

WHY SPACE BODIES COME IN DIFFERENT SIZES

Objects in space aren't the same size, but why not? A scientist used a theory he formulated earlier – to explain patterns in nature on Earth and space – to suggest a reason.

A professor of mechanical engineering at Duke has applied a theory he formulated in 1996 – called Constructal Law, related to the way that patterns in nature are generated – to the hierarchical array of sizes of space objects. In other words, why do objects in space come in different sizes, from mighty stars with over 1,000 times the diameter of our sun, to little chunks of rocks like those that sometimes enter Earth's atmosphere and makes bright streaks across our sky? Why isn't everything the same size?

Adrian Bejan at Duke University used his earlier theory to determine a possible reason. He says it's because:

... a universe that contains some big objects and many small objects relieves gravitational tension faster than a uniform universe.

He and his team reported their findings in the *Journal of Applied Physics*.

So ... what does it mean? Bejan's specialty is in thermodynamics, which describes how different forms of energy affect each other and the matter around them. His Constructal Law, which he's worked on for years and which isn't accepted by all scientists but which has a certain logic and beauty about it, is all about flow. It states that natural systems evolve to facilitate flow. So, for example:

Raindrops coalesce and move together, generating rivulets, streams and the mighty river basins of the world because this design allows them to move more easily.

That's raindrops and water. How about solid bodies in space and their array of different sizes? Bejan and his student, **Russell Wagstaff**, started by calculating the tension caused by gravitational attraction between bodies of the same size, uniformly distributed in space. They showed that if the bodies coalesce into some large bodies and some small bodies, the tension is reduced faster than if the bodies merged uniformly.

Bejan says this break-up of the uniform suspension of bodies into a few large and many small bodies occurs because it's the fastest way to ease the internal tension caused by gravity. In other words, it happens because – in our particular universe, with our particular nature working as it does – it's the easiest thing that can happen. Bejan commented:

Researchers have explained why objects in the universe come in a wide variety of sizes, from the largest stars to the smallest asteroids -- and it has a lot to do with how paint cracks when it dries. When a volume is under internal tension -- as the early universe was due to gravity -- the most efficient way to relieve that tension is by 'cracking' hierarchically -- few large and many small

I never thought I would have anything to say about celestial bodies in pure physics, but by chance I realized I have a key to open a new door.

Though unknowably large and spread out, the very early universe can be thought of as a finite volume of suspended particles. And because every object in the universe exerts a gravitational force on every other object in the universe, this volume was in internal tension. It was only a matter of time before particles began coming together to form larger objects. But why did they come together to form objects in such a wide variety of sizes, rather than in a uniform manner?

In a series of thought experiments and simple physics equations, Bejan's paper shows that the fastest way for the tension to be released was through the formation of bodies in a hierarchy. That is, he demonstrates that if all bodies formed were of the same size, the tension would not be released as effectively as when a few large bodies were formed along with many smaller bodies.

According to Bejan, this pattern of relief follows the constructal law, which he penned in 1996. The constructal law states that any flowing system allowed to change freely over time will trend toward an easier flowing architecture. For rivers, roots and vascular systems, this means a few large channels carry massive flows to numerous smaller branches for evacuation. For a young universe with particles pulling every which way, this means its internal tension released in the fastest way possible.

