# Hydrodynamics of structure formation in the early Universe

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**Abstract.** - Theory and observations reveal fatal flaws in the standard ΛCDM model. The cold dark matter hierarchical clustering paradigm predicts a gradual bottom-up growth of gravitational structures assuming linear, collisionless, ideal flows and unrealistic CDM condensations and mergers. Collisional fluid mechanics with viscosity, turbulence, and diffusion predicts a turbulent big bang and top-down viscous-gravitational fragmentation from supercluster to galaxy scales in the plasma epoch, as observed from 0.3 Gpc void sizes, 1.5 Gpc spins and Kolmogorov-fingerprint-turbulence-signatures in the CMB. Turbulence produced at expanding gravitational void boundaries causes a linear morphology of 3 Kpc fragmenting plasma-protogalaxies along vortex lines, as observed in deep HST images. After decoupling, gas-protogalaxies fragment into primordial-density, million-solar-mass clumps of earth-mass planets forming ≤0.3 Mpc galactic-dark-matter. White-dwarf-heated planet-atmospheres give dimmed Supernova Ia events and false gamma-ray-burst luminosity distances, not dark-energy-Λ. Quasar microlensing observations rule out "no-hair" black hole models and require galaxy-dark-matter to be planets-in-clumps.

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**Introduction.** – According to the 5-year WMAP data on the cosmic microwave background (CMB), the standard ΛCDM model of cosmology adjusts 4% of the critical density to baryons, 26% to non-baryonic dark matter and 70% to dark energy [1]. Here Λ is Einstein's cosmological constant or dark energy, predicting an accelerated expansion of the universe on the basis of Supernova Ia dimming observations [2], while cold dark matter (CDM) is required to produce sufficiently slow sound speeds in the plasma epoch after the big bang for gravitational condensation to occur by the Jeans criterion. Jeans 1902 proposed that scales for gravitational condensation of a uniform fluid of density $\rho$ must be larger than the Jeans acoustic scale $L_J = V_S/(\rho G)^{1/2}$, where $V_S$ is the sound speed of the plasma and $G = 6.67\,10^{-11}\mathrm{m}^3/\mathrm{kg\,s}^2$ is Newton's constant. Because $V_S = c/\sqrt{3}$ is nearly the speed of light $c = 3\,10^8$m/s during the plasma epoch $10^{11} \le t \le 10^{13}$ s, the plasma Jeans scale is always larger than the horizon scale of causal connection, $L_H = ct$, until decoupling at $t \approx 10^{13}$ s (300,000 yr): The Jeans criterion forbids gravitational structure formation in the plasma.

But gravitational structures formed very early. Increasingly observations conflict with the CDMHC claim that the first stars were short-lived superstars in microgalaxies at $10^{16}$ s. The only possibility besides baryonic matter (BM) is the unknown, weakly-collisional, non-baryonic dark matter component NBDM. For NBDM particles to condense by the Jeans criterion (ignoring their problematic diffusivity) they must be colder than the baryonic plasma. Thus an unknown out-of-equilibrium cold-dark-matter CDM material is assumed to (magically) condense in the plasma epoch. NBDM halos collect the plasma in sonically oscillating (inviscid) potential wells. These hierarchically cluster (HC) to form larger and larger "CDM" halos that guide the formation of stars, then galaxies, and finally clusters and superclusters of galaxies in "CDMHC" cosmology.

This "deus ex machina" solution to the apparently impossible problem of gravitational structure formation in the early universe is fluid mechanically untenable [3]. Observations of dense clumps of ancient small stars in old globular clusters (OGCs) contradict CDMHC predictions

that star formation should not begin for about 300 million years of "dark ages" and that the first stars should be 100-1000 $M_\odot$ "Population III" superstars. OGCs do not spin rapidly so they cannot be condensations, and small stars imply gentle flows inconsistent with superstars. The existence of identical OGCs in all galaxies with baryonic density $\rho_0 = 4 \times 10^{-17}$ kg m$^{-3}$ [4] that existed at time $t = 10^{12}$ seconds (30,000 years) when the horizon mass matched the supercluster mass cannot be reconciled with CDMHC models. Neither can empty supercluster-voids with 300 Mpc ($10^{25}$ m) scales reported from radio telescope measurements [5], nor a preferred "axis of evil" spin direction (AE) that appears at scales extending to 1.5 gigaparsecs ($4.5 \times 10^{25}$ m), nearly half the horizon scale $L_H \approx 10^{26}$ m [6]. However, the AE spin axis has been explained on the basis of fluid mechanics: It reflects density gradients of big bang turbulence [7] and mixing [8] subject to established universal similarity laws of fossil turbulence and turbulent mixing [9]. Such turbulence fossils appear in CMB spherical harmonics axes and in turbulence-fingerprint-signatures (see figs. 2bcd).

Because the CDM material is nearly collisionless it will diffuse away from and smooth out any NBDM density irregularities. The Jeans 1902 criterion reflects a linear gravitational instability from acoustics, but neglects the fact that self gravitational instability of a gas is absolute [4]. All density variations will grow or decrease unless prevented by the viscous forces, turbulent forces and diffusivity effects, all neglected by Jeans 1902. Gibson 1996 [3] derives several Schwarz scale criteria for gravitational structure formation, $L_H \geq L_{min} \geq L_{SXmax}$, where $L_{SX}$ stands for the viscous $L_{SV}$, the turbulent $L_{ST}$ or the diffusive length scale $L_{SD}$. The first gravitational structures appear when $L_{ST} \approx L_{SV} \leq L_H = ct$ for $t \geq 10^{12}$ s. Because the universe is rapidly expanding the process is by fragmentation at baryonic density minima. This forms baryonic protosupervoids that expand as rarefaction waves approaching sonic speeds from the Rankine-Hugoniot relations and the second law of thermodynamics.

Weak turbulence forms in the protosupercluster plasma at void boundaries from vorticity production by baroclinic torques reflecting misalignment of pressure and density gradients at the void boundaries. BM fragmentation proceeds to galaxy scales with a morphology reflecting strain-tensor-eigenvalues of the plasma turbulence [10]. Weak turbulence is produced at void boundaries with the Nomura-Kolmogorov $L_N = 10^{20}$ m viscous-inertial-vortex scale and geometry of the plasma protogalaxies at transition to gas at $t = 10^{13}$ s. NBDM later follows these BM concentrations. Observations of the Hubble Ultra Deep Field [11] show chains of protogalaxies and spiral clump clusters, as well as DM filaments, formed in this way. It is easy to understand 300 Mpc ($10^{25}$ m) superclustervoids observed by radio telescopes from this hydrogravitational dynamics picture, but impossible from CDMHC models where such voids are formed last and full of debris rather than first and empty as observed [5]. The first voids expand to $L_{SV} \approx 10^{20}$ m scales by $t \approx 10^{12}$ s at density minima in the plasma and continue to expand at near light speeds until decoupling.

At decoupling the viscosity $\nu$ decreases from photon viscosity values $\approx 10^{26}$ m$^2$ s$^{-1}$ to hot-gas values of $\approx 10^{13}$ m$^2$ s$^{-1}$, reducing the fragmentation scale $L_{SV} = (\gamma\nu/\rho G)^{1/2}$ to $\approx 10^{14}$ m, where $\gamma \approx 10^{-13}$ s$^{-1}$ is the rate-of-strain, $\rho \approx \rho_0 \approx 10^{-17}$ kg m$^{-3}$ is the gas density, giving gas clouds of mass $M = \rho {L_{SV}}^3 \approx 10^{25}$ kg corresponding to that of the Earth. Simultaneously with the same free fall time the gas protogalaxies fragmented at the Jeans acoustic scale with Jeans mass $\approx 10^6 M_\odot$. Thus the entire baryonic universe turned to a fog of planet mass clouds in proto-globular-star-cluster mass clumps destined to become globulars, material for galaxies, and, mostly, the dark matter of galaxies. The planets are termed "primordial fog particles" PFPs and the clumps are termed proto-globular-star-clusters PGCs. Spin-radiation of compressing white dwarfs reheat some PFPs to attain $10^{13}$ m diameter atmospheres that can randomly dim eventual Supernova Ia events as a systematic error rather than by a dark energy driven accelerated expansion [12]. The prediction [3] that the dark matter of galaxies should be planets was independently proposed by the Schild 1996 interpretation of 90 day twinkling periods in quasar microlensing observations [13].

From the HGD scenario following recombination the first stars form gently by a frictional binary accretion of still warm PFPs to form larger planet pairs and finally small stars as observed in old globular star clusters. We see that all stars form as binaries in PGC clumps of a trillion planets. As the universe expands the planets freeze and the PGCs become less collisional and diffuse out of the $10^{20}$ m $L_N$ scale protogalaxies to form $10^{22}$ m dark matter halos with 97% of the galaxy mass for the universe to be flat and for the BM density to match that of GCs. NBDM sets the DM at larger scales. Spiral galaxies reflect the accretion disks of dark halo PGCs frictionally spiraling back toward the $L_N$ scale protogalaxy remnant of ancient stars [10]. The NBDM diffuses to $L_{SD} = (D^2/\rho G)^{1/4} \geq 10^{23}$ m scales to form galaxy cluster halos with 96% of the mass of the universe. Dark energy is not needed in this scenario and may have a content equal to zero. Violent massive stars form at $L_{ST} = (\varepsilon/[\rho G]^{3/2})^{1/2}$ as turbulent maelstroms at protogalaxy cores giving spin radiation quasar and gamma ray burst events, where $\varepsilon$ is the viscous dissipation rate of the turbulence, confronting standard black hole models.

The plan of the Letter is to review theories of hydrogravitational structure formation, to compare them to observations, and to present conclusions.

**Theory.** – As discussed, the standard ΛCDM theory neglects viscous forces, turbulence forces, and effects of the large particle diffusivity implied by the necessarily small cross section for collisions of the NBDM, including CDM. These assumptions conflict with every stage of HGD cos-

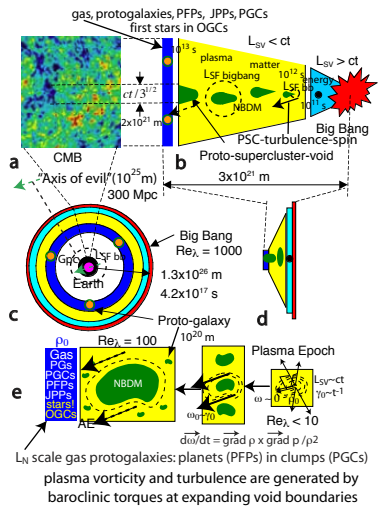


Fig. 1: Hydro-Gravitational-Dynamics cosmology.

mology, as expressed in Fig. 1abcde.

Conservation of specific momentum in a fluid is expressed by the Navier-Stokes equations ($\vec{\omega} = \nabla \times \vec{v}$)

$$\partial \vec{v}/\partial t = \nabla B + \vec{v} \times \vec{\omega} + \vec{F}_{viscous} + \vec{F}_{other}, \qquad (1)$$

averaged over system control volumes exceeding the momentum collision length scale. $B$ is the Bernoulli group of mechanical energy terms $B = p/\rho + \frac{1}{2}v^2 + lw$ and various viscous and other fluid forces may arise. The inertial-vortex force per unit mass $\vec{v} \times \vec{\omega}$ produces turbulence if it dominates the other forces; for example, $Re \equiv |\vec{v} \times \vec{\omega}|/|\vec{F}_{viscous}|$ is the Reynolds number, $|\vec{v} \times \vec{\omega}|/|\vec{F}_{buoyancy}|$ is the Froude number and $|\vec{v} \times \vec{\omega}|/|\vec{F}_{Coriolis}|$ is the Rossby number. In particular, a small Reynolds number corresponds to large viscosity that damps turbulence.

For adiabatic flows the "lost work" term $lw$ due to frictional losses is negligible so the enthalpy $p/\rho$ decreases or increases to compensate for changes in the kinetic energy per unit mass $\frac{1}{2}v^2$. From Eq. (1), turbulence is defined as an eddy-like state of fluid motion where the inertial-vortex forces of the flow are larger than any other forces that tend to damp the eddies out [9, 12]. By this definition, irrotational flows are non-turbulent. All turbulence cascades from small scales to large because vorticity is produced at small scales and adjacent eddies with the same spin induce inertial vortex forces that cause the eddies to merge and form bigger structures.

It is instructive to solve Eq. (1) for the case of a uniform fluid of density $\rho$ initially at rest, where either a "cannon ball" or "vacuum beach ball" is suddenly introduced at time zero [4]. In the absence of viscous or other forces all material within $L_H = ct$ of the object is accelerated either toward or away from it by gravity. The mass at the object remains nearly constant for a gravitational free fall time $\tau_{FF} = (\rho G)^{-1/2}$ and then either increases exponentially until a hydrostatic state is reached or decreases exponentially until a void and rarefaction shock are formed.

In natural flows, turbulence events are typically intermittent in time and patchy in space due to buoyancy or rotational constraints that produce fossil turbulence. Fossil turbulence is defined as a perturbation in any hydrophysical field produced by turbulence that persists after the fluid is no longer turbulent at the small scale of the initial perturbation. Vertical transport processes in the ocean and atmosphere are dominated by a complex interaction between turbulence, fossil turbulence, secondary (zombie) turbulence, and fossil and zombie turbulence internal wave motions. The dominant oceanic transport mechanism, beamed zombie turbulence maser action or BZTMA, takes place in channels termed mixing chimneys.

Temperature anisotropies of the cosmic microwave background Fig. 1a are only $\approx 10^{-5}$, much too small for a plasma epoch dominated by high Reynolds number turbulent mixing at all scales. Either viscous forces or self gravitational buoyancy forces are required to explain this result. The plasma photon viscosity $\nu \approx c/(n_e \sigma_T) \approx 4 \times 10^{26}$ m$^2$/s where $\sigma_T$ is the Thomson photon-electron scattering cross section $6.7 \times 10^{-29}$ m$^2$, $n_e \approx 10^{10}$m$^{-3}$ is the electron number density at $t = 10^{12}$ s, and the collision length $L_C = 1/(n_e \sigma_T) \approx 10^{18}$ m is less than $ct = 3 \times 10^{20}$ m. $L_C < L_H$ is consistent with the continuum hypothesis of fluid mechanics. This gives a Reynolds number $Re = c^2 t/\nu$ at plasma-gas transition $\approx 2000$ significantly above the critical value $\approx 200$, suggesting gravitational structure formation in the plasma has suppressed strong turbulence and that weak turbulence guides the "chain galaxy" morphology of protogalaxies, as observed [10].

Given the large photon viscosity in the plasma epoch $10^{11} \leq t \leq 10^{13}$ s, our first task is to estimate the Reynolds number for the standard CDM model in this epoch. The CDM claim is that an inviscid plasma flows into the gravitational potential wells of the seeds, and that sonic oscillations result giving the observed sonic peak and subharmonic peaks of the CMB temperature anisotropy spectrum. Taking the seed mass to be that of a globular star cluster $10^{36}$ kg and the density to be $10^{-15}$ kg m$^{-3}$ gives the seed size to be $10^{17}$ m. If the flow velocity is $10^8$ m s$^{-1}$ the Reynolds number $Re = LV/\nu \leq 0.1$, much less than critical. Obviously the neglect of photon viscosity is fatal. Even if CDM seeds should condense, the viscous plasma would not have time to flow into the potential wells and would not produce any sonic oscillations: the CDM model is physically inconsistent (Fig. 2a).

We see that the NBDM has no effect on gravitational structure formations in the plasma epoch, contrary to CDMHC theory. The baryonic plasma of protons, electrons and alpha particles dominates all gravitational structure formation, even though its mass is only about 4% of the total. Because the universe is expanding with rate-of-strain $\gamma = 1/t$ and because the gravitational decrease of density at density minima is enhanced by expansion, the first structures occur by fragmentation due to void

formation when $L_{SV}$ becomes less than $L_H$ at time $10^{12}$ s to produce protosupercluster voids and protosuperclusters with baryonic mass $\approx 10^{46}$ kg $\approx 10^{16} M_\odot$, see Fig. 1b.

As the voids expand at speeds approaching the sonic velocity $V_S = c/\sqrt{3}$, baroclinic torques develop at the void boundaries that produce vorticity and turbulence due to the misalignment of pressure gradients and density gradients. Pressure gradients will be normal to void boundaries, but density gradients are determined by fossil density turbulence values [8] produced by big bang turbulence [7] up to the strong force freeze-out scale $L_{SF}$. The total growth by space stretching of $L_{SF}$ is from $10^{-27}$ m at the end of big bang turbulence to $\approx 3 \times 10^{25}$ m at present, based on the Gpc scales of quasar polarization shown in fig. 1c and the small wavenumber $L_{SF}$ cutoff scale of the CMB power spectrum (see fig. 2a). The rate of vorticity and turbulence production at the gravitationally expanding protosuperclustervoid boundaries in the plasma is $\partial\vec{\omega}/\partial t = \nabla\rho \times \nabla p/\rho^2$, fig. 1e.

At decoupling the kinematic viscosity and Schwarz viscous scale decrease dramatically, giving a viscous planetary fragmentation mass of $10^{25}$ kg and an acoustic protoglobularstarcluster fragmentation mass of $10^{36}$ kg. Thus the baryonic universe fragmented into primordial-fog-particle PFP gas clouds in PGC clumps in a gravitational free fall time of about $10^{13}$ s (300,000 yr). The freezing temperature of hydrogen and helium occurred at redshift $z \approx 30$ a few hundred million years later to produce the frozen baryonic dark matter planets in clumps predicted as the galaxy dark matter by Gibson 1996 [3]. As mentioned previously, the interpretation that galaxy dark matter is mostly planets of earth mass was independently proposed from rapid twinkling frequencies in quasar microlensing by Schild 1996 [13].

The clumps of dark matter planets are quite stable. Most have persisted without stars for nearly 14 billion years. When agitated by tidal forces the collision frequency of the planets will increase causing re-evaporation of the frozen gases, increased friction, and the possibility of planet mergers to produce larger planets and eventually new stars. The existence of galaxy dark matter in the form of clumps of frozen primordial planets is clearly revealed in galaxy mergers such as Tadpole, Mice and Antennae, where numerous young globular clusters of stars can be seen in star wakes as the merging galaxies enter each others dark matter halos. Within a PGC of frozen PFPs the number density $n_0 = \rho_0/m \approx 4 \times 10^{-42}$ m$^{-3}$ gives a mean-free-path for a photon $2.5 \times 10^3 L_H$. Thus PFPs are invisible unless they are at least partially evaporated.

**Observations.** – The fifth year WMAP power spectrum is displayed in fig. 2a compared to turbulence statistical parameters computed at wavenumbers $k$ near the sonic peak in figs. 2bcd ($\theta = 0.9 - 4$) [1]. Unbinned samples are shown in the background as grey dots. Open circles have been added by us to show variation in the range of values and intermittency, which increases with Reynolds number from Kolmogorov's third similarity law.

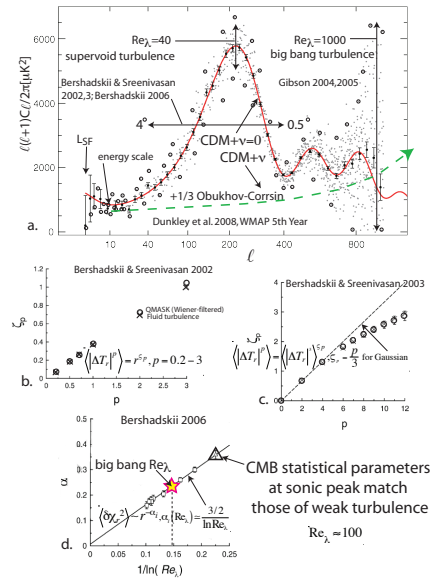


Fig. 2: CMB temperature anomaly spectra from WMAP year 5 (a) with unbinned samples. Turbulence statistics agree with those of the CMB anomalies in (b), (c) and (d). Agreement between the CMB and fluid turbulence statistical parameters at sonic peak scales suggests weakly turbulent supervoid driven turbulence (see fig. 1e).

The unbinned spectral sample intermittency is smaller at the sonic peak than at the highest wavenumbers, as shown by the vertical double arrows in Fig. 2a. We attribute the change to the difference in Reynolds numbers of the turbulence producing the scatter. At the sonic peak the turbulence is due to weak protosupervoid driven turbulence with Taylor microscale Reynolds number $Re_\lambda \approx 40$ [20], but at high wavenumbers the scatter of unbinned samples presumably reflects scatter from big bang turbulence with $Re_\lambda \approx 1000$ [7, 8].

The dashed green line in fig 2a with Corrsin-Oboukov slope $+1/3$ is expected from big bang turbulent mixing or a proper CDM model with plasma photon viscosity $\nu$, rather than the red line produced by simulations neglecting viscous damping of sonic oscillations.

A CMB connection to turbulence was established by Bershadskii and Sreenivasan [18] from $\Delta T$ structure functions as a function of spatial separation $r$, $\langle|\Delta T|^p\rangle \sim r^{\zeta_p}$, for a variety of powers $p$ between 0.1 and 3 (fig. 2b). The CMB data is Weiner filtered to remove foreground noise for angular ranges between 0.9 and 4 degrees. This allowed to deduce the exponent $\zeta_p \approx p/3$. A test of Gaussianity of turbulence and CMB anisotropy data (fig. 2c), $\langle|\Delta T|^p\rangle \sim \langle|\Delta T|^3\rangle^{\zeta_p}$ reveals a marked deviation from the Gaussian value $\zeta_p = p/3$ in the interval $3 < p < 12$, with $\zeta_{12} \approx 2.8$ [19]. $Re_\lambda$ is estimated (fig. 2d) [20] from a temperature $\chi$ surrogate $(\delta\chi_r)^2 \sim r^{-\alpha_i}$ of the sonic peak

turbulent Reynolds number using a linear expansion of the $Re_\lambda$ dependence of the intermittency exponent $\alpha_i(Re_\lambda)$. Extrapolating measured high $Re_\lambda$ turbulence values to the CMB value $\alpha_i \approx 0.45$ gives $Re_\lambda \approx 40$, only slightly larger than transitional values to laminar flow of 10-25, and less than the big bang $Re_\lambda \approx 10^3$ value (red star). The agreement further supports the HGD model of fig. 1, where turbulence is produced at the boundaries of gravitationally expanding voids in the plasma epoch.

Fig. 3 shows evidence that the the dark-energy-hypothesis is actually a systematic dimming error for Supernova Ia events due to evaporated dark-matter-planet atmospheres produced in planetary nebulae PNe where undimmed lines of sight are possible. Riess et al. and Purlmutter et al. SNe Ia collaborations examined all sources of dimming except planet atmospheres to conclude the 0.25 magnitude dimming at redshift $z = 0.5$ is conclusive evidence of the time of transition from cosmic deceleration to acceleration from dark energy.

From HGD all stars are formed as accretions of PFP dark-matter-planets within PGC clumps. If a star grows rather slowly then turbulent mixing from the rain of planets will not mix away the dense carbon core. By conservation of angular momentum the star spins rapidly as it compresses producing strong spin radiation along the spin axis and at the star equator. Dark matter planets at the boundary of the $3 \times 10^{15}$ m Oort cavity are evaporated to form planetary nebula such as the nearby Helix PNe shown in fig. 3 (center). HST optical images show $\approx 10^4$ "cometary knot" $\approx 10^{13}$ m planet-atmospheres in Helix, and Spitzer shows $\geq 10^5$ in the infrared from the $10^3 M_\odot$ available [12].

Planet atmosphere diameters are $\approx 10^{13}$ m, the size of the solar system out to Pluto, bringing this dominant galaxy-dark-matter component out of the dark. The separation distance between planets is $\approx 10^{14}$ m, as expected if the PGC density of planets is the primordial density $\rho_0 = 4 \times 10^{-17}$ kg m$^{-3}$. The planet atmosphere cross section for SNe Ia dimming $\sigma \approx 10^{26}$ m$^2$ gives a photon mean free path $1/n\sigma \approx 3 \times 10^{15}$ m from the primordial PFP number density $n_0$, comparable to the observed Helix planetary nebula shell thickness and consistent with $\approx 5\%$ of the SNe Ia lines of sight unobscured as indicated by the brightest observations of fig. 3.

The diagram at lower left from Sandage 2006 gives the same result. Dimmed SNe Ia events indicate small $H_0 = 1/T$ values and large ages of the universe $T = 15.9$ Gyr. Red circles emphasize brighter values of SNe Ia events and a younger age $T = 13.7$ Gyr more acceptable from CMB $T$ values and those suggested by the age of old globular star clusters.

Gamma ray bursts GMBs [22] in fig. 4 have maximum power exceeding $3 \times 10^{49}$ W, permitting observations to redshift values $z \geq 5.8$ much larger than SNe Ia values $z \leq 1.8$. When the dimming uncorrected SNe Ia luminosities of fig. 3 are used to establish GMB luminosity distance scales $D_L$, gamma ray burst events appear to be at distances that

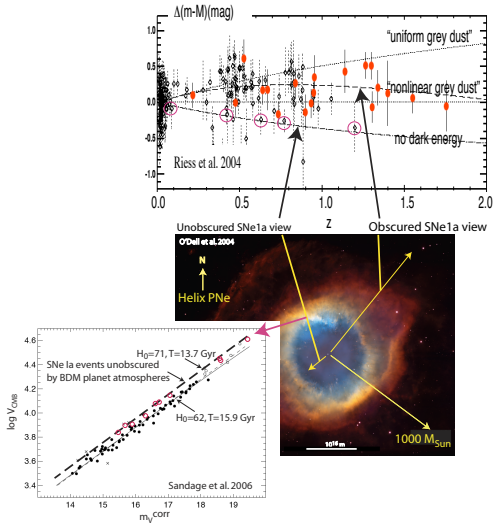


Fig. 3: Planet atmospheres obscure SNe Ia events to give systematic dimming errors rather than dark energy.

are physically impossible.

How are such bright GRBs possible? From HGD they represent the formation of $10^9 M_\odot$ galaxy central objects in a maelstrom of superstars, contradicting the concept that black holes have event horizons with weak radiation. This "no hair" central galactic black hole concept is contradicted by the Niewenhuizen not-so-general bimetric relativity theory [16, 17]. A supermassive black hole is described as a giant Bose-Einstein condensate with redshift $z \approx 10^{15}$ at the Schwarzschild event horizon $r_S$. Oscillations of the metric require emission of gravity waves to increase the binding energy of the condensate, up to 100% of the BH rest mass, thus providing an energy source for the powerful jets and radiation observed in quasars and gamma ray bursts. Standard black hole models are also confronted by Schild et al. quasar reverberation observations indicating magnetic moments, $140 r_S$ scales, and powerful radiation also inconsistent with "no hair" black holes [14, 15, 23, 24] and late-forming CDMHC galaxies.

How is are the systematic dimming errors of figs. 3 and 4 produced? Dimming by dense $10^{13}$ m planet atmosphere at the 20% levels observed is negligible by gases and realistic quantities of dust [25]. Such large dimming on obscured lines of sight in a planetary nebula (fig. 3) requires post turbulent electron density forward scattering [26] as observed by radio telescope pulsar scintillation spectra, embedded in the Kolmogorovian "great power law on the sky" [9], which can now be understood from HGD as remnants of supernova powered turbulent mixing in our local PGC [26].

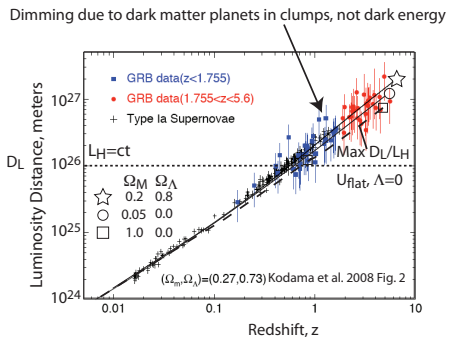


Fig. 4: GRBs [22] extrapolate SNe Ia events to give luminosity distances $D_L/L_H$ that exceed maximum possible values for world models including flat (squares), empty (circles), and concordance with $\Lambda$ (stars). Systematic dimming errors from planet atmospheres are indicated, not dark energy [12].

**Conclusions.** – From a variety of new observations of Hubble, WMAP, GRB, lensing and SNe Ia events we extend the 1996 HGD conclusion [3], supported by microlensing [13, 21], that the cold dark matter hierarchical clustering model for gravitational structure formation in the universe is fatally flawed. $\Lambda$CDM is based on obsolete fluid mechanics of Jeans 1902 that assumes inviscid fluids without turbulence and without diffusivity. A proper cosmological description requires a collisional-fluid-mechanics description based on modern fluid mechanical concepts including inertial-vortex turbulence that cascades from small scales to large and preserves important information about the turbulence and turbulent mixing in universally similar, and dynamically active, fossil turbulence structures [9, 12, 27–29]. In the plasma era the photon viscosity is so large that it damps CDM sonic oscillations. HGD predicts supervoid fragmentation at Schwarz viscous scales $L_{SV} \leq L_H$ with BM density $\rho_0$ at 30,000 years when gravitational structure formation first begins. Baryonic protosupervoids and baryonic protosuperclusters of $10^{16} M_\odot$ appear, detaching from the diffusive NBDM that later forms cluster halos. CMB sonic peaks reflect sonic speeds of gravitationally driven rarefaction waves at void boundaries, contradicting CDM potential well models. The next stage of structure formation concerns breakup into H-He $10^6 M_\odot$ PGC clumps of $10^{11-12}$ earth-mass planet-clouds, now frozen. Star formation always occurs by coalescence of planets within these PGC clumps with primordial density $\rho_0$. Some of the clumps formed old globular clusters with density $\rho_0$, so often a puzzle in theoretical approaches, but a natural process in our theory. Others diffused frictionally out from the protogalaxy core as the dominant form of galaxy dark matter. Dark energy and $\Lambda$ are explained by HGD as dimming of SNe Ia and GRBs by BDM planets and clumps of planets.

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