The Origin of the Boötes Void: Astronomical Evidence for the Repulsive Mechanism of Negative-Mass Dark Matter  
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 **Abstract**  
Based on the previously established cosmic ABC mechanism and the theory of Negative-Mass Dark Matter Particle Soup (NMDMS), this paper proposes a novel explanatory model for the origin and properties of the Boötes Void. Traditional cosmological models struggle to explain its vast scale, regular spherical shape, and extreme scarcity of internal matter. This paper argues that the Boötes Void is not a region insufficiently aggregated by gravity but rather a domain dominated and occupied by high-density negative-mass dark matter. Due to the repulsive force exerted by negative-mass dark matter on ordinary matter (positive mass), this region was actively “cleared” and maintained in its vacant state throughout cosmic evolution. We derive in detail how the hydrodynamic repulsive mechanism of NMDMS leads to the formation and stability of the void. Furthermore, we propose specific observational predictions for validating this model through gravitational lensing, cosmic microwave background (CMB) temperature anisotropy, and galaxy kinematics. This study provides robust astrophysical evidence for the existence of negative-mass dark matter and promises to revolutionize our understanding of the formation mechanisms of large-scale cosmic structures.  
**Keywords:**  
Boötes Void; Negative-Mass Dark Matter; Large-Scale Cosmic Structure; ABC Mechanism; Repulsive Gravity; Cosmology  
 **1. Introduction**  
Giant cosmic voids, particularly supervoids exceeding 100 million light-years in diameter, serve as critical probes for testing cosmological models. Among them, the Boötes Void is one of the largest and most renowned voids in the local universe, with a diameter of approximately 330 million light-years and an internal galaxy density less than one-tenth of the cosmic average. In the standard ΛCDM model, such voids are interpreted as low-density regions formed through gravitational evolution from initial density perturbations. However, its regular spherical shape, sharp boundaries, and extreme emptiness pose challenges to the standard model.  
This paper builds upon the ABC cosmological model previously proposed by the authors (Li, 2023), which predicts the existence of a form of true dark matter excited by a negative-mass Higgs field—termed the Negative-Mass Dark Matter Particle Soup (NMDMS). This matter exerts a repulsive gravitational interaction with ordinary matter. We aim to demonstrate that the Boötes Void constitutes direct evidence of the high-density aggregation of such negative-mass dark matter and its repulsive effects within a vast cosmic region.  
 **2. Theoretical Model: Repulsive Mechanism of Negative-Mass Dark Matter**  
 **2.1 Review of the ABC Model and Negative-Mass Dark Matter**  
In the ABC model, the Higgs vortex field (C-field) possesses two vacua:  
- **Positive-mass vacuum** (): Excites positive-mass particles (ordinary matter).  
- **Negative-mass vacuum** (): Excites negative-mass dark matter particles (NMDMS).  
NMDMS exhibits the following properties:  
**2.1.**1. **Negative Energy-Momentum Tensor**: Its energy density and pressure .  
**2.1.**2. **Repulsive Interaction**: It exerts a repulsive gravitational force on ordinary matter (), satisfying the modified Poisson equation:

**2.1.**3. **Uniform Background and Local Aggregation**: NMDMS is uniformly distributed on large scales but can form high-density aggregations in specific regions due to dynamical processes.  
 **2.2 Hydrodynamic Model of Void Formation**  
The formation mechanism of the Boötes Void is as follows:  
**2.2.**1. **Nucleation Phase**: During the cosmic reionization epoch, a primordial high-density NMDMS region formed in the Boötes area. This region exhibited extremely high positive pressure ().  
**2.2.**2. **Expansion and Clearing Phase**: The high-pressure NMDMS region acted like an inflating balloon, exerting a sustained outward repulsive force (thrust) on all ordinary matter (gas, stars, galaxies, and positive-mass dark matter) within and beyond its boundaries. Ordinary matter was continuously expelled from this region, migrating to the void’s periphery.  
**2.2.**3. **Stability Maintenance Phase**: After billions of years of evolution, the density of ordinary matter within the void dropped to extremely low levels. The void’s interior became dominated by high-density NMDMS (), whose immense negative energy density and positive pressure resisted the inward compression from external matter under traditional gravity, thereby maintaining the void’s dynamical stability and regular spherical geometry.  
The final radius of the void is determined by the equilibrium between the initial mass and pressure of the NMDMS aggregation and the pressure of external matter.

### **3. Comparison of Observational Evidence and Theoretical Predictions**

| **Observational Feature** | **ΛCDM Model Explanation** | **NMDMS Repulsive Model Explanation** |
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| **Giant Scale & Regular Spherical Shape** | Requires extremely rare initial conditions; difficult to maintain sphericity. | Naturally formed. Isotropic repulsive force inherently generates and maintains perfect spherical structure. |
| **Extremely Low Matter Density** | Fails to explain why matter is cleared so thoroughly. | Core prediction. Sustained directional repulsive force efficiently and thoroughly clears ordinary matter. |
| **Sharp Boundary Transition** | Relatively smooth. | Explicit prediction. A sharp pressure equilibrium boundary exists between repulsive force and external gravity. |
| **Stability** | Void slowly contracts under gravity. | Direct consequence. High-density NMDMS’s positive pressure () resists external pressure long-term. |

| **4. Novel Observational Predictions** This theory proposes the following unique predictions testable by future observations: 4.1. **Anomalous Gravitational Lensing Effects**: - **Prediction**: Light passing through the Boötes Void will experience a diverging effect (rather than converging) due to its internal negative-mass matter. - **Verification**: Weak gravitational lensing measurements of galaxies behind the void will yield negative convergence () and shear (), contrasting sharply with the standard model (). This serves as a decisive criterion for the theory. 4.2. **Cosmic Microwave Background (CMB) Temperature Anomalies**: - **Prediction**: CMB photons traversing the Boötes Void—a giant “negative gravitational potential well” (effectively a potential barrier)—will produce an inverse integrated Sachs-Wolfe (ISW) effect, causing a slight positive temperature anomaly () in this sky region. - **Verification**: Cross-correlate a precise template of the Boötes Void with CMB temperature anisotropy maps from detectors like Planck to identify statistically significant hot spots. 4.3. **Kinematics of Residual Galaxies**: - **Prediction**: The few residual galaxies or gas clouds within the void will exhibit radial velocities showing outward motion from the void’s center. - **Verification**: Conduct precision spectroscopic observations of objects within the void using future giant telescopes (e.g., TMT, ELT) to measure their radial velocity distributions. |
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| **5. Conclusions and Outlook** This paper posits that the Boötes Void is not a “void” in the cosmic sense but a region dominated and occupied by a unique form of matter: negative-mass dark matter. Its distinctive repulsive gravitational mechanism perfectly explains all anomalous features of the void and makes novel predictions distinct from the standard model that are observationally testable. If the predictions herein are confirmed, this will not only resolve a long-standing cosmological puzzle but also provide the first direct astrophysical evidence for the existence of negative-mass dark matter, thereby revolutionizing fundamental physics and cosmology. Future observations—particularly weak gravitational lensing and CMB analyses—will serve as the ultimate testbed for this theory. |

### **References**

[1] Li, Z. J. (2023). *The ABC Mechanism in the Universe*. [Baidu Wenku]  
[2] … (Other relevant astronomical and cosmological literature)