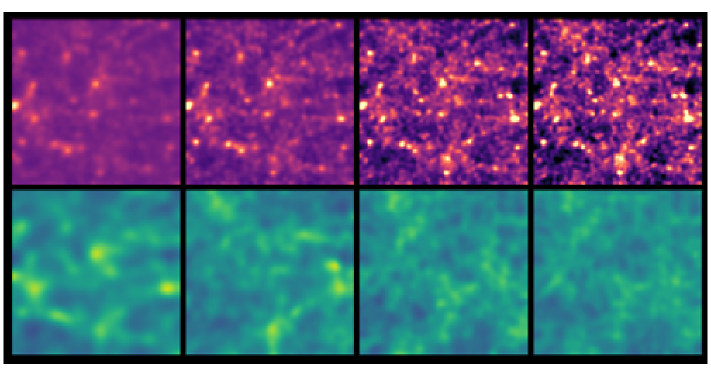
Machine Learning Pins Down Cosmological Parameters

Cosmological constraints can be improved by applying machine learning to a combination of data from two leading probes of the large-scale structure of the Universe.

By **Ryan Wilkinson**

The history of the Universe is governed by a handful of cosmological parameters, such as the present-day matter density and amplitude of density fluctuations (Ω_m and σ_8, respectively). Astronomers have measured these parameters by observing the large-scale structure of the Universe, but the measurement precision has been limited by several parameter degeneracies. For example, an increase in Ω_m can counteract a decrease in σ_8 and vice versa. Now Tomasz Kacprzak and Janis Fluri at the Swiss Federal Institute of Technology (ETH), Zurich, have found a way to break such degeneracies, strengthening the constraints on these parameters [1].

The Universe's large-scale structure is typically probed by studying galaxy clustering or via a statistical gravitational-lensing signature called weak gravitational lensing (see **Viewpoint: Weak Lensing Becomes a High-Precision Survey Science**). Each of these techniques has associated parameter degeneracies: for galaxy clustering, Ω_m and σ_8 can take on any number of values depending on the assumed galaxy bias, which quantifies how well visible matter traces invisible dark matter; for weak lensing, Ω_m and σ_8 are similarly degenerate with the intrinsic alignment amplitude, which measures the extent to which galaxies are aligned with one another.



Credit: T. Kacprzak and J. Fluri [1]

Kacprzak and Fluri found that these degeneracies could be lifted by using deep learning—a type of machine learning inspired by the human brain—to perform a collective analysis of galaxy-clustering and weak-lensing data. The researchers show that, for future large-scale-structure surveys, this approach could tighten constraints on the galaxy bias and on the intrinsic alignment amplitude by factors of about 1.5 and 8, respectively. In turn, the method could substantially strengthen constraints on both Ω_m and σ_8. However, the team says that an improved data analysis and understanding of survey systematic effects is needed before the technique can be used in practice.

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REFERENCES

1. T. Kacprzak and J. Fluri, "DeepLSS: Breaking parameter degeneracies in large-scale structure with deep-learning analysis of combined probes," **Phys. Rev. X 12, 031029 (2022).**