UNIVERSITÉ DE GENÈVE

PRESS RELEASE

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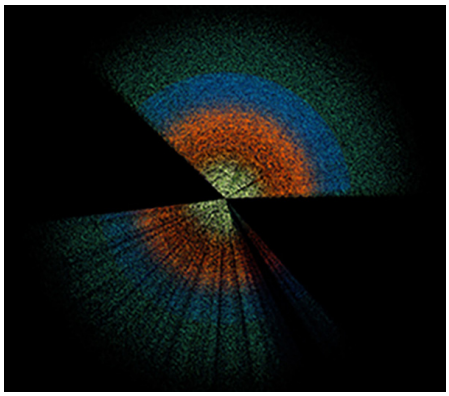
Dark matter does not defy gravity

A team led by UNIGE shows that the most mysterious component of our Universe obeys the laws of classical physics. But doubts remain.

Does dark matter follow the same laws as ordinary matter? The mystery of this invisible and hypothetical component of our Universe — which neither emits nor reflects light — remains unsolved. A team involving members from the University of Geneva (UNIGE) set out to determine whether, on a cosmological scale, this matter behaves like ordinary matter or whether other forces come into play. Their findings, published in *Nature Communications*, suggest a similar behaviour, while leaving open the possibility of an as-yet-unknown interaction. This breakthrough sheds a little more light on the properties of this elusive matter, which is five times more abundant than ordinary matter.

Ordinary matter obeys four well-known forces: gravity, electromagnetism, and the strong and weak forces at the atomic level. But what about dark matter? Invisible and elusive, it could be subject to the same laws or governed by a fifth, as yet unknown force.

To unravel this mystery, a team led by UNIGE set out to determine whether, on a cosmic scale, dark matter falls into gravitational wells in the same way as ordinary matter. Under the influence of massive celestial bodies, the space occupied by our Universe is distorted, creating wells. Ordinary matter — planets, stars and galaxies — falls into these wells according to well-established physical laws, including Einstein's theory of general relativity and Euler's equations. But what about dark matter?



Map of the distribution of galaxies observed by the DESI collaboration, from which it is possible to accurately measure the velocities of galaxies.

High resolution pictures

"To answer this question, we compared the velocities of galaxies across the Universe with the depth of gravitational wells," explains Camille Bonvin, associate professor in the Department of Theoretical Physics at UNIGE's Faculty of Science and co-author of the study. "If dark matter is not subject to a fifth force, then galaxies — which are mostly made of dark matter — will fall into these wells like ordinary matter, governed only by gravity. On the other hand, if a fifth force acts on dark matter, it will influence the motion of galaxies, which would then fall into the wells differently. By comparing the depth of the wells with the galaxies' velocities, we can therefore test for the presence of such a force."

Euler's equations still valid

Applying this approach to current cosmological data, the research team concluded that dark matter falls into gravitational wells in the same way as ordinary matter, thus obeying Euler's equations. "At this stage, however, these conclusions do not yet rule out the presence of an unknown force. But if such a fifth force exists, it cannot exceed 7% of the strength of gravity — otherwise it would already have

appeared in our analyses," says Nastassia Grimm, first author of the study and former postdoctoral researcher at the Department of Theoretical Physics at UNIGE's Faculty of Science who has recently joined the Institute of Cosmology and Gravitation at the University of Portsmouth.

These initial results mark a major step forward in characterising dark matter. The next challenge will be to determine whether a fifth force governs it. "Upcoming data from the newest experiments, such as LSST and DESI, will be sensitive to forces as weak as 2% of gravity. They should therefore allow us to learn even more about the behaviour of dark matter," concludes Isaac Tutusaus, researcher at ICE-CSIC and IEEC and associate professor at IRAP, Midi-Pyrénées Observatory, University of Toulouse, co-author of the study.

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