimated 20,000-solar-mass black hole lies above the galactic plane. This is an unlikely place for such a massive black hole to exist, unless it belonged to a small galaxy that was gravitationally torn apart by this one. The circle identifies a unique X-ray source that pinpoints the black hole.



### Stephan's Quintet – 290 mly



Here we are zooming into the Stephan's Quintet. As the name implies, it is a group of five galaxies. The name, however, is a bit of a misnomer. Studies have shown that group member NGC 7320 is actually a foreground galaxy. At 40 million light years, it is about seven times closer to Earth than the rest of the group.

Three of the galaxies have distorted shapes, elongated spiral arms, and long, gaseous tidal tails containing myriad star clusters, proof of their close encounters. These interactions have sparked a frenzy of star birth in the central pair of galaxies.

7319 is a barred spiral with distinct spiral arms that follow along 180 degrees back to the bar. Continuing clockwise, the next galaxy appears to have two cores, but it is actually two galaxies, 7318A and 7318B. NGC 7317 is a normal-looking elliptical galaxy that is less affected by the interactions. These farther members are markedly redder than the foreground galaxy, suggesting that older stars reside in their cores.

### NGC 1410, NGC 1409 – 300 mly

This visible-light Hubble picture reveals an intergalactic "pipeline" of material flowing between two battered galaxies that bumped into each other about 100 million years ago. The pipeline (the dark string of matter) begins in 1410 (the galaxy on the left), crosses over 20,000 light-years of intergalactic space, and wraps around 1409 (the companion galaxy on the right).



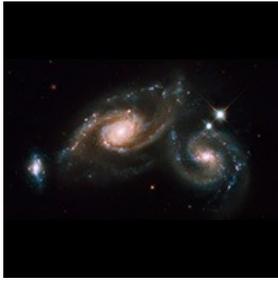
**[Additional info:** Scientists believe that the tussle between these compact galaxies somehow created the pipeline, but they're not certain why 1409 was the one to begin gravitationally siphoning material from its partner. And they don't know where the pipeline begins in 1410.

More perplexing to astronomers is that NGC 1409 is seemingly unaware that it is gobbling up a steady flow of material. A stream of matter funneling into the galaxy should have fueled a spate of star birth. But astronomers don't see it. They speculate that perhaps the gas flowing into NGC 1409 is too hot to gravitationally collapse and form stars.]

## How Far Away Is It – Local Superclusters



### Arp 274, NGC 5679 – 400 mly



Here we are zooming into three galaxies that appear to be partially overlapping in the image, although they may be at somewhat different distances. The spiral shapes of two of these galaxies appear mostly intact. The third galaxy (on the far left) is more compact, but shows evidence of star formation.

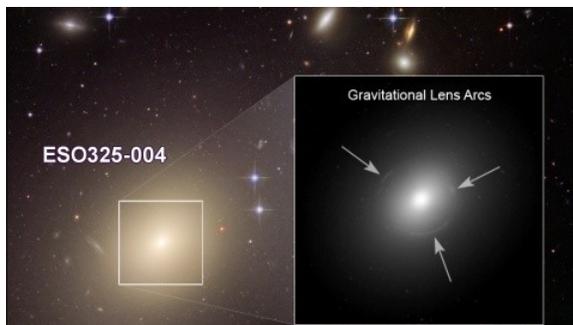
**[Additional info:** Two of the three galaxies are forming new stars at a high rate. This is evident in the bright blue knots of star formation that are strung along the arms of the galaxy on the right and along the small galaxy on the left.]

### Abell S0740 – 450 mly

This image shows the diverse collection of galaxies in the cluster Abell S0740. [Other fuzzy elliptical galaxies dot the image. Some have evidence of a disk or ring structure that gives them a bow-tie shape. Several spiral galaxies are also present.]



The giant elliptical ESO 325-G004 looms large at the cluster's center.



In the course of analyzing this Hubble image, astronomers discovered that ESO325 is actually a "**gravitational lens.**" This means that the focusing power of the enormous mass making up the galaxy caused the light from some background object, probably a distant "dwarf" galaxy, to be deflected and magnified. As a result, the more distant galaxy appears brighter, and distorted into the shape of an arc, or ring, known as an "**Einstein ring**" because the phenomenon was first predicted by Albert Einstein.

**[Additional info:** Although the universe is filled with galaxies, gravitational lensing is a rare occurrence because it requires an almost perfect alignment of a distant galaxy with an intervening one that has enough mass to gravitationally focus the light.

This particular system is unique because it is the closest known example of strong gravitational lensing. The galaxy is close enough that the dynamics of its stars can be studied in detail using spectrographs. The spectrographs reveal how fast the stars in the galaxy are moving, and this allows astronomers to estimate how much mass must be present in the center of the galaxy. This estimate can in turn be compared to the amount of mass needed to produce the observed gravitational lensing effect.

In this way, astronomers can build up a detailed, self-consistent picture of the matter distribution and dynamics of this unique nearby lensing system.]

## How Far Away Is It – Local Superclusters



### Hoag's Object – 600 mly

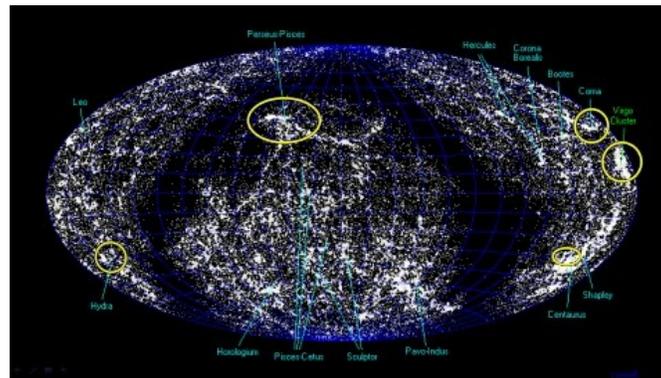
A nearly perfect ring of hot blue stars pinwheels about the yellow nucleus of an unusual galaxy known as Hoag's Object. A blue ring, which is dominated by clusters of young, massive stars, contrasts sharply with the yellow nucleus of mostly older stars. What appears to be a "gap" separating the two stellar populations may actually contain some star clusters that are just too faint to see.



Curiously, an object that bears an uncanny resemblance to Hoag's Object can be seen in the gap at the one o'clock position. The object is probably a background ring galaxy.

### The Big Picture

Here's another view of our local superclusters. I've circled the ones we covered. The empty space is the area we can't see due to the clutter from our own galaxy's disk.



Within this 1 Billion light year radius from us, there are:

- 100 superclusters
- 240 thousand galaxy groups
- 3 million large galaxies
- 60 million dwarf galaxies
- 250,000 trillion stars

At this range, the Milky Way is too small to show up. Our entire local volume is little more than a dot. But the entire map only represents about 7 percent of the entire visible Universe.

In this segment, we've seen several interacting galaxies. So, before we conclude the video book covering the cosmos as a whole, we'll take a closer look in our next segment at what it means for galaxies to collide.