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# The Cosmological Principle Breaks Down as Superstructures Grow in the Universe

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Humanity's cosmic physics relies on the assumption that, "the Universe looks the same for all observers, regardless of location." This assumption is called the Cosmological Principle, which is defined by the properties of homogeneity and isotropy. Homogeneity states that, the Universe looks the same at each point, while isotropy states that the Universe looks the same in all directions. While it is known that the cosmological principle breaks down at smaller cosmic scales (e.g., clusters of galaxies and solar systems), most research suggests that it holds at larger scales where clusters of galaxies are simply dots on the cosmic landscape. However, we now know that galaxies are not randomly distributed throughout the Universe. Greater than 90% of galaxies are located in dense areas of dark matter, where dark matter has condensed to form a cosmic web across the Universe. This cosmic, dark matter web is not static, but is continuing to condense, with "branches" in the web merging to become thicker "superstructures" over time. These findings suggest that the Cosmological Principle will eventually break down at all scales. The questions, then, are (1) at what scale does the Cosmological Principle fail now and (2) when will the largest scales of the Universe look like this current, "failed" scale? Using a database from The Max Planck Institute for Astrophysics, the distribution of dark matter hot spots was tested for significant deviations from random at different scales. Then, the database was used to estimate the growth rate of dark matter superstructures. These data were then combined to find that the Cosmological Principle will fail, at all scales, in another 54.7 billion years (a 68.4 billion-year-old Universe). Given that life could exist in the Universe for another 120 trillion years, the Cosmological Principle appears to be a fleeting characteristic of the infant Universe.

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