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Dark Matter: An Invisible Universe

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Dark Matter

An Invisible Universe

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Stars, planets, black holes. These are the three main objects that we consistently see throughout the universe. The Milky Way contains about 250 billion stars—but that's just our galaxy. Astronomers estimate 200 billion to 2 trillion galaxies exist in our observable universe, including over 50,000 billion stars. Yet all of this material only makes up about five percent of the universe. Everything you see when you look at the night sky on a dark, clear night is only a fraction of what's out there. Dark energy and dark matter make up the other 95 percent of the universe. But what are dark energy and dark matter?

The answer is, we don't really know. Dark energy is a mostly unknown form of energy that repels matter, acts on a large cosmic scale, and is believed to cause the ongoing expansion of the universe. On the other hand, dark matter is a form of energy that attracts matter, acts on both a large and small scale, and is more directly implied by calculations from observable galactic activity (especially near black holes, another mystery of the universe). Dark energy is especially mysterious and difficult to study, but people are making significant headway in understanding dark matter.

Everything we know about the universe today is information we've gathered via the electromagnetic spectrum, or the range of waves that carry energy produced by electrically charged particles. For example, we observe black holes through radio waves and

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X-rays. However, dark matter doesn't interact with electromagnetic waves or light waves, which means that it is arduous for researchers to observe its activity. Any wavelength of light will pass right by dark matter without changing its path. As far as we know, dark matter only interacts through gravitational waves and energy, a completely different type of energy than electromagnetic energy. Logistically this means that scientists who study dark matter primarily use highly sensitive instruments to decipher absolutely miniscule changes in gravitational waves which are easily distorted in space. Though many scientists are trying, no one has actually succeeded in detecting dark matter yet.

So how do we know that dark matter is there? Scientists first discovered this mysterious material with so many unknown properties by studying the rotation of galaxies and the motion of stars within them. Researchers realized that the observed rotational speeds of galaxies were too fast for the galaxies to stay intact without some kind of internal, attractive force. The only explanation was that there must be some strange matter in galaxies that keeps them from spinning themselves apart.

In Albert Einstein's thought experiments about gravity, he discovered that masses bend the fabric of space-time. Imagine the Universe as a big, stretched out sheet. Stars and planets and black holes and any massive objects create a curvature in the sheet. This curvature is gravity. The nature of light is to travel in the straightest way across a curved path, meaning that as light comes across a massive object in space, it's going to travel in the direction which is the least amount of distance for it to traverse. This can happen in such a way that light will appear as a circle around a massive object or that a star can be seen at the side of one object even if the star is really directly behind the object. In this way, all matter, even dark matter interacts with light waves, if only through curving light's path with its gravitational pull—the only interaction of dark matter and electromagnetic energy that is known. While this property doesn't let us actually see dark matter, it does allow scientists to measure the amount of dark matter in a system. Tracking the curvature of light helps in measuring how much mass—visible or dark—is in a given galaxy.

Aside from its interaction with light, dark matter may also differ from normal matter in a more significant way: it's behavior with itself. Scientists hypothesize that dark matter is distributed almost evenly around the Universe, instead of behaving like normal matter, which aggregates into stars and planets. This speculation suggests dark matter to be diffused in individual particles. The most basic units of normal matter are protons, neutrons and electrons. A strong theory among astrophysicists is that dark matter is made of weakly interacting massive particles (WIMPs). These WIMPs could be ten to one hundred times the mass of a proton, but, because they are "weak," their interactions with normal matter are not easily detected. There may be alternate ways of discovering more about dark matter, if technological advancements can permit the detection of these "weak" interactions.

Another hypothesis is that dark matter is a different form of neutrinos, or particles that are produced from fusion in the sun. However, in an early experiment conducted by Raymond Davis and some of his colleagues, neutrinos were measured in only one-third of the predicted number. Many years later, scientists realized this occurred because neutrinos are able to switch between three different states, so the machines in the experiment only had a one in three chance of detecting neutrinos. Neutrinos are also special because they are not considered to make up regular matter. The proposed "sterile neutrino" would be a fourth state that only interacts with normal matter through gravity—just like dark matter—but this theory is a work in progress without much hard evidence.

Many scientists believe that dark matter is the scaffolding of the universe. Supporting this idea, most observed galaxies are at least 30 percent dark matter, but last year we discovered a galaxy that appears to contain almost no dark matter. This galaxy is named NGC 1052-DF2; it is very dim, about one-two-hundredth the mass of our Milky Way galaxy, and about 65 million light-years away. The reason this discovery was so bizarre is that a galaxy as isolated as NGC 1052-DF2 is expected to have an almost one hundred times greater amount of dark matter as normal matter. It also rocked the theory that all galaxies must have dark matter. In response to this discovery, scientists may need to reconsider how galaxies are defined.

The discovery of this galaxy is also exciting because, until now, dark matter was everywhere that scientists had looked in the Universe. Dark matter's ubiquitous presence created some uncertainty about the legitimacy dark matter. Because we had seemed to find dark matter everywhere, we could not be sure if it actually existed or if our laws of physics were deeply flawed. Since a galaxy completely void of dark matter has been discovered, there is more certainty of its existence. Now we have a prime example of a galaxy that exists and that could have formed without dark matter.

In spite of numerous theories, discoveries, and research efforts, dark matter remains one of the most puzzling aspects of the universe. Scientists have made incredible progress in unearthing the secrets of dark matter, but modern science promises to explore even more. • • •