cosmic void

*Robert Temple: “Voids are of immense importance, though rarely recognized. There can be no internal architecture if structures are not separated from each other by voids. The structures must be separated from the rest of the mass by a space, otherwise it is no longer a distinct structure.”*

The cosmic web (the meta pattern of galaxies) ~ among the latticeworks, between the walls and knots and filaments, are the great voids. Stretching anywhere from 20 million to hundreds of millions of light-years across, these are the true deserts of the cosmos, almost entirely devoid of matter. Galaxies are gravitationally bound together, creating huge cosmic structures known as galaxy filaments.  
  
Growing the cosmic web ~ density fluctuations increase over time ~ denser spots had slightly more gravitational attraction than less dense spots ~ matter becomes concentrated in the cosmic web structures, leaving matter-less spaces = voids (high-density spaces, low-density spaces) ~ creation of voids is part of the evolution of the cosmic web.

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Alice Pisani, Ph.D. Princeton University “Cosmology with Cosmic Voids”  
[*entire thesis here*](https://theses.hal.science/tel-01086451v1/file/pdf2star-1416564169-these_archivage_3159029.pdf)

“preserved pockets of the universe” ~   
“knowing more about dark energy will tell us more about the destiny of the universe”

p r e c i s i o n c o s m o l o g y   
standard model to explain the accelerated expansion of the universe

universe ~ 5% ordinary matter, 27% dark matter, 68% dark energy  
(95% of the universe is unexplained ~ open door for new physics!)

c o s m i c w e b  
meta pattern of galaxies

v o i d s  
~ dark energy dominated

~ low density + large scale = mimic current accelerates expansion status

~ sensitive to diffuse components

~ sweet spots to test gravity

~ multi-scale sensitivity

~ \*keep memory of initial conditions

~ high signal-to-noise for dark matter

galaxies > voronoid tessellation > watershed transform > voids  
(VIDE model on how to find voids)

In a homogenous and isotropic universe, void stacks are spherically symmetric in real space.

*“The study of the universe’s empty spaces could offer important clues to help solve the mysteries of dark matter, dark energy and the nature of the enigmatic subatomic particles called neutrinos.”*  
  
*“Voids were important not because of what they contained but because their very existence, their shapes and sizes and distances from one another, had to be the result of the same forces that gave structure to the universe.”*

*“Voids could cast light on the nature of dark matter. Although voids have much less dark matter in them than the clusters and filaments of the cosmic web do, there’s still some. And unlike the chaotic web, with its swirling hot gases and colliding galaxies, the voids are calm enough that the particles astrophysicists think make up dark matter might be detectable.”*

*“Looking into the areas where there’s nothing might yield information about some of the outstanding mysteries of the universe.”* W A N D E L T

[Scientific American, Volume 330, Issue 1](https://static.scientificamerican.com/dam/m/31ecd9ff5559dee2/original/SciAm_01_2024-1.pdf)