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ASTRONOMY

Growth of big galaxies defies chief theory of cosmic order

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Astronomers believe that the largest structures in the universe assembled gradually over its 13-billion-year history.

Stars formed first. Over time, gravity collected the stars into galaxies, the galaxies clustered into groups, and groups gathered into giant clusters of galaxies millions of light years across.

The gravitational glue that binds clusters of galaxies together is dark matter. Ordinary matter — atoms, stars, planets — were dragged along with dark matter as it assembled itself into progressively larger structures over time.

Known as the "cold dark matter" model, this framework does a remarkably good job describing the emergence of order out of the chaos that followed the big bang.

It accurately describes how collections of galaxies are strung together through space and time.

The model fares poorly, however, at predicting the properties of galaxies such as the Milky Way. It predicts that the smallest galaxies formed quickly and have changed little over time.

The largest galaxies should have grown gradually by merging with neighboring galaxies and through a persistent rain of gas that fuels the formation of new stars.

Recent studies have shown that instead of forming slowly, the largest galaxies assembled most of their mass surprisingly fast, within a few billion years of the big bang.

Although these galaxies have continued to grow during the past 10 billion years, their growth was slower than expected and they matured into smaller galaxies than the model predicts.

A decisive clue to what might have stunted their growth came from other studies that show that the period of rapid galaxy growth stopped 10 billion years ago when quasars began to shine.

Quasars are powered by matter that falls into black holes millions of times the mass of the sun.

The vast power of quasars drove the gas out of galaxies and prevented new stars from forming.

This insight has changed our view of galaxy formation. Once thought to be governed entirely by the weak tug of gravity and the theory of cooling gases, galaxy formation instead appears to be regulated by outflows powered by supermassive black holes.

Galaxy formation has turned out to be more complex than we might have hoped. It will take time to develop a complete theory of galaxy formation.

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