Evidence for Hydro-Gravitational Structure Formation Theory versus Cold-Dark-Matter, Hierarchical-Clustering, and Jeans 1902

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ABSTRACT

Observations are compared to conflicting predictions about self-gravitational structure formation by the hydro-gravitational theory (HGT) of Gibson 1996-2003 versus cold-dark-matter hierarchical-clustering-cosmology (CDMHCC) and the Jeans 1902 criterion. According to HGT, gravitational structures form immediately after mass-energy equality by plasma fragmentation at 30,000 years when viscous and weak turbulence forces first balance gravitational forces within the horizon $L_H \equiv ct < L_J = c/\sqrt{3\rho G}$, contrary to the Jeans 1902 criterion. Buoyancy forces fossilize the $10^{-12}$ s$^{-1}$ rate-of-strain and the $10^{-17}$ kg m$^{-3}$ baryonic density. The non-baryonic dark matter (NBDM) diffuses into the voids rather than forming cold-dark-matter (CDM) halos required by CDMHCC. From HGT, supercluster-mass to galaxy-mass fragments exist at the plasma to gas transition, and these fragment further to form proto-globular-star clusters (PGCs) and planetary-mass primordial-fog-particles (PFPs): the baryonic dark matter of the interstellar-medium and inner-galaxy-dark-matter-halos, from which all planets and stars are formed by accretion (Gibson 1996, Schild 1996). From HGT and a rich cluster mass profile (Tyson & Fischer 1995), $D_{NBDM} \approx 6 \times 10^{28}$ m$^2$ s$^{-1}$, $m_{NBDM} \leq 10^{-33}$ kg, and the NBDM forms outer-galaxy halos after 300,000 years.
1. Introduction

Observations are accumulating about the early universe and the interstellar medium that challenge the standard models of cosmology, galaxy formation, star formation, planet formation and comet formation. For many years no data were available to contradict the Jeans 1902 gravitational structure formation criterion that in a gas of uniform density $\rho$, gravitational condensation cannot occur on scales smaller than $L_J$ where

$$L_J \equiv V_S/\left(\rho G\right)^{1/2} \gg (p/\rho^2 G)^{1/2} \approx (RT/\rho G)^{1/2} \equiv L_{JHS},$$

(1)

$G$ is Newton’s gravitational constant, $R = k/m$ is the gas constant, $k$ is Boltzmann’s constant, $m$ is the gas particle mass, and $T$ is the temperature. Because $V_S \approx (p/\rho)^{1/2} \approx (RT)^{1/2}$ is $V_S$ for an ideal gas, Jeans 1902 and others have assumed that the Jeans acoustic scale $L_J$ defined on the left and the Jeans hydrostatic scale $L_{JHS}$ defined on the right of (1) are equivalent. They are not. It has been shown that the Jeans criterion is unreliable (Gibson 1996): non-acoustic density fluctuations are absolutely unstable to structure formation. Hydrostatic equilibrium is achieved only at small scales $L_{JHS}$ determined by the largest viscous, turbulent, or diffusive Schwarz scale (Table 1) of HGT and various planetary and star formation processes that are induced at positive non-acoustic nuclei, with $L_J \gg L_{JHS}$. Using viscous forces, turbulent forces and diffusion it was shown from HGT-cosmology that the baryonic dark matter is dominated by small frozen planets ($10^{-6} M_\odot$ primordial fog particles, or PFPs) that fragmented by self gravity at the plasma to gas transition 300,000 years after the big bang, §2. This theoretical prediction was immediately and independently supported by observations of twinkling frequencies of a lensed quasar, suggesting the lensing galaxy mass is dominated by rogue planets “likely to be the missing mass” (Schild 1996). The Gibson & Schild 1996 prediction and observational demonstration that the baryonic dark matter is primordial micro-brown-dwarfs has since been confirmed by independent observations in the same and other lensed quasars, and by other observational evidence, §3.

HGT describes the formation of structure by self-gravitational condensations and rarefactions for cosmology, astrophysics and astronomy. The first gravitational structures to form were proto-supercluster-voids in the plasma epoch by fragmentation at 30,000 years after the big bang when viscous and weak turbulent forces first matched gravity forces at the horizon scale $L_H$, followed by proto-cluster-voids and proto-galaxy-voids filled with the weakly collisional non-baryonic-dark-matter (NBDM) by diffusion (Gibson 2000).
Cold dark matter condensations (CDM-halos) are excluded by HGT for scales smaller than $L_{SD} \gg L_H$ in the plasma epoch, and are not necessary to make structure in the gas epoch (after 300,000 years) by hierarchical-clustering-cosmology (HCC), which is also excluded by HGT. Gravitational clustering of collisionless CDM-halos would produce steep core cusps in galaxies that are not observed (Sand et al. 2002). The most distant galaxies observed are clustered (Steidel et al. 2000) and the closest clusters observed are fragmenting (Gibson & Schild 2003c), contrary to HCC. The early clusters predicted by HGT serve as gravitational lenses and produce arcs and multiple arcs of background galaxies at high rates of incidence that contradict all the flat-CDM cosmologies by orders of magnitude (Bartelmann et al. 1998). It is necessary to invent special “super-lensing” clusters to explain the multiple arcs observed in the recent Red-Sequence Cluster Survey and other studies, which would otherwise exclude the presently popular flat-$\Lambda$CDM cosmology by orders of magnitude (Gladders et al. 2003). Drag forces from the expansion of the universe rapidly separated proto-galaxies and helped fragment proto-galaxy-clusters at the plasma-gas transition (Gibson 1999a), making galaxy mergers quite rare rather than mandatory as in HCC, and explaining alignments of bright central supercluster galaxies with background QSOs by perspective that otherwise would confute CDMHCC, the big bang, and standard physics (Hoyle et al. 2000) without HGT (Gibson & Schild 2003a). Two of these rare galaxy mergers were imaged by the new HST/ACS wide angle camera in the Tadpole complex VV29abcdef (Gibson & Schild 2003b) and in Mice, showing star trails of young-globular-clusters (YGCs) produced as star formation is triggered from PGC-PFPs by the mergers of galaxies and their baryonic-dark-matter (BDM) halos. High resolution wide angle images by HST/ACS in the Helix planetary nebula and other nearby PNe in the Galaxy support the HGT prediction that galaxy disks are formed by accreted PGCs, and that the ISM has the high primordial PGC-PFP density fossilized at the time of first structure and expected in star forming regions (Gibson & Schild 2003c).

From HGT, density perturbations $\delta \rho(t)$ on scales $L \ll L_J$ in a uniform density gas are absolutely unstable to the formation of gravitational structure, and grow or decrease exponentially with time depending on the sign of the perturbation (see Reyden 2003 §12.1 but ignore §12.2). Let $\rho(t) = \rho + \delta \rho(t)$ inside a sphere of radius $\vec{r}$ and constant $\rho$ outside, where $\delta \rho(0) = \delta \rho(t = 0)$ and $L_C \ll |\vec{r}| \ll L_J$ with $L_C$ the particle collision length. As correctly shown in §12.1, self gravitation causes the density perturbation to either increase in magnitude and shrink in size (gravitational condensation, $\delta \rho(t) = \delta \rho(0)e^{\exp(t\sqrt{[4\pi G\rho]})}$), with $\delta \rho(0) > 0$, or increase in magnitude and grow in size (gravitational void formation, $\delta \rho(t) = \delta \rho(0)e^{\exp(-t\sqrt{[4\pi G\rho]})}$, with $\delta \rho(0) < 0$). Non-acoustic density fluctuations are absolutely unstable to self-gravitational formation of structure, just as shear layers are absolutely unstable to the formation of turbulence due to inertial-vortex forces $\vec{v} \times \vec{\omega}$, where $\vec{v}$ is velocity
and $\mathbf{\omega}$ is vorticity (Gibson 1999b). Both processes are highly non-linear so neither can be reliably described by linear perturbation stability analysis, and both couple very large scales to very small scales so they are difficult to simulate numerically. It is stated without proof in §12.2 (Reyden 2003) that pressure will prevent the exponential growth of density perturbations on length scales $L \ll L_J$. This is not true. The idea that “pressure support” or “thermal support” prevents structure formation on scales smaller than $L_J$ is an unfortunate legacy of the erroneous Jeans 1902 criterion for structure formation.

The time $t_S$ required for pressure waves (sound) to move a distance $L$ is $t_S = L/V_S$, where $V_S$ is the speed of sound. For $t_S = t_{FF} \equiv (G\rho)^{-1/2}$, $L = L_J$, so $\nabla p \rightarrow 0$ for $|\vec{r}| \ll L_J$ and $t_S \leq t \leq t_{FF}$. Density perturbations $\delta \rho(r \leq r_0, t = 0)$ of size $r_0$ grow to large values for $t \geq t_{FF}$ as we have seen. Pressure forces have the wrong sign to resist gravitational condensation except near the gravitational stagnation point because they arise from Bernoulli’s equation, where $p/\rho + v^2/2 \approx \text{constant}$. Pressure forces overcome condensational self gravitational forces $G\rho \delta \rho L$ on scales $L_{JHS} < r_0 \ll L_J$ only at late stages in a collapse ($\delta \rho > 0$) due to local irreversible processes (e.g. turbulence stresses, viscous heating, condensation of the gas to liquid form, freezing of the liquid, star formation), and have no effect on small scale self gravitational void formation forces ($\delta \rho < 0$) until the void size reaches $L_J$. The maximum speed of void growth is the maximum speed of a rarefaction wave, which is the speed of sound. Self-gravity has the effect of a negative density diffusivity $D_\rho G(L) \approx -L^2(\rho G)^{1/2}$ in the vicinity $L \leq L_{SD}$ (see Table 1 and §2) of a non-acoustic density maximum or density minimum, with the resulting absolute instability.

High resolution numerical simulations of stagnant gas show fragmentation and condensation at scales smaller than the Jeans scale, but in calculations to date these have been systematically filtered out as numerical artifacts (Truelove et al. 1997). The authors assume that pressure support or thermal support prevent sub-Jeans-scale self-gravitational condensations and fragmentations in astrophysical fluids and adjust their numerical simulations to conform to these assumptions.

The large gassy Jovian planets beyond Mars in the solar system are a mystery from the Jeans criterion because they violate the Jeans limit $M_J \geq 0.1M_\odot$ (Larson 1985). If we compute the Jeans mass $M_J = L_J^3 \rho$ and solve for the Jeans temperature $T_J$ we find

$$T_J \approx M_J^{2/3} \rho^{1/3} G R^{-1},$$

where $R = 8314/M_{mol} \text{ m}^2 \text{s}^{-2} \text{K}^{-1}$ is the gas constant and $M_{mol}$ is the gas molecular weight. Substituting a primordial H-He gas constant $R_{PM} \approx 3612 \text{ m}^2 \text{s}^{-2} \text{K}^{-1}$ and the primordial (first structure) gas density $\rho = 10^{-17} \text{ kg m}^{-3}$ for Jupiter mass $\approx 10^{27} \text{ kg}$ with $G = 6.7 \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}$ gives a Jeans temperature $T_J \approx 3.9 \times 10^{-2} \text{ K}$ that is impossibly cold. Why are Jupiter, Saturn, Uranus and Neptune all contrary to the Jeans limit? Numerous
extra-solar planets with Jupiter mass have now been detected that must also be composed of H-He gas. How are these possible? How are rocky planets possible? How are rocks possible? All are impossible by the Jeans criterion, and all are easily explained by HGT, §2. According to HGT, all large planets are formed by a hierarchical clustering of PFPs to form Jovian-PFP-Planets (JPPs) and all stars are formed by further accretion of PFP-JPPs and from their fragments and gas formed by the close proximity to the proto-star. Dust from supernovas is collected by numerous PFP-JPPs in the ISM and turned into rocks near their cores and the cores of the numerous large planets and brown dwarfs (JPPs) formed as the PFPs accrete. Multiple hydrogen freeze-thaw cycles of wandering PFP-JPPs produces many crushing central pressure episodes and layerings. Rocky planets like Earth are thus rocky cores of Jupiters evaporated as the star grows by JPP accretion.

Long period comets with random Oort cloud orbits $\approx 10^{16}$ m matching a typical PNe radius suggest that the trillions of Oort comets are from a few hundred PFPs constantly drizzling in from the sun’s accretion hole in the ISM (its Oort cloud inner radius according to HGT) that were not captured by the sun and its Jovians in their first accretional attempt and have not yet been completely fragmented by tidal forces and evaporated by radiation (Gibson & Schild 2003c). Orbit perturbations of 82 new (first-entry) class I (accurate) Oort comets imply the existence of a SIRTF-infrared and VLA-radio detectable $10^{28}$ kg JPP at $4 \times 10^{15}$ m (Matese et al. 1999). From HGT the inner radius of the Oort cloud is $3 \times 10^{15}$ m, corresponding to a solar mass accreted from a PGC, and the outer radius is $3 \times 10^{17}$ m, corresponding to the average extent of a PGC. Without HGT the origin of the huge numbers of fragile, frozen, Oort comets with their eccentric orbits, specific distance scale, and random directions is mysterious.

What about the inter-stellar-medium (ISM)? If there are really 30,000,000 PFPs per star in the average galaxy, shouldn’t some of these be revealed by their evaporated gas near very hot objects; for example, near carbon white dwarfs formed when ordinary stars have burned most of their H-He gas to form planetary nebulae, or in the ISM after novas and supernovas? Evidence that mysterious “free-floating planets pepper our galaxy” (June 2003 Astronomy cover page) is rapidly accumulating (Naeye 2003). The number of rogue Jupiters greatly exceeds predictions of “failed brown dwarf” and star expulsion models. Why do mysterious knots, comets and Herbig-Haro objects appear from the dark ISM whenever young stars form plasma jets? Where does the huge amount of gas in the halos of planetary nebulae come from? Are ordinary stars really so inefficient that most of their mass is wasted forming PNe halos? See §3 for a discussion of HST images of the Helix Planetary Nebula (Gibson & Schild 2003c), which is the closest PNe to earth, and its thousands of cometary globule PFP and JPP candidates.
HGT contradicts cold-dark-matter hierarchical-clustering-cosmologies (CDMHCC). CDM “halos” cannot remain gravitationally bound because the weakly collisional CDM particles are intrinsically much too diffusive, with \((L_{SD})_{CDM} \gg L_H\) during the plasma epoch. Hence, small primordial CDM “halos” (the key misconception) cannot cluster to provide massive gravitational potential wells to collect the baryonic matter and hierarchically form galaxies, clusters and superclusters with ever increasing mass as proposed by CDMHCC. Instead, HGT forms protosuperclusters first in the hot plasma epoch and these gently fragment to proto-clusters and then proto-galaxies as the plasma cools, starting at 30,000 years and finishing at the plasma to gas transition at 300,000 years. The gentle fragmentation from viscous-gravitational beginnings in a uniformly expanding universe explains the remarkable angular and geometric correlations observed between galaxies and quasi-stellar-objects (QSOs) with highly discordant red shifts that are used to contradict the big bang hypothesis (Hoyle et al. 2000).

Compact galaxy clusters like Stephan’s Quintet (SQ) with highly discordant redshifts support the hypothesis that redshifts may be intrinsic (Arp 1973) and that all the SQ galaxies are at the same distance and were ejected by galaxy NGC 7331 located at the same redshift \(z = 0.0027\) as the nearest member NGC 7320 of the SQ cluster. No physical explanation has been put forth for intrinsic redshifts and QSO ejections. The observations supporting these hypotheses can be easily explained by HGT without inventing new physics by recognizing that the galaxies and QSOs are aligned by perspective, and stay aligned along narrow lines of sight as the universe expands because their sticky beginnings allow only small transverse velocities. CDMHCCs are contradicted by the accumulation of evidence showing strong angular coincidences of QSOs and bright galaxies (Burbidge 2003). Stephan’s Quintet is presented as an example in §3.

2. Hydro-Gravitational Theory

Standard CDM cosmologies are flawed by their adoption of simplistic fluid mechanical equations that fail to incorporate significant forces, and by their inappropriate use of collisionless fluid mechanics. The ill-posed Jeans 1902 theory (neglecting non-acoustic density perturbations) is far too limited a basis for discussion of structure formation because it neglects viscous forces, turbulence forces, non-acoustic density fluctuations, particle collisions, and the effects of diffusion on gravitational structure formation. Jeans did linear perturbation stability analysis (neglecting turbulence) of Euler’s equations (neglecting viscous forces) to reduce the problem of gravitational instability of a nearly uniform ideal gas with density \(\rho\) only a function of pressure (the barotropic assumption) to one of gravita-
tional acoustics. Furthermore, to reconcile his equations with the linearized collisionless Boltzmann’s equations and the resulting Poisson’s equation for the gravitational potential (Binney & Tremaine 1987), Jeans assumed the density was zero in a maneuver appropriately known as the “Jeans swindle”. The critical wavelength for stability with all these questionable assumptions is the Jeans length scale $L_J$ given in Eq. 1 (see Table 1).

Density fluctuations in natural fluids are generally not barotropic as assumed by Jeans 1902 except in small regions and short times near powerful sound sources, but are dominated by non-acoustic (non-barotropic) density variations from turbulent mixing of temperature or chemical species concentrations (Gibson 2001). Even in the context of Jeans’ theory (without the Jeans swindle), any gravitational condensation on an acoustical density maximum rapidly converts to a non-acoustical density maximum because the accreted mass retains the momentum of the presumed motionless ambient gas. At this point one faces the more realistic problem of gravitational structure formation in a moving, viscous, diffusive, possibly turbulent gas that was addressed by Gibson 1996. Turbulence or viscous forces will dominate gravitational forces at small distances from a non-acoustic point of maximum or minimum density, but gravitational forces will dominate turbulent or viscous forces at larger distances if the gas does not diffuse away faster than it can condense or rarify due to gravity.

The Jeans 1902 analysis fails because the problem was ill posed. Self-gravitational structure formation in nature occurs on non-acoustic density maxima and minima, not sound wave crests, but Jeans started by assuming a uniform density, and was forced to set the density to zero in the Jeans swindle to avoid the nonlinear problems of non-acoustic density maxima forming at acoustic wavecrest. The geometry of evolving non-acoustic density fields at scales $L \leq L_J$ is shown in Figure 1, with (top) and without (bottom) self-gravitational instability. Without self-gravity a quasi-equilibrium at the Batchelor length scale (Table 1) exists, where the competition between diffusive smoothing of density gradients and strain rate steepening produces a universal turbulent mixing scale $L_B \equiv (D/\gamma)^{1/2}$ at points of maximum and minimum density (Gibson 1968) that begin to decay by diffusion as soon as turbulence scrambles a uniform density gradient to form such extrema with zero density gradients, as shown by experiments and numerical simulations (Gibson et al. 1988). Without gravity, points of maximum density always decrease by diffusion and points of minimum density increase, always moving and diffusing back toward the original configuration with uniform gradient and no density extrema.

Evidence of primordial turbulence in CMB anisotropies (Bershadskii & Sreenivasan 2002) suggests non-acoustic density maxima necessary to seed primordial gravitational structures were available in the plasma epoch. Assuming the same initial density conditions as Fig. 1 (top), the evolution of density with self gravity (bottom) is very different. The reason is that
gravity has the effect of causing a negative diffusivity $D_{\rho G}(L) = -L^2(\rho G)^{1/2}$ for distances $L < (D^2/\rho G)^{1/4}$ close to the points of zero density gradient and maximum or minimum density value. Negative density diffusivity causes absolute gravitational instability at non-acoustic density extrema. With self gravity (bottom) density maxima increase their density values toward infinity and density minima decrease their density values toward zero. Both experience exponential growth to form condensates and voids for all length scales $L \leq L_J$ unless limited by turbulent, viscous or diffusive effects at the appropriate Schwarz length scales.

Consider a well posed problem in self-gravitation. A mass perturbation $M(0)$ with scale $L \ll L_J$ suddenly placed in a motionless fluid of constant density $\rho$ at time $t = 0$ will increase as $M(t) = M(0)e^{2\pi\rho G t^2}$ unless viscous, turbulent, other forces or diffusion arise to prevent the exponential growth (Gibson 2000). Everything slowly begins to move toward or away from the mass perturbation for $t > 0$ and everything happens at once at $t \approx t_{FF} = (\rho G)^{-1/2}$. For $t < t_{FF}$ the radial velocity $v_r \approx -GM(0)t/r^2$ from Newton’s law of gravity, so the mass flow $dM(t)/dt \approx -4\pi r^2 v_r \approx 4\pi \rho GM(t)t$ and density $\rho$ are independent of radius. Thus, $dM(t)/M(t) \approx 4\rho G t$, so $M(t) = M(0)e^{2\pi\rho G t^2}$. Since everything happens within $L$ of the perturbation at $t \approx t_{FF}$, any “pressure support” mechanism is confined to this small space-time region and has no affect on the weakly accelerated fluid that slowly gains momentum at scales $L \leq L_J \leq x \leq ct$ and $L \leq x \leq L_J$ for times $t \leq t_{FF}$. Since it takes a time $t \approx t_{FF}$ for a sound wave to reach a distance $x \approx L_J$ in time $t \approx t_{FF}$, any hypothetical acoustic “pressure support” mechanism of the Jeans criterion would be too late to prevent the exponential density singularity at $t \approx t_{FF}$. Note that the time required for self-gravitational structure formation depends almost entirely on the mean density $\rho$ and only very slightly on the size of the density perturbation $\delta \rho \approx M(0)L^{-3}$.

The diffusion velocity is $D/L$ for diffusivity $D$ at distance $L$ and the gravitational velocity is $L(\rho G)^{1/2}$. The two velocities are equal at the diffusive Schwarz length scale

$$L_{SD} \equiv [D^2/\rho G]^{1/4}. \quad (3)$$

Weakly collisional particles such as the hypothetical cold-dark-matter (CDM) material cannot possibly form potential wells for baryonic matter collection because such particles have large diffusivity and will disperse, consistent with observations (Sand et al. 2002). Diffusivity $D \approx V_p \times L_C$, where $V_p$ is the particle speed and $L_C \approx 1/n\sigma$ is the collision distance for particles with number density $n = \rho/m$, $\sigma$ is the collision cross section, and $m$ is the particle mass. CDM particles have $\sigma_{CDM} \approx 10^{-40}$ m$^2$ or less compared to baryonic $\sigma_B \approx 10^{-20}$ m$^2$ values. Weakly collisional particles thus have large collision distances $L_C$ and therefore large diffusivities $D$ and large diffusive Schwarz lengths $L_{SD}$. Therefore, the non-baryonic dark matter (possibly neutrinos) must be the last material to fragment by self gravity and not
the first as assumed by CDM cosmologies. In HGT galaxy formation (Gibson 1996), the NBDM diffuses to form either an outer halo of the galaxy if the galaxy is isolated, or diffuses completely away from the baryonic galaxy to become part of a galaxy cluster halo or galaxy supercluster halo at Mpc scales $3 \times 10^{22}$ m or more.

The baryonic matter is subject to large viscous forces, especially in the hot primordial plasma from photon viscosity and gas states from large $V_p$ values existing when most gravitational structures first formed, where $\nu \approx V_p \times L_C$ if $L_C \leq L_H$. The viscous forces per unit volume $\rho \nu \gamma L^2$ dominate gravitational forces $\rho^2 G L^4$ at small scales, where $\nu$ is the kinematic viscosity and $\gamma$ is the rate of strain of the fluid. The forces match at the viscous Schwarz length

$$L_{SV} \equiv (\nu \gamma / \rho G)^{1/2},$$

which is the smallest size for self gravitational condensation or void formation in such a flow. Turbulent forces may require even larger scales of gravitational structures. Turbulent forces $\rho \varepsilon^{2/3} L^{8/3}$ match gravitational forces at the turbulent Schwarz scale

$$L_{ST} \equiv \varepsilon^{1/2} / (\rho G)^{3/4},$$

where $\varepsilon$ is the viscous dissipation rate of the turbulence. Thus in strongly turbulent regions with large $\varepsilon$ values one expects large stars to form because the turbulent Schwarz scales are larger than any other hydro-gravitational scale. In the cold, turbulent, dense molecular clouds of the Milky Way Galaxy disk where the Jeans mass is near $M_\odot$ or less, few stars form compared to the rate expected by the Jeans criterion because $L_{ST} \gg L_J$.

The Jeans criterion is nearly irrelevant to gravitational structure formation triggered by non-acoustic density maxima and minima where structures can form at scales that are either larger or smaller than $L_J$. By Jeans’ criterion no structures can form in the primordial plasma because $L_J$ during this hot, dense, epoch is always larger than the scale of causal connection $L_H \equiv c t$, where $c$ is the speed of light and $t$ is the time since the big bang. However, the viscous and turbulent Schwarz scales $L_{SV} \approx L_{ST}$ became smaller than $L_J$ during this period, and first matched the more rapidly increasing $L_H$ at time $t \approx 10^{12}$ seconds (Gibson 1996), well before $10^{13}$ seconds which is the time of plasma to gas transition (300,000 years). Because the expansion of the universe inhibited condensation but enhanced void formation in the weakly turbulent plasma, the first structures were proto-supercluster-voids. At $10^{12}$ s the Reynolds number was near critical so that

$$(L_{SD})_{NBDM} \gg L_{SV} \approx L_{ST} \approx 5 \times L_K \approx L_H \approx 3 \times 10^{20} \text{m},$$

where $L_{SD}$ applies to the non-baryonic component and $L_{SV}$, $L_{ST}$, and $L_K$ apply to the baryonic component.
As proto-supercluster fragments formed the voids between filled with non-baryonic matter by diffusion, inhibiting further structure formation by decreasing the gravitational driving force. The baryonic mass density $\rho \approx 2 \times 10^{-17}$ kg/m$^3$ and rate of strain $\gamma \approx 10^{-12}$ s$^{-1}$ were preserved as hydrodynamic fossils within the proto-supercluster fragments and within proto-cluster and proto-galaxy objects resulting from subsequent fragmentation as the photon viscosity and $L_{SV}$ decreased prior to the plasma-gas transition and photon decoupling (Gibson 2000). As shown in Eq. 5, the Kolmogorov scale $L_K \equiv [\nu^3/\varepsilon]^{1/4}$ at the time of first structure nearly matched the horizon scale $L_H \equiv ct$ and the viscous and turbulent Schwarz scales, freezing in the density, strain-rate, and spin magnitudes and directions of the proto-cluster and proto-galaxy fragments of proto-superclusters. Remnants of the strain-rate and spin magnitudes and directions of the weak turbulence at the time of first structure formation are forms of fossil vorticity turbulence (Gibson 1999b). Thus HGT naturally explains observed bright galaxy spin alignments and close angular associations with each other and quasars without assuming intrinsic red shifts and mutual ejections.

The quiet condition of the primordial gas is revealed by measurements of temperature fluctuations of the cosmic microwave background radiation, which show an average $\delta T/T \approx 10^{-5}$, much too small for any turbulence to have existed at that time of plasma-gas transition. This is to be expected because any turbulent plasma motions would have been strongly damped by buoyancy forces after the first gravitational fragmentation time $10^{12}$ s. Viscous forces in the plasma are inadequate to explain the lack of primordial turbulence (kinematic viscosity $\nu \geq 10^{30}$ m$^2$ s$^{-1}$ is required versus only $4 \times 10^{26}$ m$^2$ s$^{-1}$ from Gibson 2000). The gas temperature, density, viscosity, and rate of strain are all precisely known at transition, so the gas viscous Schwarz mass $L_{SV}^3 \rho$ is $\approx 10^{24}$ kg, the mass of a small planet, or $\approx 10^{-6} M_\odot$. From HGT, soon after the cooling primordial plasma turned to gas at $10^{13}$ s (300,000 yr), the entire baryonic universe condensed to a fog of planetary-mass primordial-fog-particles (PFPs). These gas-cloud objects gradually cooled, formed H-He rain, and eventually froze solid to become the baryonic dark matter and the basic material of construction for stars and everything else, $\approx 30 \times 10^6$ rogue planets per star. The PFP mass $\approx 10^{-6} M_\odot$ is above the evaporation stability limit $\approx 10^{-7} M_\odot$ (De Rujula et al. 1992).

The Jeans mass $L_J^3 \rho$ of the primordial gas at transition was $\approx 10^6 M_\odot$, the mass of a globular star cluster. Proto-galaxies fragmented at the PFP scale but also at this proto-globular-star-cluster PGC scale $L_J$, although not for the reason given by the Jeans 1902 theory. Density fluctuations in the gaseous proto-galaxies were absolutely unstable to void formation at all scales larger than the viscous Schwarz scale $L_{SV}$. Pressure can only remain in equilibrium with density without temperature changes in a gravitationally expanding void on scales smaller than the Jeans scale. From the second law of thermodynamics, rarefaction wave speeds that develop as density minima expand due to gravity to form voids are limited
to speeds less than the sonic velocity. Cooling would therefore occur and be compensated by radiation in the otherwise isothermal primordial gas when the expanding voids approached the Jeans scale. Gravitational fragmentation of proto-galaxies will then be accelerated by radiative heat transfer to these cooler regions, resulting in fragmentation at the Jeans scale and isolation of proto-globular-star-clusters (PGCs) with the primordial-gas-Jeans-mass.

These $10^{36}$ kg PGC objects were not able to collapse from their own self gravity because of their internal fragmentation at the viscous Schwarz scale to form $10^{24}$ kg PFPs. The fact that globular star clusters have precisely the same density and primordial-gas-Jeans-mass from galaxy to galaxy proves they were all formed simultaneously soon after the time of the plasma to gas transition $10^{13}$ s. The gas has never been so uniform since, and no mechanism exists to recover such a high density, let alone such a high uniform density, as the fossil turbulent density value $\rho \approx 2 \times 10^{-17}$ kg/m$^3$. Young globular cluster formation in BDM halos in the Tadpole, Mice, and Antennae galaxy mergers show that dark PGC clusters of PFPs are remarkably stable structures, persisting without disruption or star formation for more than ten billion years.

So the proto-galaxies (PGs) before stars were rapidly fragmented at both the Jeans and viscous Schwarz scales to form PGCs, a million per galaxy, with embedded PFPs, a trillion per PGC and $10^{18}$ per PG. Viscous forces inhibited the formation of larger planetoids by accretion of the PFPs except at the cores of the PGCs and the cores of the PGs. It was a very quiet and gentle time. The gentleness of this time of first star formation is reflected in the small, uniformly distributed, long-lived, Population II stars of the ancient globular-star-clusters observed in the Milky Way Galaxy. The time to form the first of these stars was probably one million years (the primordial density free fall time), not the 275 million “dark age” years required by the standard CDM model while the CDM halos formed by frictionless clustering of CDM seeds. Open star clusters formed from captured and disrupted PGCs in the Galaxy disk are exposed to higher levels of radiation and tidal friction than PGCs in the BDM halo, and form large irregularly distributed stars. The large sizes of the disk stars and their slow rate of formation reflect the high turbulence levels of disk star forming regions (from supernovas) compared to the low turbulence levels existing where stars are formed in isolated PGCs. From HGT, the thin disks of spiral galaxies are accretion disks forming within large, massive, spherical BDM halos surrounding the original smaller denser $\approx 10^{20}$ m galaxy cores from which the PGCs diffused, rather than collapsed gaseous pancakes in CDM halos as envisaged in CDM standard models. Relatively low gas levels are observed in spiral galaxy cores according to HGT, where excess gas is frozen out on the ambient PFPs.

With the expansion of the universe and further cooling, the PGCs and PFPs cooled as well, reaching the 14 K freezing point of hydrogen at about a redshift of 30 at a time
about 80 My. Because most of the gas is isolated in individual PFPs separated from their neighbors by distances of about $10^{14}$ m corresponding to the primordial density, and because most PFPs within a PGC are initially surrounded homogeneously by identical objects with the same spacing, the tendency without external forcing would be for them to slow down due to friction from the inter-PFP gas and remain isolated indefinitely. After freezing, the PFP collision cross section will decrease but the inter-PFP gas density and friction will also decrease, permitting speedup of the PFPs and a new meta-stable state of equilibrium. The Gunn-Peterson trough phenomenon shows intergalactic gas effectively vanishes for red shifts smaller than 6 ($t \approx 700$ My) in quasar spectra with their Lyman-α forests of intervening galaxies. This suggests that most baryonic-dark-matter galaxy halo gas has frozen out on PFPs embedded in the BDM halos at times less than a billion years after the big bang.

As the inter-PGC gas density decreases with time since PFP creation, these PGC clumps of condensing baryonic dark matter become increasingly collisionless and diffusional. Those formed near the core of the proto-galaxy have a higher likelihood of mutual capture, interaction, disruption, and conversion to stars, but those formed on the periphery of the proto-galaxy will tend to either capture each other to form proto-dwarf-galaxies or diffuse to larger and larger orbits. The inner PGCs should be the most agitated by tidal forces and therefore the most likely to form stars and eventually the full population of $10^6$ stars observed in a globular star cluster. Those further out might form only a few thousand stars and drift to the outskirts of the luminous portion of the galaxy, sometimes being captured or disrupted by the disk, but the largest number diffusing farther out to form the baryonic-dark-matter (BDM) halo of the galaxy, invisible unless disturbed by intruders as in the case of the Tadpole merging galaxy system (VV29=Arp 188=UGC 10214). Figure 3 shows the HST/ACS image with its combination of wide field and high resolution, which clearly reveals the existence of star wakes, a dark dwarf galaxy and young-globular-clusters triggered into existence from the dark baryonic-dark-matter halo by the merging cluster of galaxy components VV29cdef as they spiral in to the central galaxy VV29a and merge (Gibson & Schild 2003b).

Sparse globular clusters such as Palomar 5 with luminous mass $10^4 M_\odot$ and Palomar 13 with luminous mass $10^3 M_\odot$ observed in the Milky Way are likely dim rather than disrupted PGCs with 98% to 99.9% of their mass intact as dark-matter PFPs. Nearly half of the stars of Pal 5 are observed as long tidal tails along its orbit about the Galaxy center (Rockosi et al. 2002), suggesting that the same tidal forces that produced the tails may also be producing the stars from a large supply of remaining PFPs. The amount of dark matter in dim globular clusters like Pal 5 and Pal 13 in the Milky Way, and in Galactic dwarf spherical galaxies (dSphs), is likely underestimated in virial estimates $M \approx (Rv^2/G)$ of the dark mass $M$ because friction from PFP gas is neglected that reduces the velocity variance $v^2$ of the stars within radius $R$. A mass-to-light ratio $\Upsilon \approx 40$ for Palomar 13 was recently
reported (Cote et al. 2002), which is the first estimate from \( v^2 \) measurements in dim globular star clusters and is much higher than \( \Upsilon \approx 2 \) expected. In another estimate (Cote et al. 2002 Fig. 14b) \( \Upsilon \approx 7000 \) fitting to the luminosity relation for dSphs which is closer to the value \( \Upsilon \approx 1000 \) expected from HGT. Large \( \Upsilon \) values measured in dSph galaxies have been assumed to reflect non-baryonic CDM halos (Cote et al. 2002), but from Tadpole we see PGC and dSph dark matter is mostly baryonic because it forms stars when agitated.

The hydro-gravitation-theory (HGT) scenario presented here is significantly different from standard CDMHC cosmology based on Jeans 1902 precepts. Gravitational structures in the baryonic matter fragmented during the plasma epoch with supercluster to galaxy masses. The protosuperclusters have the observed uniform supercluster mass of about \( 10^{47} \) kg (including their non-baryonic halos), with a uniformity not expected for hierarchical clustering of CDM halos assumed in the standard CDMHC model. Weak primordial turbulence is damped by buoyancy forces of the first structures to form fossil vorticity turbulence (Gibson 1999b). The density and rate-of-strain values at the time of first structure (\( 10^{12} \) s) are preserved (fossilized), and can still be detected in the density of globular star clusters and the masses of PFPs. The non-baryonic matter diffused to fill the protosupercluster-voids, limiting the amplitude of the density contrast formed to the small values observed in the CMB. Superclusters, clusters and galaxies never contracted or collapsed but continue to fragment and gently expand at slower rates than the rest of the universe.

3. Evidence Supporting the Hydro-Gravitational Theory

Evidence supporting the hydro-gravitational theory of structure formation is gradually accumulating. High resolution telescope images in star forming regions and supernova remnants are full of poorly explained small objects, knots and “ejecta” that are likely to be evaporating PFPs. Cometary globules and the huge masses of gas observed by the HST near hot dying stars in planetary nebulae are much more easily explained as the result of evaporating ambient PFPs in the interstellar medium than they are as ejecta. Plasma beams from young stars produce Herbig-Haro objects with cometary tails, and the plasma beams themselves pulsate as though the accreted material forming the star contained planetary mass chunks. Numerous brown dwarfs and Jupiters have been detected whose origin is mysterious without HGT. The total mass of extra-solar planets discovered increases with decreasing planet-mass, even though low mass extra-solar planets are more difficult to detect, as expected if extra-solar planets are formed by accretion of ambient PFPs before their capture by stars.

The closest planetary nebula is Helix, Figure 2, where some 6500 cometary globules
have been identified, each with mass about $10^{25} \text{ kg}$ and size $10^{13} \text{ m}$, and separated by about $10^{14} \text{ m}$ (O’Dell & Handron 1996). Radial tails point away from the hot, central, white dwarf star at $\approx 4 \times 10^{15} \text{ m}$. The mass $\approx 2 \times 10^{25} \text{ kg}$ and separation distances $\approx 10^{14} \text{ m}$ of the Helix cometary globules give a halo density $\rho \approx 10^{-17} \text{ kg m}^{-3}$, suggesting that PFPs originally in a sphere with radius $\approx 4 \times 10^{15} \text{ m}$ have accreted to form the central star out of an ISM with mass dominated by PFPs, with primordial density $\rho \approx 10^{-17} \text{ kg m}^{-3}$, leaving PFPs at the hole boundary (Oort Cloud) evaporated and illuminated by the hot dying star. Measured evaporation rates (Meaburn et al. 1998) are too high for the globules shown in Figure 2 to be PFPs, so they must be JPPs with at least Jupiter mass to have survived this long (Gibson & Schild 2003c). If the ISM surrounding the Helix represents a dark proto-globular-star-cluster (PGC), the PN represents the luminous boundary of a hole formed by accreted PFPs to form the illuminating central star, with mass $\approx 10^{-5} \text{ of the surrounding ISM PGC baryonic dark matter cloud of PFPs}$. The gas in the nebula is of order the mass of the star, but the total mass of the atmosphere of the dying star before it is ejected should be less than about $10^{-7} M_\odot$.

The mass density for the Helix globules $10^{-14} \text{ kg/m}^3$ is three orders of magnitude larger than the density of any atmosphere ejected by the white dwarf star. Shock waves can increase densities by no more than factors $\approx 6$, not the factors $\approx 10^7$ required to explain the objects of Figure 2. These cometary globules are usually explained as due to Rayleigh-Taylor instability, where a dense gas shell ejected first is accelerated by a lighter shell ejected more rapidly later, but RT instability cannot increase the density of the dense shell by many orders of magnitude or decrease the density in the RT fingers to form wakes as observed. RT fingers only form in a narrow range of Reynolds numbers near critical, but this is not the case for the Helix objects. If the cometary globule separations in Helix reflects that of the ambient PFP population, the mass density of PFPs is near the value $10^{-17} \text{ kg/m}^3$ expected for a PGC. The PGC may have supplied the PFPs from which the Helix star was formed, consistent with the size of the $4 \times 10^{15} \text{ m}$ region surrounding the white dwarf that is observed to be empty of cometary globules (Gibson & Schild 2003c).

However, the most conclusive and convincing evidence for the PGC-PFP HGT scenario is still the technically challenging one of quasar microlensing. The Schild 1996 interpretation that the QSO 0957+561A,B quasar lens galaxy must be dominated by planetary mass objects is based on the observed high twinkling frequency of the two quasar images A,B. The initially controversial Schild time delay has now been confirmed by several independent observers, and is in the process of further refinement by an international team of observers using telescopes at sufficient points on the Earth to provide continuous coverage and independent confirmation of the twinkling QSO 0957+561A,B light curves (Colley et al. 2002, 2003). At this time four other lensed quasars have been observed with sufficiently precise time
delays of the mirage images to extract the planetary mass twinkling frequencies, and these have been observed and reported (Burud et al, 2000, 2002; Hjorth et al. 2002, Schechter et al. 2002). The specific microlensing profile discovered in Q0957 by Colley and Schild (2003) with high statistical significance shows that the lens galaxy G1 halo population has a significant optical depth of planetary mass objects, and the double-ring halo model of Schild and Vakulik (2003) shows how such rapid microlensing plausibly follows from simulations.

Evidence of substructure in several lensing galaxies is reported by Dalal and Kochanek 2002 from the difference in brightness of the background source mirages, with substructure masses in the range $10^6 - 10^9 M_\odot$. This evidence is presented to suggest that the missing CDM halos of the local group of galaxies is not a crisis for the hierarchical CDM model of galaxy formation that overestimates the numbers of dwarf galaxies by orders of magnitude compared to observations because the actual galaxy substructures may be dark. However, the substructure evidence (Dalal and Kochanek 2002) of dark non-baryonic CDM halos may also be interpreted as evidence that significant fractions of the lens galaxies central masses are in dark baryonic clumps. Dark PGC clumps of PFPs dominating central galaxy masses is predicted by HGT. Clumps of dark PGCs triggered to form clumps of YGCs by the star formation wake of VV29c are indicated in the VV29b filament of Tadpole by the HST/ACS images (Tran et al. 2003), Figure 3.

Merging galaxy systems such as the Tadpole, Mice, and Antennae are characterized by the appearance out of the dark of young-globular-clusters (YGCs) and large quantities of gas. Using the HST and a wide variety of other telescopes to cover a broad range of frequencies (Zhang et al. 2001), nearly a thousand YGCs have been identified and studied in the Antennae system (NGC 4038/9), which is the closest merging galaxy system at only $6 \times 10^{23}$ m. At this distance the clusters are well resolved. The mass function inferred from the luminosity for the young (5 Myr) globular clusters in Antennae (Fall and Zhang 2001) is very different than that for old ($\geq 10$ Gyr) globular clusters (OGCs), falling with power law slope -2 from a maximum near $10^4 M_\odot$ rather than showing the narrow lognormal peak near $2 \times 10^5 M_\odot$ widely observed for OGCs. The brightest YGCs have the same mass as the OGCs. We suggest that the low masses of the most numerous YGCs is simply because most of the mass of the PGCs from which these YGCs are forming is still tied up in dark matter PFPs that are rapidly accreting to form stars under the influence of the tidal merger.

Figure 4 shows an HST image of Stephan’s Quintet (SQ, HGC 92, Arp 319, VV 288) which is number 92 in the Hickson catalog of compact clusters. Like over 40% of the HGCs, the SQ galaxies (Burbidge and Burbidge 1961) have highly discordant redshifts. These are easily explained by HGT, where the SQ and other HGC galaxies with discordant redshifts represent galaxy clusters that have gently separated only recently due to the expansion of the
universe (Gibson & Schild 2003a). The star wakes in Figure 4 show luminous evidence of the baryonic dark matter cluster halo and its boundary. No evidence of a galaxy merger is shown, in contrast to the Tadpole merger in Figure 3 where the merged galaxy is revealed. Numerous young globular clusters (YGCs) have been identified in SQ (Gallagher et al. 2001), confirming the HGT prediction that the baryonic dark matter consists of PGC clumps of PFPs that can be triggered to form stars by radiation and tidal forces.

Figure 5 shows the tomographic mass distribution of the rich galaxy cluster Abell 1689 determined from the gravitational distortion of 6000 background galaxy images by 4000 foreground galaxies in the cluster (Tyson & Fischer 1995). A mass to light ratio of about 400 suggests the cluster halo is non-baryonic dark matter with an extent determined by the NBDM particle diffusivity $D_{NBDM}$ and the large cluster density. The Schwarz diffusive scale $L_{SD} \equiv (D_{NBDM}^2/\rho G)^{1/4}$ from the mass profile is $\approx 10^{22}$ m, giving $D_{NBDM} \approx 6 \times 10^{28}$ m$^2$ s$^{-1}$ from the cluster density $5 \times 10^{-21}$ kg m$^{-3}$. Such a large diffusivity excludes any possibility that the outer dark matter halo is baryonic. It fixes the value of the $m/\sigma$ ratio to a value $\rho D(r/GM)^{1/2} \approx 10^3$ kg m$^{-2}$. Because the maximum collision cross section $\sigma$ for non-baryonic matter is about $\leq 10^{-36}$ m$^2$, the maximum particle mass for the NBDM is $\leq 10^{-33}$ kg, excluding WIMPs with $m \gg 10^{-27}$ kg as NBDM candidates by large factors. For example, the neutralino mass is about $10^{-24}$ kg, giving a $\sigma$ value of $10^{-27}$ m$^2$, which is so large that neutralino-NBDM would be easily detected. The NBDM becomes unstable to gravitational fragmentation when $L_{SD}$ becomes less than the horizon scale $L_H$. This occurs at $t \approx (D^2/\rho G)^{1/4}c^{-1}$, soon after the plasma-gas transition at 300,000 years, for the indicated diffusivity. Outer halos scale with $M^{-1/4}$ so the galaxy NBDM outer-halo-radius is $\approx 1.5 \times 10^{22}$ m, or about four times the observed BDM inner-halo-radius for the Tadpole galaxy (Gibson & Schild 2003b). Since baryons can be no more than $\approx 1/30$ of the mass of a flat universe from nucleosynthesis, non-baryons can be no more than $\approx 30$ times the mass of baryons. Thus (neglecting any $\Lambda$ contribution) galaxy outer halo densities are dominated by non-baryons and galaxy inner halo densities are dominated by baryons.

4. Conclusions

High resolution images of the Helix Nebula, the Tadpole merger and the Stephan Quintet (SQ) compact cluster support the hydro-gravitational theory (HGT) prediction that primordial-fog-particles (PFPs) in proto-globular-star-clusters (PGCs) dominate baryonic dark matter (BDM) inner-galaxy-halos and the interstellar medium (ISM). Young globular clusters and star wake alignments in Tadpole and SQ are explained by HGT and are not explained by previous models. Evidence accumulates showing high frequency twinkling of
quasar images lensed by foreground galaxies, confirming that the galaxy missing baryonic mass is dominated by PFP mass “rogue planets” (Schild 1996).

Large numbers of extra-solar planets have been discovered with Jupiter mass which must be made of H-He gas, but which are shown to be impossible by the Jeans 1902 gravitational structure formation criterion in §1. Such planets cannot be formed by condensation on rocky cores because the formation of rocks is also impossible by the Jeans criterion. Jupiters and rocks form naturally using hydro-gravitational theory (Gibson 1996) by accretion of PFPs to form larger planets and stars, and by gravitational accumulation of the dust of supernovas by PFPs and larger planets to form rocky cores. The Helix Nebula and other planetary nebula show evidence that the ISM mass is dominated by PFPs as predicted by HGT. These accrete to form JPPs; Jupiters, brown dwarfs and stars. Evidence that the total mass of small extra-solar JPPs exceeds the total mass of larger extra-solar JPPs, as expected from HGT, suggests that the total mass of brown dwarfs in a galaxy exceeds the mass of stars. This prediction of HGT can be tested by the Space InfraRed Telescope Facility (SIRTF) when it is launched, possibly this year.

Stephan’s Quintet is an example of many compact clusters of galaxies with discordant red shifts that refute CDMHCC and support HGT. HST images confirm the PGC-PFP baryonic dark matter halo model indicated by the Tadpole merger, but show star wakes of cluster galaxies separating through the BDM cluster halo rather than merging as shown by Tadpole and as predicted by HGT. Angular clustering of QSOs and bright galaxies (Burbidge 2003) also rule out CDMHCC and support either HGT without new physics or intrinsic red shifts and QSO ejection by AGN galaxies (Arp et al. 2001) and a possible failure of the big bang hypothesis (Hoyle et al. 2000). The forty year authoritative accumulation of inexplicable angular clustering of galaxies, clusters and QSOs with anomalous red shifts are readily explained by HGT as the result of perspective and gentle straining along lines of sight by the expansion of the universe, with small transverse velocities reflecting the viscous origins and frictional effects of fragmenting clusters in gassy, baryonic, galaxy and cluster halos.

From HGT and the mass distribution (Tyson & Fischer 1995) computed for a rich galaxy cluster we find the NBDM particle mass is too small to be a CDM candidate, with fragmentation scales for non-baryonic-dominated outer-galaxy-halos larger than radius values observed for baryon-dominated inner-galaxy-halos. Cusps at galaxy cores expected from small, clustered, collisionless, CDM-halos are not observed (Sand et al. 2002). Hierarchical clustering cosmologies are contradicted by the incidence of strong-lensing clusters (Gladders et al. 2003). The most distant observable galaxies are already clustered (Steidel et al. 2000) and the closest clusters (Gibson & Schild 2003c) are fragmenting. HGT and the preponderance of accumulated evidence suggest that cold-dark-matter, hierarchical-
clustering-cosmologies (CDMHCCs), and the Jeans 1902 gravitational structure formation criterion are physically incorrect and contrary to observation, and should be abandoned.

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Non-acoustic density extrema without self-gravity

Condensation and void formation with self-gravity

\[ L_J \geq L \geq L_{SD} \quad t = \left[ \rho G \right]^{-1/2} \]

Fig. 1.— Schematic diagrams of non-acoustic iso-density surfaces without self-gravitation (top) and with self-gravitation (bottom). The mean density is \( \bar{\rho} \). Without self-gravitation turbulence scrambles density to produce maximum points (+), minimum points (−) and doublets (+−) that diffuse to symmetric geometries and then move with the fluid (Gibson 1968) at the Batchelor diffusive scale \( L_B \) (see Table 1). With self-gravitation (bottom) on scales smaller than the Jeans scale \( L_J \) the effective diffusivity becomes negative for scales \( L \) smaller than the diffusive Schwarz scale \( L_{SD} \). Density maxima and minima are absolutely unstable and grow exponentially to form condensates or voids unless limited by turbulence, viscosity or diffusion at the appropriate Schwarz scale \( L_{ST}, L_{SV}, \) or \( L_{SD} \), whichever is largest. Note that for primordial non-baryonic cold dark matter (CDM) \( L_{SD} \gg L_J > L_H \); consequently no self-gravitational (CDM-halo) structures can form.
Fig. 2.— Evaporating JPPs observed by HST in the Helix Planetary Nebula, $4.5 \times 10^{18}$ m from Earth (O’Dell & Handron 1996).
Fig. 3.— Interpretation of HST/ACS Tadpole image (April 30, 2002 press release) using the Gibson 1996-2000 hydro-gravitational structure formation cosmology, where the merging galaxy structures VV29cdef enter the VV29a dark halo at lower right (dashed line) and merge along luminous trails of star formation triggered by radiation and tidal forces acting on the PGCs and PFPs of the dark halo of VV29a. The VV29b galaxy is interpreted as a star-wake of VV29cdef merging galaxy components in the VV29a dark baryonic halo, and not as any sort of collisionless tidal tail. Star formation regions (visible in higher resolution images) triggered in the baryonic-dark-matter by AGN jets of VV29e and a background galaxy are shown by arrows. A dark dwarf galaxy is revealed by a straight row of $\geq 42$ closely spaced YGCs (Tran et al. 2003) pointing precisely ($\leq 1^\circ$) toward the VV29c entry star-wake. North is to the left and East is to the bottom.
Fig. 4.— Hubble Space Telescope image of Stephan’s Quintet. Dust and star wakes (arrows) are produced as SQ related galaxies gently separate from each other through the cluster baryonic-dark-matter (BDM) halo of PGCs and PFPs, triggering star formation. Star wakes of mergers and collisions are not observed. Widely differing red shifts ($z = 0.022, 0.022, 0.019, 0.0027$) show the galaxies are in a thin (1/700) pencil stretched by the expansion of the universe (Gibson & Schild 2003a). The galaxies fragmented recently and stay in the line-of-sight pencil due to perspective and their small transverse velocities and viscous-gravitational origin according to HGT, contradicting CDMHCC.
Fig. 5.— Mass distribution of rich galaxy cluster Abell 1689 determined by a tomographic analysis using gravitational distortions of 6000 background galaxies by 4000 foreground galaxies (Tyson & Fischer 1995). The mass of the cluster is about $10^{45}$ kg with redshift $z = 0.18$ and average core density $5 \times 10^{-21}$ kg m$^{-3}$. The large mass to light ratio of 400 suggests that the dark matter halo is non-baryonic. Interpreting the halo size $10^{22}$ m as the Schwarz diffusive scale $L_{SD}$ gives a large diffusivity $D_{NBDM} \approx 6 \times 10^{28}$ m$^2$ s$^{-1}$ that also suggests the halo is non-baryonic.
Table 1. Length scales of self-gravitational structure formation

| Length scale name     | Symbol | Definition$^a$                                  | Physical significance$^b$ |
|-----------------------|--------|-----------------------------------------------|---------------------------|
| Jeans Acoustic        | $L_J$  | $V_S/\sqrt[2]{\rho G}$                       | ideal gas pressure equilibration |
| Jeans Hydrostatic     | $L_{JHS}$ | $[p/\rho^2 G]^{1/2}$                         | hydrostatic pressure equilibration |
| Schwarz Diffusive     | $L_{SD}$ | $[D^2/\rho G]^{1/4}$                         | $V_D$ balances $V_G$         |
| Schwarz Viscous       | $L_{SV}$ | $\gamma \nu/\rho G^{1/2}$                     | viscous force balances gravitational force |
| Schwarz Turbulent     | $L_{ST}$ | $\varepsilon^{1/2}/[\rho G]^{3/4}$          | turbulence force balances gravitational force |
| Kolmogorov Viscous    | $L_K$  | $[\nu^3/\varepsilon]^{1/4}$                   | turbulence force balances viscous force |
| Batchelor Diffusive   | $L_B$  | $[D/\gamma]^{1/2}$                           | diffusion balances strain rate |
| Collision             | $L_C$  | $m\sigma^{-1}\rho^{-1}$                       | distance between particle collisions |
| Horizon, Hubble       | $L_H$  | $ct$                                          | maximum scale of causal connection |

$^aV_S$ is sound speed, $\rho$ is density, $G$ is Newton’s constant, $D$ is the diffusivity, $V_D \equiv D/L$ is the diffusive velocity at scale $L$, $V_G \equiv L[\rho G]^{1/2}$ is the gravitational velocity, $\gamma$ is the strain rate, $\nu$ is the kinematic viscosity, $\varepsilon$ is the viscous dissipation rate, $m$ is the particle mass, $\sigma$ is the collision cross section, light speed $c$, age of universe $t$.

$^b$Magnetic and other forces (besides viscous and turbulence) are negligible for the epoch of primordial self-gravitational structure formation considered here (Gibson 1996).
### Table 2. Acronyms

| Acronym | Meaning | Physical significance |
|---------|---------|-----------------------|
| BDM     | Baryonic Dark Matter | PGC clumps of PFPs from HGT |
| CDM     | Cold Dark Matter     | questioned concept     |
| CDMHCC  | CDM HCC             | questioned concepts    |
| HCC     | Hierarchical Clustering Cosmology | questioned concept |
| HGC     | Hickson compact Galaxy Cluster | Stephan’s Quintet (SQ=HGC 92) |
| HGT     | Hydro-Gravitational Theory | modifies Jeans 1902 |
| ISM     | Inter-Stellar Medium | mostly PFPs and gas from PFPs |
| JPP     | Jovian PFP Planet   | planet formed by PFP accretion |
| NBDM    | Non-Baryonic Dark Matter | possibly neutrinos |
| OGC     | Old Globular star Cluster | PGC forms stars at $t \approx 10^6$ yr |
| PFP     | Primordial Fog Particle | planet-mass protogalaxy fragment |
| PGC     | Proto-Globular star Cluster | Jeans-mass protogalaxy fragment |
| YGC     | Young Globular star Cluster | PGC forms stars at $t \approx$ now |