A video map of motions in the nearby universe

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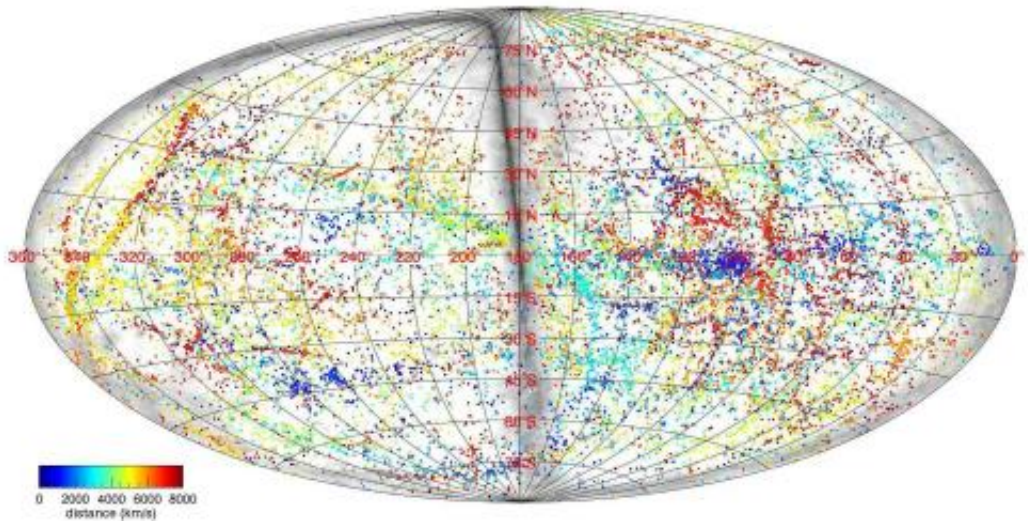


Map showing all galaxies in the local universe color-coded by their distance to us: blue galaxies are the closest, and red are farther, up to 300 million light-years away.

(Phys.org) —An international team of researchers, including University of Hawaii at Manoa astronomer Brent Tully, has mapped the motions of structures of the nearby universe in greater detail than ever before. The maps are presented as a video, which provides a dynamic three-dimensional representation of the universe through the use of rotation, panning, and zooming. The video was announced last week at the conference "Cosmic Flows: Observations and Simulations" in Marseille, France, that honored the career and 70th birthday of Tully.

The Cosmic Flows project has mapped visible and dark matter densities around our Milky Way galaxy up to a distance of 300 million light-years.

The team includes Helene Courtois, associate professor at the University of Lyon, France, and associate researcher at the Institute for Astronomy (IfA), University of Hawaii (UH) at Manoa, USA; Daniel Pomarede, Institute of Research on Fundamental Laws of the Universe, CEA/Saclay, France; Brent Tully, IfA, UH Manoa; and Yehuda Hoffman, Racah Institute of Physics, University of Jerusalem, Israel.

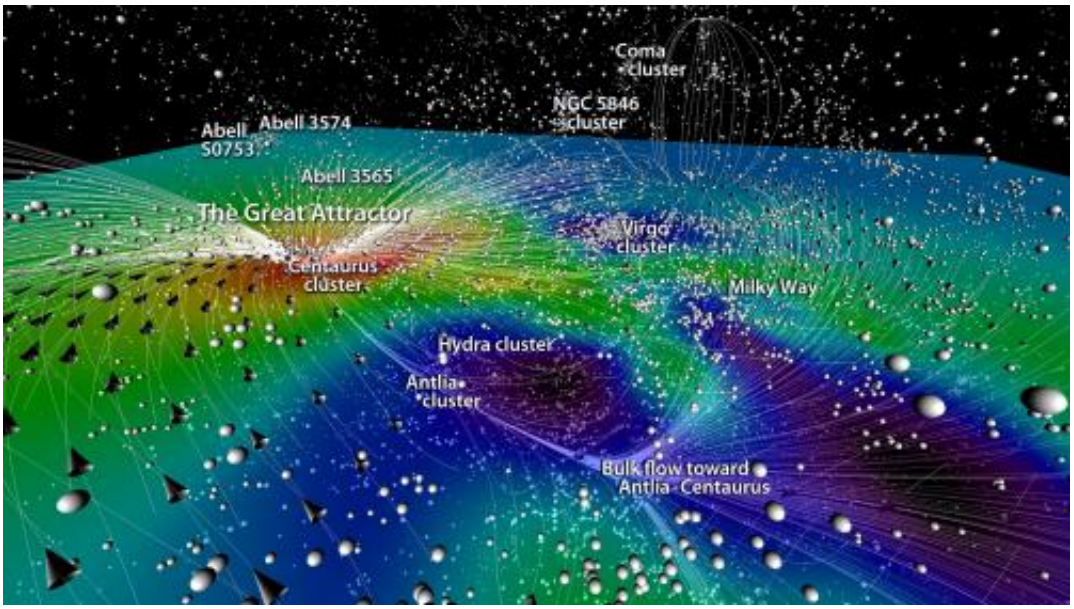
The large-scale structure of the universe is a complex web of clusters, filaments, and voids. Large voids—relatively empty spaces—are bounded by filaments that form superclusters of galaxies, the largest structures in the universe. Our Milky Way galaxy lies in a supercluster of 100,000 galaxies.

Just as the movement of tectonic plates reveals the properties of Earth's interior, the movements of the galaxies reveal information about the main constituents of the Universe: dark energy and dark matter. Dark matter is unseen matter whose presence can be deduced only by its effect on the motions of galaxies and stars because it does not give off or reflect light. Dark energy is the mysterious force that is causing the expansion of the universe to accelerate.

The video captures with precision not only the distribution of visible matter concentrated in galaxies, but also the invisible components, the voids and the dark matter. Dark matter constitutes 80 percent of the total matter of our universe and is the main cause of the motions of galaxies with respect to each other. This precision 3-D cartography of all matter (luminous and dark) is a substantial advance.

The correspondence between wells of dark matter and the positions of

galaxies (luminous matter) is clearly established, providing a confirmation of the standard cosmological model. Through zooms and displacements of the viewing position, this video follows structures in three dimensions and helps the viewer grasp relations between features on different scales, while retaining a sense of orientation.



This map shows the currents of galaxies in the universe. The galaxies (white spheres) are like dead branches in a sea. Currents carry them from an island (galaxy cluster) to the closest larger island of galaxies, the Great Attractor region. Red and yellow colors show the islands, and dark blue shows the voids that galaxies avoid by following the currents.

The scientific community now has a better representation of the moving distribution of galaxies around us and a valuable tool for future research.

The scientific article, "Cosmography of the Local Universe," which explains the research behind the video, will be published in a forthcoming issue of The *Astronomical Journal*. It is now available at

arxiv.org/abs/1306.0091 .