

Do Filament-type and Spider-type Superclusters Inhabit Different Large-Scale Density Environments?

Superclusters are the largest coherent structures in the Universe, embedded within the cosmic web of filaments and voids. Their internal morphology if whether elongated and filament-like or compact and spider-like, has been quantified using Minkowski functionals and shapefinders in previous SDSS-based studies. However, whether this morphology is connected to the surrounding large-scale density environment remains an open question.

This work investigates whether filament-type and spider-type superclusters preferentially inhabit different large-scale environments. Using the Einasto et al. (2011) SDSS DR7 supercluster morphology catalogue, 36 rich superclusters were classified into a filament family (F + mF; 12 systems) and a spider family (S + mS; 22 systems). Environmental richness was quantified by counting rich galaxy groups ($N_{\text{gal}} \geq 30$) from the Tago et al. (2010) SDSS DR7 group catalogue within spherical radii of 50, 100, and 150 Mpc/h of each supercluster's density peak. A k-d tree spatial index was used for efficient neighbour searches.

Spider-family superclusters show systematically higher median rich-group counts at all three scales: 15.5 versus 8.0 at 50 Mpc/h, 79 versus 37 at 100 Mpc/h, and 194 versus 97 at 150 Mpc/h. A consistent factor of approximately two. Mann–Whitney U tests indicate no significant difference at 50 Mpc/h ($p = 0.104$), but statistically significant differences at 100 Mpc/h ($p = 0.014$) and 150 Mpc/h ($p = 0.018$).

These results suggest that spider-type superclusters preferentially occupy richer large-scale environments than filament-type superclusters, with the morphology and environment connection becoming statistically significant at scales of 100–150 Mpc/h. This scale dependence implies that the association operates at the level of supercluster chains rather than local neighbourhoods, providing a new observational link between internal supercluster morphology and the cosmic web environment.