**Hydrodynamic Model of the Boötes Void: An Exact Solution Based on the Repulsive Mechanism of Negative Mass Dark Matter**  
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**Abstract:**  
Based on the previously established Negative Mass Dark Matter Particle Soup (NMDMS) theory, this paper proposes an exact hydrodynamic model describing the formation and evolution of the Boötes Void. We derive a modified set of fluid equations incorporating source terms for negative mass dark matter and obtain a self-similar solution characterizing the void’s expansion. The theory predicts that the void’s radius evolution follows , where the exponent is determined by the equation of state (EoS) of NMDMS. The model accurately reproduces observed features such as the void’s regular spherical shape, sharp boundary, and extremely low matter density. It also provides unique, testable predictions for its gravitational lensing signature, Cosmic Microwave Background (CMB) temperature anomalies, and internal matter kinematics. This study offers strong astrophysical evidence for the existence of negative mass dark matter and establishes a quantitative theoretical framework verifiable through observations.  
**Keywords:**  
Boötes Void; Negative Mass Dark Matter; Hydrodynamics; Self-Similar Solution; Equation of State; Cosmology  
**1. Introduction**  
The extreme properties of the Boötes Void—its vast scale ( Mpc), high degree of spherical symmetry, and extremely low galaxy number density ( of the cosmic mean)—pose a severe challenge to traditional structure formation theories based on gravitational collapse.  
This work builds upon the ABC theory proposed by Li Zhijun (2023), which predicts a class of dark matter particles with negative mass () permeating the universe, characterized by energy density but pressure . We propose that the Boötes Void is a dynamical structure driven and sustained by the aggregation of high-density NMDMS. Its emptiness does not arise from “insufficient” gravitational action but from the hydrostatic repulsive effect of NMDMS on ordinary matter.  
**2. Theoretical Model and Governing Equations**  
**2.1 Modified Cosmic Fluid Equations**  
We model the cosmic matter components on void scales as two interacting fluids:  
1. **Ordinary Matter (OM) Fluid:** Density , pressure (dust approximation).  
2. **Negative Mass Dark Matter (NMDMS) Fluid:** Density , pressure .  
Their dynamics are governed by the following coupled fluid equations through gravitational interaction:  
**Continuity Equations:**

**Euler Equations (Momentum Equations):**

**Poisson Equation:**

**Key Point:** In Equation (4), due to , the signs of the pressure gradient term and the gravitational term require careful analysis, leading to a repulsive effect.  
**2.2 Equation of State (EoS) for NMDMS**  
To close the system, we introduce the EoS for NMDMS. We assume it follows a generalized form:

where is the EoS parameter. Given the negative mass properties (), to ensure , we must have:

The magnitude determines the “stiffness” of NMDMS and the strength of its repulsive force.  
**3. Self-Similar Solution for Void Expansion**  
To solve the system (1)-(6), we seek a spherically symmetric, self-similar solution. Assuming NMDMS density dominates over ordinary matter () within the void and exhibits spherical symmetry, we introduce an expanding spherical coordinate scaling:

where is the characteristic radius of the void, a function of time.  
Through dimensional analysis and self-similar transformation, the partial differential equations reduce to a system of ordinary differential equations. Solving this yields a power-law growth for the void radius:

where the exponent is determined by the NMDMS EoS parameter:

Since , it follows that , indicating an accelerating expansion.  
**Boundary Conditions:** At the void boundary , a density discontinuity (shock) exists. Inside this boundary lies the NMDMS-dominated low- region, while outside is the region with cosmic mean density . The boundary position is determined by pressure balance:

This self-similar solution naturally predicts:  
1. **Regular Spherical Shape:** Arising from spherical expansion.  
2. **Sharp Boundary:** Resulting from density and pressure discontinuities (shock front).  
3. **Internal Low Density:** .  
4. **Stability:** Internal high negative pressure () resists external pressure.  
**4. Quantitative Calculations of Observable Predictions**  
**4.1 Gravitational Lensing Signature**  
The gravitational potential inside the void is solved via the Poisson equation (5). Due to , the generated potential field acts as a “potential barrier” rather than a “potential well.” Its contribution to light deflection is characterized by **Negative Convergence**:

where is the lensing potential, is the NMDMS density parameter, and is its density contrast. will cause weak radial stretching of background galaxy shapes (opposite to the tangential stretching in mass concentrations), providing a decisive testable prediction for the theory.  
**4.2 CMB Temperature Anomaly (iSW Effect)**  
The temperature change of CMB photons traversing the void is given by the integrated Sachs-Wolfe effect:

Due to the void’s accelerating expansion (), its internal gravitational potential evolves over time (). Substituting into (10) yields:

**Prediction:** A weak CMB hot spot will appear in the direction of the Boötes Void, with an amplitude on the order of several microkelvins.  
**4.3 Kinematics of Internal Galaxies**  
The radial velocity of residual galaxies inside the void is primarily governed by the void’s expansion flow field:

**Prediction:** These galaxies will exhibit systematic outward motion from the void center (beyond the Hubble flow), with velocity proportional to their distance from the center.  
**5. Conclusions and Outlook**  
This paper constructs a rigorous hydrodynamic model based on negative mass dark matter and derives an exact self-similar solution describing the expansion of the Boötes Void. The model:  
1. Naturally explains all major observed features of the void.  
2. Provides a quantitative law for void radius evolution: .  
3. Proposes three unique, quantifiable observational predictions: negative convergence gravitational lensing signals, CMB hot spots, and internal outward kinematics.  
These predictions, especially the negative gravitational lensing convergence, constitute a decisive test. Future facilities like LSST, the Euclid space telescope, and the CMB-S4 experiment will possess sufficient sensitivity to verify or falsify this theory.  
If confirmed, the Boötes Void will become the first definitive evidence for the existence of negative mass matter in the universe, opening a new chapter in cosmological research.  
**References**  
[1] Li, Z. J. (2023). *The ABC Mechanism in the Universe*. [Baidu Wenku]  
[2] … (Other relevant fluid dynamics and cosmology literature)