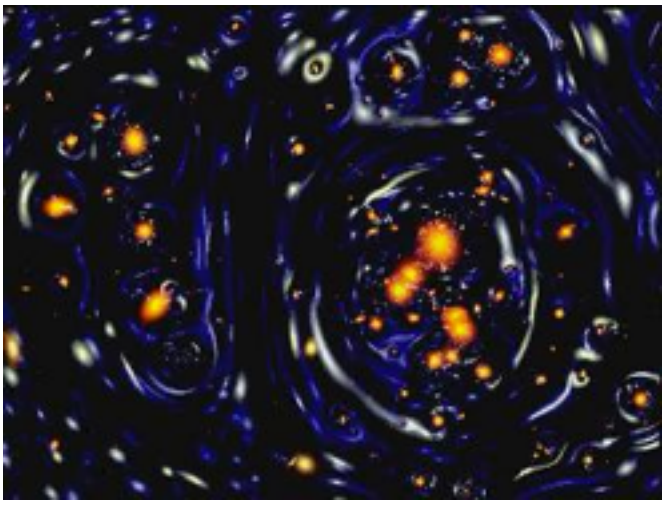
THE UNIVERSITY OF CHICAGO

Studying Dark Matter with Gravity

What observations tell us that dark matter exists? - Stars orbiting around all galaxies are “lasso-ed” by the gravitational pull of all the other mass in the galaxy. Observations found that stars near the outskirts of nearby galaxies moved much faster than if they were only pulled by the mass of observable stars and gas Therefore, scientists predict that another, unseen, mass must be pulling stars around galaxies. The search is on to understand the nature of this dark portion of our universe!

Where else do we see dark matter? - *Almost everywhere!* The gravitational pull of dark matter can bend the light from background sources, stretching background galaxies into circular arcs. Scientists use the stretching of these sources to infer the amount of mass that the light traveled through, finding that a significant dark matter mass must exist in most galaxy and galaxy clusters.



Here we see an extreme example of the lensing of background galaxies by clumps of dark matter in nearby galaxies. See the circular patterns of light on the sky? Each circle contains multiple images of the same galaxy, stretched into this unique configuration by the pull of dark matter!

How do we know dark matter is a new particle? - *From a multitude of experiments and observations.* Most charged particles (like those that make up the electrons and protons in our body) interact strongly with light and with each other. Astronomers searched for hints of these interactions in the dark matter in our universe, and found no hints that dark matter can effectively interact. They have used this evidence to show that dark matter must be capable of only very weak interactions, unlike the majority of the visible matter in our universe.

The Bullet cluster is an incredible system where two massive galaxy clusters are crashing into each other at thousands of kilometers per second. This image depicts the Bullet Cluster as shown in X-Ray observations of gas (pink) and via the gravitational lensing of background galaxies (blue). Note that the majority of the mass (blue) is not at the same location as the majority of the gas and that we observe. This observation is one of the strongest indications that dark matter is a separate particle, with different properties than the regular matter we can see.

How can we use gravity to understand dark matter? - There is nearly 6x as much dark matter mass in our galaxy as their is mass from normal particles. This means that dark matter provides most of the gravitational force that causes galaxies to form and interact. Carefully studying the distribution, shape, and size of galaxies will continue to provide new insights into the characteristics of dark matter.