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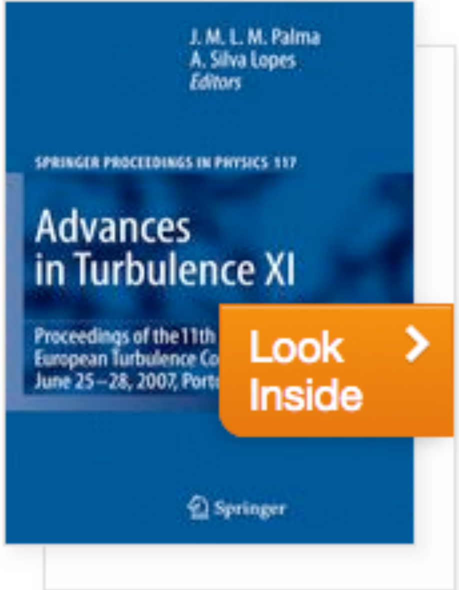

The Fluid Mechanics of Gravitational Structure Formation

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The standard model for gravitational structure formation in astrophysics, astronomy, and cosmology is questioned. Cold dark matter (CDM) hierarchical clustering cosmology neglects particle collisions, viscosity, turbulence and diffusion and makes predictions in conflict with observations. According to CDMHC cosmology, the non-baryonic dark matter NBDM forms small clumps during the plasma epoch after the big bang that "cluster" into larger clumps. Growing "CDM halo clusters" collect the baryonic matter (H and He) by gravity so that after 300 Myr of "dark ages" huge, explosive (Population III) first stars appear and then galaxies and galaxy clusters. Contrary to CDMHC cosmology, "hydro-gravitational-dynamics" HGD cosmology shows the diffusive NBDM material cannot clump and the clumps cannot cluster. The big bang results from an exothermic turbulent instability at Planck scales (10^{-35} m). Big bang stresses cause inflation of space, which produces fossil density turbulence remnants that trigger gravitational instability at protosupercluster masses (10^{46} kg) in the H-He plasma. These fragment along plasma turbulence vortex lines to form protogalaxy masses (10^{42} kg) just before the transition to gas. The gas has $\times 10^{-13}$ smaller viscosity, so it fragments at earth-mass and globular star cluster masses (10^{25} and 10^{36} kg) to form the baryonic dark matter (BDM). Observations from the Hubble Space Telescope show protogalaxies (PGs) in linear clusters reflecting their likely fragmentation on vortex lines. From the BDM planets, these PGs gently form small stars in globular clusters $\leq$1 Myr after the big bang without the dark ages and superstars of CDM cosmology.

1 Hydro-Gravitational-Dynamics Theory

The hydro-gravitational-dynamics theory of gravitational structure formation [1, 2, 3, 4] covers a wide range of length scales from the big bang Planck scale $L_P = 1.62 \times 10^{-35}$ m of quantum gravitational instability to the present horizon scale $L_H \approx 10^{26}$ m. The Planck temperature $T_P = [c^5 h G^{-1} k^{-2}]^{1/2} =$

1.40×10^{32} K is so large that turbulence and turbulent mixing are needed to produce entropy and make the process irreversible.

Only Planck particles and Planck anti-particles can exist at such temperatures, plus their spinning combinations (Planck-Kerr particles), so the viscosity is low. Planck-Kerr particles are the smallest possible Kerr (spinning) black holes. They represent the big bang equivalent of positronium particles formed from electrons and positrons during the pair production process that occurs at 10^9 K supernova temperatures. Prograde accretion of Planck particles by Planck-Kerr particles can release up to 42% of the Planck particle rest mass $m_P = [chG^{-1}]^{1/2}$, resulting in the highly efficient exothermic production of turbulent Planck gas [3, 4]. Large negative turbulent Reynolds stresses $\tau_P = [c^{13} h^{-3} G^{-3}]^{1/2} = 2.1 \times 10^{121}$ $\mathrm{m^{-1} s^{-2}}$ rapidly stretch space until the turbulent fireball cools to the strong force freeze-out temperature $T_{SF} \approx 10^{28}$ K so that quarks and gluons can form. Besides Planck particles, the smallest possible Schwarzschild (non-spinning) black hole, only magnetic monopole est possible Schwarzschild (non-spinning) black hole, only magnetic monopole particles are possible in the big bang temperature range.

Gluon viscosity damps the big bang turbulence at a Reynolds number $\approx 10^6$ and increases negative stresses and the rate of expansion of space. Turbulence and viscous stresses combine with false vacuum energy in the stress energy tensor of Einstein's equations to produce an exponential expansion of space (inflation) by a factor of about 10^{25} in the time range $t = 10^{-35} - 10^{-33}$ s [5]. Fossil temperature turbulence patterns produced by the big bang and preserved by nucleosynthesis and cosmic microwave background temperature anisotropies indicate a similar large value (10^5) for the big bang turbulence Reynolds number [6]. Only small, transitional Reynolds numbers $c^2 t/\nu \approx 10^2$ are permitted by photon kinematic viscosity $\nu = 4 \times 10^{26}$ $\mathrm{m^2 s^{-1}}$ at the time ($t = 10^{12}$ s) of first structure [2].

Gluon, neutrino, and photon viscosities dominated momentum transport and prevented turbulence during the electroweak, nucleosynthesis, and energy dominated epochs before $t = 10^{11}$ s, and also the formation of gravitational structures. Soon after this beginning of the matter dominated epoch the neutrinos ceased scattering on electrons and became super diffusive. Neutrinos were produced in great quantities at the 10^{-12} s electroweak transition that may still exist as part, or most, of the non-baryonic dark matter that dominates the mass of the universe. Momentum transport became dominated by photon viscosity, with the possibility of weak turbulence [2, 7].

The conservation of momentum equations for a fluid subject to viscous, magnetic and other forces is

$$\frac{\partial \boldsymbol{v}}{\partial t} = -\nabla B + \boldsymbol{v} \times \boldsymbol{\omega} + \boldsymbol{F_g} + \boldsymbol{F_\nu} + \boldsymbol{F_m} + \boldsymbol{F_{etc.}} \tag{1}$$

where $B = p/\rho + v^2/2$ is the Bernoulli group, p is pressure, ρ is density, $\boldsymbol{v}$ is velocity, t is time, $\boldsymbol{\omega}$ is vorticity, $\boldsymbol{F_m}$ is magnetic force, and $\boldsymbol{F_{etc.}}$ are miscellaneous other forces. In the early universe, ∇B, $\boldsymbol{F_m}$. and $\boldsymbol{F_{etc.}}$ are small