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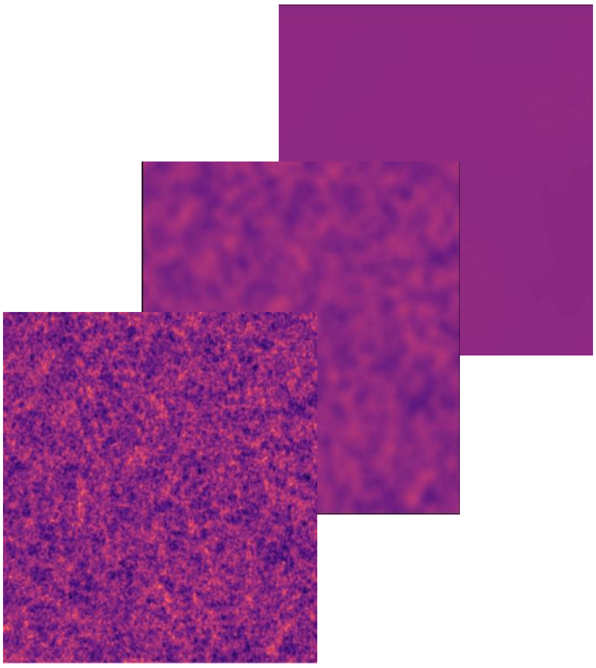
**PRESS RELEASE**

# Little Ado About Everything: SISSA study explains the Universe without invoking dark energy

**A new model shows how a small "noise" originating from the formation of the cosmic web could explain the accelerated expansion of the Universe.**



Trieste, 20 December 2023

According to the most accredited cosmological model, the Universe is composed of two-thirds dark energy, a mysterious form of energy that, in opposition to gravity, generates a repulsive force and is accelerating the expansion of the Universe. A recent study by the Astrophysics and Cosmology group at SISSA, published in *The Astrophysical Journal* and led by Professor Andrea Lapi, challenges this conventional view: a new approach, which introduces “noise” during the evolution of the Universe, allows for an explanation of its acceleration without modifying general relativity or invoking dark energy.

One of the greatest mysteries of modern cosmology concerns the expansion of the Universe. Einstein, during the formulation of the theory of general relativity, introduced the “cosmological constant” to keep the Universe static. Later, after observations demonstrated the Universe's expansion, he called it his “biggest blunder.” However, at the end of the 20th century, new cosmological observations revealed that the Universe is not only expanding, but this expansion is accelerating: the cosmological constant was then reintroduced, still denoted by the Greek letter Λ (Lambda), and reinterpreted as an effect of dark energy.

The standard model of modern cosmology is therefore called ΛCDM (Lambda Cold Dark Matter), and it explains the nature of the cosmos on a large scale at the cost of introducing two “dark” components: dark energy and dark matter. The ΛCDM model has proven extremely effective in explaining numerous observational data, but the cosmological constant, in particular, remains an unconvincing solution, since the value attributed to it by observations is radically different from that predicted by particle physics.

The new research led by Professor Andrea Lapi starts from an intriguing coincidence: the acceleration of the Universe begins almost in synch with the formation of the cosmic web, the large-scale structure of the Universe, composed of filaments of matter surrounding vast empty spaces. The cosmic web forms due to gravity, which draws matter towards denser areas, leaving other zones empty, creating a heterogeneous and anisotropic Universe. According to the model proposed in the new publication, called ηCDM, it is precisely these heterogeneities and anisotropies that dynamically influence the expansion of the Universe. The key to the model lies in the “noise,” denoted by the letter η: in this innovative approach, each region of the Universe evolves with its complex gravitational dynamics, which is mathematically described through appropriate noise. The effect on the overall behaviour of the Universe is obtained by averaging together that of all the different regions. With this slight noise added, the model manages to explain the accelerated expansion of the Universe thanks to the progressive dominance of voids over the denser regions of the cosmic web.

As Professor Lapi himself explains, “Although the general idea that structure formation can have some backreaction effects on the global cosmic dynamics had been previously considered in the literature from time to time, the novelty of our work is in the approach based on stochastic dynamics. In fact, the noise term we have introduced can also describe non-perturbative effects due to the inhomogeneous and anisotropic conditions associated to the emergence of the cosmic web.”

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The new ηCDM model also resolves two additional mysteries that so far have been unexplained by the standard model. The Hubble tension, the discrepancy between estimates of the Universe's expansion rate when measured on a local scale compared to that obtained in the primordial Universe through measurements of the Cosmic Microwave Background (CMB), disappears.

The problem of the so-called “cosmic coincidence” is also solved, that is, the surprising observation that, in this era of the Universe, the densities of dark energy and matter are similar. This seems a weird coincidence because the standard model predicts that, over the course of cosmic history, the density of matter decreases radically with the expansion of the Universe, while the density of dark energy remains about constant. That our observations fall precisely in this brief period compared to the very long history of the Universe seems statistically unlikely. The ηCDM model resolves the coincidence, as it predicts that the Universe will have cosmological values similar to the current ones for a very long time, perhaps forever, dissolving this anomaly.

“We hope - concludes Lapi - that the ηCDM model, extended in a context of complete general relativity, can finally provide a theoretically solid explanation of cosmic acceleration, without invoking exotic forms of energy or resorting to substantial revisions of Einstein's theory of gravity (which so far has remained unsurpassed by observations).”

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**IMAGE CREDITS**
Andrea Lapi

**Paper:**
https://tinyurl.com/4vk3bvbd

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