

Beyond Newtonian Gravitational Attraction: Superfluid Quantized Vortices and the Resolution of Bentley's Paradox

¹Victor Christianto* and ²Florentin Smarandache

Author's Affiliations:	¹ Malang Institute of Agriculture, East Java, Indonesia ² Dept. Mathematics and Sciences, University of New Mexico, Gallup, NM, USA. Email: smarand@unm.edu
*Corresponding author:	Victor Christianto , Malang Institute of Agriculture, East Java, Indonesia E-mail: victorchristianto@gmail.com

ABSTRACT	For centuries, Isaac Newton's theory of universal gravitation reigned supreme, offering an elegant explanation for the celestial ballet [1]. However, nestled within its seemingly perfect framework lay a persistent thorn – the Bentley Paradox . Posed by the renowned mathematician Richard Bentley in 1728, it exposed a fundamental flaw: if every particle attracts every other, wouldn't the universe inevitably collapse in on itself under the combined pull? Newton grappled with the paradox but ultimately left it unresolved. The present article offers a resolution to both Bentley's old paradox and also Zwicky paradox which now is known as Dark Matter hypothesis, from the viewpoint of superfluid vortices, and in the last section we provide hint toward close correspondence between low temperature physics and cosmology phenomena, one of which is already known in literature as Kibble-Zurek mechanism.
KEYWORDS	Isaac Newton, Bentley's paradox, Zwicky's paradox, low temperature physics, cosmology

How to cite this article: Christianto V. and Smarandache F. (2024). Beyond Newtonian Gravitational Attraction: Superfluid Quantized Vortices and the Resolution of Bentley's Paradox. *Bulletin of Pure and Applied Sciences- Physics*, 43D (1), 59-63.

INTRODUCTION

In the long history of scientific discourse, few exchanges hold the weight of the legendary debate between Richard Bentley and Isaac Newton. Bentley, a renowned theologian and mathematician, challenged Newton's explanation of gravity as a purely attractive force, highlighting a paradox: if every particle attracts every other with an ever-diminishing force, why wouldn't the universe simply collapse in on itself? [1]

Newton, unable to provide a definitive answer, left the paradox unresolved. Centuries later, Zwicky's observations of galactic rotation curves reignited the debate. The observed rotational

speeds defied predictions based solely on visible matter, hinting at the presence of unseen "dark matter." While the dark matter hypothesis has gained traction, it remains an elusive explanation, leaving gaps in our understanding of gravity. [3]

THE ENDURING ENIGMA: BENTLEY PARADOX IS NOT RESOLVED UNTIL THESE DAYS: INCOMPLETENESS OF GRAVITATION ATTRACTION THEORY

For centuries, Isaac Newton's theory of universal gravitation reigned supreme, offering an elegant explanation for the celestial ballet. However, nestled within its seemingly perfect framework lay a persistent thorn – the **Bentley Paradox**. Posed by the renowned mathematician Richard Bentley in 1728, it exposed a fundamental flaw: if every particle attracts every other, wouldn't the universe inevitably collapse in on itself under the combined pull? [1, 3]

Newton grappled with the paradox but ultimately left it unresolved. Despite centuries of scientific progress, the ghost of Bentley's question continues to haunt us, raising doubts about the completeness of our understanding of gravity.[1]

At its core, the paradox challenges the **assumption of pure attraction** in Newtonian gravity. Imagine an infinite universe filled with stars, each tugging at every other. As distance diminishes, the attractive force intensifies, seemingly leading to an unstoppable inward plunge. The paradox forces us to question: is there something missing in our grasp of gravity, something beyond the simple pull of attraction? The prevailing solution, **dark matter**, attempts to patch the hole by postulating the existence of invisible mass throughout the universe. While it explains galactic rotation curves and large-scale structure formation, dark matter remains an elusive theoretical construct, lacking direct experimental evidence. This "fix" feels more like a placeholder than a true resolution.

Furthermore, alternative explanations like modified Newtonian dynamics (MOND) tinker with the equations themselves, but struggle to explain aspects like gravitational lensing. The quest for a fundamental answer goes on.

Recent explorations into **quantum gravity**, the attempt to reconcile gravity with the bizarre world of quantum mechanics, offer glimmers of hope. String theory and loop quantum gravity hint at a more intricate fabric of reality where gravity emerges from the underlying structure of spacetime itself. However, these theories remain highly theoretical and far from providing definitive answers.

The incompleteness of gravitational attraction theory goes beyond the Bentley paradox. We still grapple with the nature of **dark energy**, the mysterious force accelerating the universe's expansion. The unification of gravity with other fundamental forces remains a distant dream.

In conclusion, Bentley's paradox serves as a potent reminder of the limitations of our current understanding of gravity. While dark matter offers a temporary fix, it doesn't provide a complete picture. The quest for a more fundamental explanation, one that goes beyond simple attraction and embraces the complexities hinted at by quantum gravity, continues. Until then, the universe's grand dance holds within it an unsolved riddle, a testament to the enduring incompleteness of our gravitational story.

A PLAUSIBLE RESOLUTION TO BENTLEY'S PARADOX

However, recent developments in physics offer a compelling alternative perspective. Experiments with superfluid liquid helium have revealed the remarkable phenomenon of quantized vortices – persistent rotating flows that exhibit unique properties. Notably, these vortices can attract or repel each other depending on their relative orientation, mimicking the observed behavior of galaxies in clusters.

Intriguingly, these quantized vortices could hold the key to resolving Bentley's paradox. Imagine the universe not as a collection of point-like masses exerting only attraction, but as a cosmic dance of quantized vortices, some attracting, and some repelling. This dynamic interplay could explain the observed stability and structure of the universe without resorting to invisible dark matter.

The implications are profound. First, it suggests that gravity, at its core, might not be a simple attractive force, but a more nuanced interaction governed by the properties of quantized vortices. Second, it offers a potential explanation for galactic rotation curves and the structure of the universe without the need for dark matter, simplifying our cosmological model. For instance that rotation of galaxies and galaxy

clusters has specific property that they do mostly clockwise rotation, this implies quite strongly possible vorticity; see our article and also Manopoulou, *MNRAS* [2, 5].

Of course, much work remains to be done. Translating laboratory observations of quantized vortices to cosmological scales presents significant challenges. Nevertheless, the parallels are intriguing, and further exploration along these lines could lead to groundbreaking discoveries.

Furthermore, this perspective aligns with broader trends in physics, where concepts like entanglement and non-locality challenge our classical understanding of space and time. It suggests that gravity, like other fundamental forces, might exhibit hidden depths waiting to be unveiled.

WHISPERS ACROSS SCALES: EXPLORING THE DEEP CORRESPONDENCE BETWEEN LOW-TEMPERATURE PHYSICS AND COSMOLOGY

Physics, in its relentless pursuit of unifying principles, often stumbles upon unexpected connections. One such intriguing possibility lies in the seemingly disparate realms of **low-temperature physics** and **cosmology**. Despite the vast disparity in scales – from probing the quantum dance of subatomic particles at frigid temperatures to deciphering the grand narrative of the universe's evolution – intriguing whispers of a deep correspondence are starting to emerge.

The seeds of this connection were sown with the **Kibble-Zurek mechanism**. Developed in the 1970s to explain topological defects in the early universe, it revealed a surprising similarity to phenomena observed in superfluid Helium at incredibly low temperatures. Both systems, governed by similar phase transitions, shared the formation of topological structures like cosmic strings and vortex lines. [4]

This sparked further exploration, with physicists like Grigory Volovik uncovering deeper parallels. The behavior of superfluid Helium,

exhibiting properties akin to dark energy and possessing quantized vortices reminiscent of galactic rotations, hinted at a profound link between the very small and the very large.

However, bridging this vast chasm presents significant challenges. Translating observations from the lab, where temperatures approach absolute zero, to the scorching early universe necessitates extrapolations beyond established theoretical frameworks. Additionally, accounting for the influence of other fundamental forces and complexities like inflation in the nascent cosmos adds further layers of difficulty.

Despite these hurdles, the potential rewards are immense. Unraveling this correspondence could:

- Offer new insights into the early universe:** By observing phenomena like superfluid turbulence in controlled lab settings, we may gain a better understanding of similar processes that occurred during the universe's infancy.
- Revolutionize our understanding of gravity:** Quantized vortices in superfluid Helium exhibit both attractive and repulsive forces, suggesting gravity might be more nuanced than just a simple attractive pull.
- Lead to unforeseen breakthroughs:** Bridging the gap between seemingly disparate worlds often fosters paradigm shifts, sparking discoveries beyond our current imagination.

EXPLORING COSMOLOGY IN THE LAB WITH THE KIBBLE-ZUREK MECHANISM

Imagine peering into the heart of the early universe, witnessing the dance of particles as they condense and solidify, shaping the very fabric of spacetime. While currently beyond our direct reach, the **Kibble-Zurek mechanism (KZM)** offers a captivating possibility: recreating echoes of these cosmic events in the controlled environment of a laboratory. [4]

Developed in the 1970s, KZM describes the inevitable formation of **topological defects** during **phase transitions**. Imagine cooling a pot of water – as it transitions from liquid to ice, defects like cracks or air bubbles can arise. Similarly, during the universe's rapid cooling

after the Big Bang, exotic defects like cosmic strings and magnetic monopoles might have formed, influencing its subsequent evolution.

The key lies in the **universality of phase transitions**. Whether in water freezing or the universe expanding and cooling, KZM predicts similar defect formation patterns. By meticulously recreating these phase transitions in cold atom experiments or superfluid Helium systems, we can potentially observe miniature versions of these cosmic phenomena.

But how exactly can we observe these elusive defects? One promising approach involves probing the system's **energy landscape**. Defects act like ripples in the smooth energy terrain, creating characteristic signatures that can be detected using sensitive tools like laser interferometers or magnetic field sensors. Observing these miniaturized echoes wouldn't be simply a scientific novelty. It could:

- Validate KZM:** Experimentally confirming the mechanism in controlled settings would bolster our confidence in its application to the early universe.
- Probe exotic phenomena:** Defects might harbor traces of dark matter or shed light on the nature of gravity, offering insights into these cosmic mysteries.
- Refine cosmological models:** By comparing lab observations with simulations of the early universe, we can refine our understanding of its evolution and fine-tune cosmological models.

While challenges remain, such as mimicking the extreme conditions of the early universe and scaling up observations to relevant sizes, the potential rewards are significant. KZM offers a unique bridge between the microscopic and the macroscopic, allowing us to explore the cosmos from the comfort of our labs.

Furthermore, this quest isn't limited to KZM. Other areas of low-temperature physics, like studying quantized vortices in superfluid Helium, also show promising connections to phenomena like galaxy rotation and the structure of the universe.

In conclusion, the possibility of observing cosmological echoes in the lab is more than just science fiction. It's a testament to the

interconnectedness of nature, where the tiniest ripples in a cup of superfluid Helium might hold secrets to the vastness of the cosmos. As we continue to push the boundaries of experimental ingenuity, who knows what other echoes from the depths of creation we might uncover? The journey to unveil the universe's hidden music has just begun.

CONCLUDING REMARK

In conclusion, Richard Bentley's paradox, once a thorn in the side of Newtonian gravity, could hold the key to unlocking a deeper understanding of the cosmos. By embracing the possibility of quantized vortices and moving beyond the limitations of purely attractive forces, we might not only resolve the paradox but also rewrite our understanding of gravity and the universe itself. The journey beyond attraction has just begun, and the potential rewards are nothing short of revolutionary.

While the deep connection between low-temperature physics and cosmology remains just that – a possibility – the whispers are getting louder. The growing body of research, supported by experimental observations and theoretical models, suggests a hidden melody resonating across scales, waiting to be deciphered.

Further exploration along these lines could not only answer fundamental questions about the universe's origin and evolution but also open entirely new avenues of scientific inquiry. So, let us turn our ears to the whispers across scales, for they might hold the key to unlocking some of the greatest mysteries of our universe.

Acknowledgement:

This short review article were written with assistance of a large language model/AI.

Version 1.0: 14th Feb. 2024, pk. 16:08
VC & FS

REFERENCES

- [1] Cohen, I. Bernard. *Isaac Newton's On Natural Philosophy*. Cambridge: Harvard University Press, 1958
- [2] Christianto, V., Y. Umniyati, & Florentin Smarandache. Towards Gross-Pitaevskiiian Description of Solar System & Galaxies. *Prespacetime J.* (2020). url: https://digitalrepository.unm.edu/math_fs/p/300/
- [3] Sfetcu, Nicolae, "Isaac Newton on the action at a distance in gravity: With or without God?", MultiMedia Publishing (2019), DOI: 10.13140/RG.2.2.25823.92320, ISBN: 978-606-033-201-5
- [4] Bacsı, A. & B. Dora. Kibble–Zurek scaling due to environment temperature quench in the transverse field Ising model. *Nature Scientific Reports* 13, Article number: 4034 (2023) url: <https://www.nature.com/articles/s41598-023-30840-4>.
- [5] Manolopoulou, M. & M. Plionis. Galaxy cluster's rotation, *MNRAS* 465, 2616–2633 (2017). Published by Oxford University Press on behalf of the Royal Astronomical Society. url: https://manolisplionis.gr/wp-content/uploads/2020/08/Plionis_2017_110.pdf