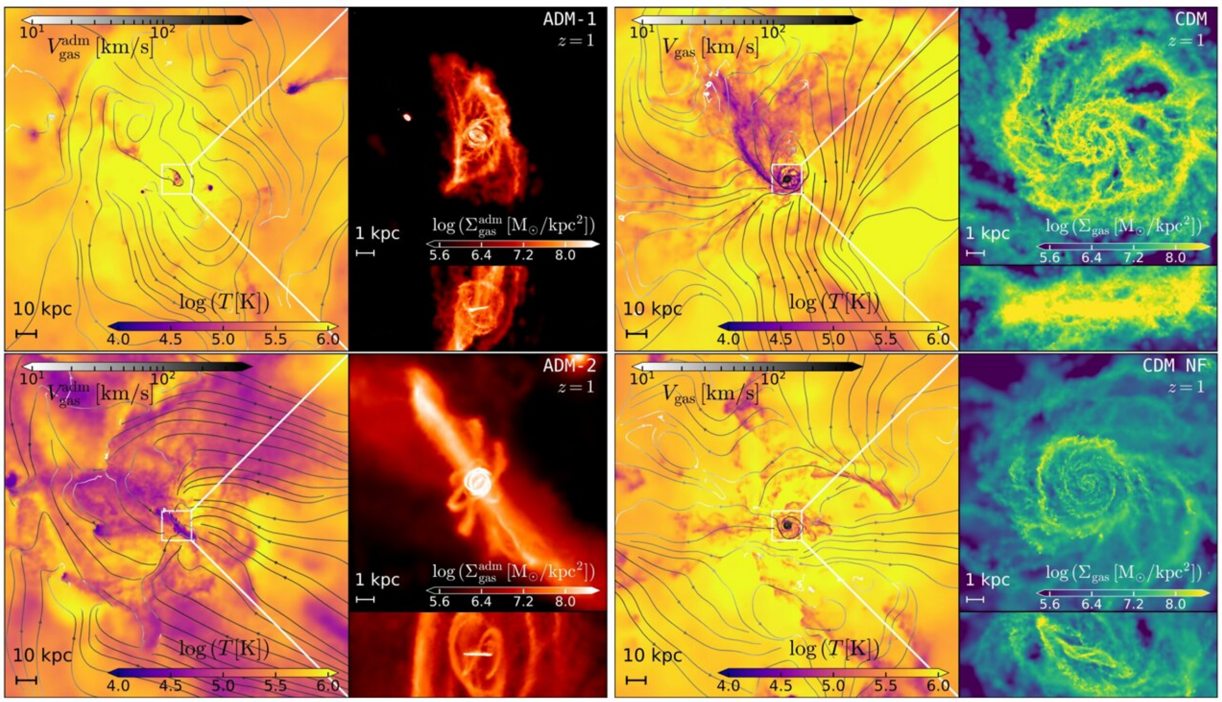
# Dark matter can make dark atoms, say theoretical astrophysicists

May 12 2023, by Paul M. Sutter




Four panels displaying the temperature and surface density distributions of ADM gas in ADM-1 and ADM-2 (left panels) and of baryonic gas in CDM and CDM-NF (right panels). Left of each panel: Gas temperature distribution on the CGM scale at z ~ 1 (350 comoving kpc field-of-view). It is overlaid with the velocity field of the gas, where darker streamlines indicate higher velocities. Cooling physics and gravity determine the thermal properties of gas at this scale. Due to an order-of-magnitude stronger cooling efficiency, the ADM gas in ADM-2 is distinct from the other three cases, exhibiting stronger cooling flows at z ~ 1 and delayed inner CGM virialization. Right of each panel: Surface density of cold, neutral gas in the central halo (30 comoving kpc field-of-view). Both face-on and edge-on views are shown. The neutral gas distributions are sensitive to gas accretion from the CGM, feedback from star formation (relevant for baryonic gas in the CDM, ADM-1 and ADM-2 simulations), as well as the thermal instability of the gas. For baryons in CDM, an extended, co-rotating gaseous disk already forms at z ~ 1. For ADM-1 and ADM-2, we find compact ADM gas disks surrounded by streams of cold gas accreted from the CGM with poor alignment to the angular momentum of the central disk. The baryons in CDM-NF exhibit a more extended gas disk than the ADM cases at this redshift, likely due to enhanced accretion via the helium peak in Fig. 1. Credit: *arXiv* (2023). DOI: 10.48550/arxiv.2304.09878

A team of theoretical astrophysicists have studied in detail a hypothetical form of dark matter that combines to form dark atoms. They found that the existence of dark atoms can drastically affect the evolution of galaxies.

We don't understand the vast majority of matter in the universe. We call it dark matter, but that's about the best we've got. To the best of our knowledge dark matter is composed of some new kind of particle currently unknown to modern physics. Whatever the particle is, it does not interact with light and it does not interact with normal matter except through the gravitational force.

Given our lack of understanding of this mysterious substance, we have a lot of room to play with in our theoretical models. Some of these models suggest that dark matter isn't made of a single species of particle that floods the universe. Instead it can be composed of different many different kinds of particles. There can also be new forces of nature, beyond the four that we are familiar with, that operate only among the dark matter particles.

In this picture the various components of dark matter can collect together to form dark atoms, and even molecules and more complex structures. Most importantly, in these models the dark matter can clump together very tightly. A team of researchers used this fact to explore the observational consequences of these models of dark atoms using simulations of the evolution of galaxies.

They found that atomic dark matter can very rapidly clump up, forting forming a "shadow disk" to go along with the disk of stars in the typical galaxy. From there the dark atoms continue to clump, forming the equivalent of dark stars and dark black holes. It can even quickly sink into the core of the galaxy, rapidly increasing the density there.

All of these effects of atomic dark matter would be invisible at cosmological scales. But they would drastically affect the evolution of stars within the galaxy. Stars form from the collapse of material, and any gravitational influence can affect the trajectory of star formation.

The researchers found differences in star formation rates and the population and distribution of stars in a galaxy that includes dark atoms versus a galaxy that only includes a single dark matter component. The researchers hope that these results will be useful to further pinning down this mysterious substance that dominates our universe.

The research is published on the *arXiv* preprint server.

**More information:** Sandip Roy et al, Simulating Atomic Dark Matter in Milky Way Analogues, *arXiv* (2023). DOI: 10.48550/arxiv.2304.09878

Provided by Universe Today