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SPACE & COSMOS

Stalking the Shadow Universe

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OUT THERE

For centuries people have found meaning — or thought they did — in what they could see in the sky, the shapes of the constellations echoing old myths, the sudden feathery intrusion of comets, the regular dances of the planets, the chains of galaxies, spanning unfathomable distances of time and space.

Since the 1980s, however, astronomers have been forced to confront the possibility that most of the universe is invisible, and that all the glittering chains of galaxies are no more substantial, no more reliable guides to physical reality, than greasepaint on the face of a clown.

The brute mathematical truth is that atoms, the stuff of stars, you and me, make up only 5 percent of the universe by weight. A quarter of it is made of mysterious particles known as dark matter, and the remaining 70 percent a mysterious form of energy called dark energy. Physicists theorize that dark matter could be exotic particles left over from the Big Bang. They don't know what it is, but they can deduce that dark matter is there by its gravitational effect on the things they can see. If Newton's laws of gravity held over cosmic distances, huge amounts of more matter than we can see were needed to provide the gravitational glue to keep clusters of galaxies from flying apart, and to keep the stars swirling

around in galaxies at high speed.

Cosmologists have theorized that it is in fact dark matter, slowly congealing under its own weight into vast clouds, that provides the scaffolding for stars and galaxies.

To strip the greasepaint from cosmic history, astronomers have performed computer simulations of how dark matter would evolve from a nearly uniform cloud into the filaments and clumps characteristic of the arrangement of galaxies today in the luminous universe. A multinational group led by Mark Vogelsberger of the Massachusetts Institute of Technology has recently performed one of the most detailed of these studies yet, a calculation called Illustris.

Their model sought to take into account not just the gravity of dark matter particles pulling atoms and one another around, but the electromagnetic and nuclear interactions between atoms — so-called gastrophysics — like the formation and explosion of stars.

The result, they said, is the closest match yet between dark matter models and the distribution and types of galaxies in the visible universe.

Meanwhile, astronomers at the California Institute of Technology have begun to be able to illuminate and map the weblike structure of the dark matter in space using an instrument they call the Cosmic Web Imager on the 200-inch telescope at Palomar Observatory. The imager in effect uses bright galaxies and quasars as a kind of flashlight to light up the sparse atoms strewn along with the dark matter in space, confirming the tendril structure predicted by the computer simulations.

More evidence of the power of the dark side.

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