arXiv:0710.5449v3 [astro-ph] 31 Oct 2007

Interpretation of the Stephan Quintet Galaxy Cluster using Hydro-Gravitational-Dynamics: Viscosity and Fragmentation

Carl H. Gibson[1]

Departments of Mechanical and Aerospace Engineering and Scripps Institution of Oceanography, University of California, San Diego, CA 92093-0411

cgibson@ucsd.edu

and

Rudolph E. Schild

Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138

rschild@cfa.harvard.edu

ABSTRACT

Stephan's Quintet (SQ) is a compact group of galaxies that has been well studied since its discovery in 1877 but is mysterious using cold dark matter hierarchical clustering cosmology (CDMHCC). Anomalous red shifts $z = (0.0027, 0.019, 0.022, 0.022, 0.022)$ among galaxies in SQ either reduce it to a Trio with two highly improbable intruders from CDMHCC or support the Arp (1973) hypothesis that its red shifts are intrinsic. An alternative is provided by the Gibson 1996-2006 hydro-gravitational-dynamics (HGD) theory where superclusters, clusters and galaxies all originate by gravitational fragmentation in the super-viscous plasma epoch and at planetary and star cluster mass scales in the primordial gas of the expanding universe. By this fluid-mechanical cosmology, the SQ galaxies gently separate and remain precisely along a line of sight because of perspective and the small transverse velocities permitted by their sticky viscous-gravitational beginnings. Star and gas bridges and young-globular-star-cluster (YGC) trails observed by the Hubble Space Telescope are triggered as SQ galaxies separate through viscous baryonic-dark-matter halos of dark proto-globular-cluster (PGC) clumps of frozen Earth-mass primordial-fog-particles (PFPs).

[1]Center for Astrophysics and Space Sciences, UCSD

– 2 –

Subject headings: cosmology: theory, observations — dark matter — Galaxy: halo — gravitational lensing — turbulence

1. Introduction

Stephan's Quintet (SQ, HCG 92, Arp 319, VV 288) is one of the first known (Stephan 1877) and best studied of the Hickson 1982 catalog of very compact groups of galaxies, and increasingly the most mysterious. The group consists of the Trio NGC 7319, NGC 7318A, and NGC 7317, all of which have precisely the same redshift 0.022, NGC 7318B with redshift 0.019 closely aligned with the Trio member NGC 7318A, and NGC 7320 with $z = 0.0027$. Burbidge and Burbidge 1959 noted that the large discrepancy of redshifts for the double galaxy NGC 7318AB would require very large mass/light (M/L) ratios $\approx 300 \pm 200$ from dynamical models to achieve virial equilibrium. However, the true mystery of SQ began when the missing redshift for NGC 7320 was determined by Burbidge and Burbidge 1961 to be a mere $z = 0.0027$, with relative velocity $cz = 8.1 \times 10^5$ m s^{-1} compared to 6.7×10^6 for the Trio. For virial equilibrium, this increases the kinetic energy of the group by a factor ~ 30 and would require $M/L \approx 10,000$: much too large to be credible. Thus it was concluded (Burbidge and Burbidge 1961) that the system must be in a state of explosive expansion since the *a priori* chance of NGC 7320 not being a member of the group but a random foreground galaxy is about 1/1500. A connecting gas bridge to the Trio (Gutierrez et al. 2002) confirms that NGC 7320 is not a chance intruder but a separated companion. This conflicts with cold-dark-matter hierarchical-clustering (CDMHC) cosmology where galaxy clusters form by condensation, not fragmentation.

An alternative cosmological proposal is that the SQ galaxy redshifts are simply variable by unknown physics after ejection from the same parent-galaxy active-galactive-nucleus (AGN) and remain at the same distance closely clumped. Arp 1973 summarizes several of his papers of 1970-1972 from which he concludes that the AGN of the nearby large spiral galaxy NGC 7331 ($z = 0.0027$) has ejected all of the SQ galaxies, some with intrinsic red shifts, so that the SQ galaxies are all located at the same ≈ 9 Mpc (3×10^{23} m) distance of their parent NGC 7331 and NGC 7320, not at 74 Mpc and 64 Mpc implied by red shifts of the Trio and NGC 7318B, respectively. Arp lists numerous cases where galaxies in close angular proximity not only have widely different red shifts but have coincident spin magnitudes and alignments with observed AGN jets, consistent with his claim that the ejection of galaxies and quasars from AGNs with intrinsic red shifts is amply justified by the accumulation of circumstantial evidence and the lack of an alternative hypothesis that fits all the data (Arp 1998).

In support of the Arp proposal, galaxies and quasars frequently show evidence of ejec-

– 3 –

tion with intrinsic red shifts (Hoyle et al. 2000). A Seyfert 1 galaxy (NGC 6212) is observed closely surrounded by a large number ($\geq$44) of QSOs that it may have ejected (Burbidge 2003), with QSO surface densities (69 per square degree) larger than ambient by estimated factors of 30 to 10 and decreasing (to 17) with angular distance for radii $10-50$ minutes. It has been suggested (Hoyle et al. 2000) that the big bang hypothesis itself may be questioned based on the remarkable accumulation of such coincidences that are contrary to the statistics of standard CDM hierarchical galaxy clustering cosmology (CDMHCC) and the Hubble red-shift radial-velocity relationship ($v = cz$) of big bang cosmology.

These mysteries vanish when the observations are interpreted using the hydro-gravitational-dynamics theory (HGD) of Gibson 1996-2006. From HGD cosmology the HCG92-SQ anomalies are simply fossil manifestations of the viscous-gravitational beginnings of galaxy clusters and galaxies by fragmentation early in the plasma epoch (Gibson 1996). The apparent close proximity of the SQ galaxies is an optical illusion resulting from perspective and the small transverse velocities permitted by strong friction from the increasingly sticky non-barionic dark matter (freezing earth-mass H-He planets in proto-globular-star-cluster clumps) as it slowly diffuses from a late-fragmenting dense linear galaxy-cluster reflecting Nomura scale proto-galaxies (Gibson 2000; Gibson 2006). Thus dense angular galaxy clusters may have wide spatial separations, where their galaxies lie precisely along a line of sight from their sticky origins and sticky dark matter and the uniform expansion of space expected from big bang turbulence cosmology (Gibson 2005; Gibson 2004). A nearby member of a fragmenting compact cluster affected only by universe expansion will show its origin directly behind it. From the large range of redshifts (0.03 to 2.6) and Hubble distances (150 to 3730 Mpc) of the NGC 6212-quasar system (Burbidge 2003) the observed AGN-QSO galaxies are concentrated in a thin line-of-sight pencil ($\approx$150/1), contradicting CDMHCC and supporting HGD. The pencil containing the Stephan Quintet galaxies is even thinner, with L/D $\approx$1000/1.

CDMHC cosmology is increasingly in conflict with hydrodynamic theory and with observations (Gibson 2005; Gibson 2004; Gibson & Schild 2007). It should be abandoned. Galaxies from HGD cosmology begin gently at the plasma-gas transition with dense clusters of proto-galaxies already formed by fragmentation with sizes and geometry reflecting the strain-rates and viscosity of the weak plasma turbulence. The large decrease in viscosity on transition dramatically decreased fragmentation scales and triggered the first condensations leading to frozen dark matter planets in PGC clumps. Stars formed immediately (with no dark ages) from binary mergers of the original hot planet-mass clouds.

CDMHC cosmology begins violently much later with huge unstable Population III stars that re-ionized the gas with enormous light intensities that can now be ruled out (Aharonian et al. 2006). CDM condensations based on the Jeans 1902 theory are unsta-

ble (Gibson 2006) and will disintegrate into particles from tidal forces rather than clustering as assumed by CDMHC cosmology. The "dark energy" hypothesis of ΛCDMHC is an artifact of supernova Ia events dimmed by evaporated dark matter planet atmospheres (Gibson & Schild 2007). Dark energy and Λ should be abandoned along with CDMHC.

In the following, HGD theory is reviewed (§2) and used to interpret and compare observations of SQ from the Hubble Space Telescope (§3) at optical frequencies (Gallagher et al. 2001) with ground based telescope observations (§4) in the R and Hα bands (Gutierrez et al. 2002). From the observations, clear evidence is found showing the SQ cluster red shifts are due to gentle separations of densely clustered galaxies from the expansion of the universe, contradicting CDMHC cosmology and the Arp hypothesis of intrinsic red shift galaxies ejected by AGNs. From HGD, interpretations of compact groups [CG] and fossil groups [FG] of galaxies as mergers (Mendes de Oliveira & Carrasco 2007) should be reconsidered. Conclusions are summarized (§5).

2.   Hydro-Gravitational-Dynamics Theory

Standard CDMHC cosmologies are based on highly over-simplified fluid mechanical equations that assume the fluid is collisionless and linear and that confuse hydrodynamics with hydrostatics to claim incorrectly that gravitational structure formation on scales smaller than the Jeans scale will be prevented by "pressure support" (Gibson & Schild 2007). The Jeans 1902 theory neglects viscous forces, turbulence forces, non-acoustic density fluctuations and important effects of diffusion on gravitational structure formation. Jeans did linear perturbation stability analysis (neglecting turbulence) of Euler's equations (neglecting viscous forces) for a nearly uniform ideal gas with density ρ only a function of pressure (the barotropic assumption), which reduced the problem of gravitational instability to the solvable equations of gravitational acoustics. To reconcile his equations with the linearized collisionless Boltzmann's equations and the resulting Poisson's equation for the gravitational potential, Jeans assumed the density ρ was zero. This assumption is known as the "Jeans swindle". The only critical wave length for gravitational stability with all these questionable assumptions ("swindles") is the Jeans length scale L_J where

$$L_J \equiv V_S/(\rho G)^{1/2} \approx (p/\rho^2 G)^{1/2}, \tag{1}$$

G is Newton's gravitational constant and $V_S \approx (p/\rho)^{1/2}$ is the sound speed.

Density fluctuations in fluids are not barotropic as assumed by Jeans 1902 except rarely in small regions for short times near powerful sound sources. Density fluctuations that triggered the first gravitational structures in the primordial fluids of interest were

Journal of Cosmology (2015), Vol. 24, No. 45, pp 12711-12728.

5

– 5 –

likely non-acoustic (non-barotropic) density variations from turbulent mixing of temperature or chemical species concentrations produced by the big bang (Gibson 2001; Gibson 2004; Gibson 2005; Gibson 2006) as shown by turbulent signatures in the cosmic microwave background temperature anisotropies (Bershadskii and Sreenivasan 2002).

Without viscous and turbulent forces or diffusion, fluids with non-acoustic density fluctuations are absolutely unstable to the formation of structure due to self gravity (Gibson 1996). Turbulence or viscous forces can dominate gravitational forces at small distances from a point of maximum or minimum density to prevent gravitational structure formation, but gravitational forces will dominate turbulent or viscous forces at larger distances to cause structures if the gas or plasma does not diffuse away faster than it can condense or rarify due to gravity (Gibson 2000).

The concepts of pressure support and thermal support reflect a failure to distinguish fluid dynamics from hydrostatics. Pressure forces cannot prevent gravitational structure formation in the plasma epoch because pressures equilibrate according to Bernoulli's equation in time periods smaller that the gravitational free fall time $(\rho G)^{-1/2}$ on length scales smaller than the Jeans scale. The Jeans scale in the primordial plasma is larger than the Hubble scale of causal connection $L_H = ct$, where c is light speed and t is time. Information about density variations needs time to be transmitted. The initial stages of collapse on a density maximum or fragmentation at a density minimum are quite gentle, so isentropic and adiabatic assumptions are justified (Gibson 2000). Because the early universe rapidly expanded with rate-of-strain $\gamma \approx t^{-1}$, gravitational structure formations inhibited by viscosity and turbulence were exclusively by fragmentation until after the end of the plasma epoch (Gibson 1996).

Bernoulli's equation expresses the first law of thermodynamics during gravitational structure formation. Because energy losses by viscous friction are negligible in the initial stages, the enthalpy p/ρ decreases to exactly match increases in kinetic energy $v^2/2$ during gravitational condensation or fragmentation so the Bernoulli group $B = p/\rho + v^2/2$ remains constant and the term $\mathrm{grad} B$ in the momentum equation is zero. As the speed increases the pressure goes down, which is the wrong sign for any pressure support. Because pressure only appears in the Bernoulli group in the Navier Stokes momentum equations, there is no pressure support term. Pressure support only occurs in hydrostatics; that is, when the fluid velocity is near zero and pressure gradient forces balance gravitational forces.

Therefore, if hydrodynamic gravitational forces exceed viscous and turbulence forces in the plasma epoch at scales smaller than L_H then gravitational structures will develop, independent of the Jeans criterion. Only a very large diffusivity of the plasma $(D \gg \nu)$ could interfere (Gibson 2000). The diffusion velocity is D/L for diffusivity D at distance

$$- 6 -$$

L and the gravitational velocity is $L\rho^{1/2}G^{1/2}$. The two velocities are equal at the diffusive Schwarz length scale

$$L_{SD} \equiv [D^2/\rho G]^{1/4}. \tag{2}$$

Thus very weakly collisional particles such as the hypothetical cold-dark-matter (CDM) material cannot form potential wells for baryonic matter collection because the 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 is the collision distance.

Because weakly collisional particles have large collision distances with large diffusive Schwarz lengths L_{SD} the non-baryonic dark matter (possibly neutrinos) is the last material to fragment by self gravity and not the first as assumed by CDM cosmologies. The first structures occur as proto-supercluster-voids in the baryonic plasma controlled by viscous and weak turbulence forces, independent of diffusivity ($[L_{SV}]_{plasma} \leq ct$, $D \approx \nu$). The CDM seeds postulated as the basis of CDMHCC never happened because $(L_{SD})_{NB} \geq ct$ in the plasma epoch.

The baryonic matter is subject to large viscous forces, especially in the hot primordial plasma and gas states existing when most gravitational structures first formed. The viscous forces per unit volume $\rho\nu\gamma L^2$ dominate gravitational forces $\rho^2 GL^4$ at small scales, where ν is the kinematic viscosity and γ is the rate of strain of the fluid. The forces match at the viscous Schwarz length

$$L_{SV} \equiv (\nu\gamma/\rho G)^{1/2}, \tag{3}$$

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

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

where ε is the viscous dissipation rate of the turbulence. Because in the primordial plasma the viscosity and diffusivity are identical and the rate-of-strain γ is larger than the free-fall frequency $(\rho G)^{1/2}$, the viscous and turbulent Schwarz scales L_{SV} and L_{ST} will be larger than the diffusive Schwarz scale L_{SD}, from (2), (3) and (4).

Therefore, the criterion for structure formation in the plasma epoch is that both L_{SV} and L_{ST} become less than the horizon scale $L_H = ct$. Reynolds numbers in the plasma epoch were near critical, with $L_{SV} \approx L_{ST}$. From $L_{SV} < ct$ and (3), gravitational structures first formed when $\nu < c^2 t(t^2 \rho G) \approx c^2 t$ 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

– 7 –

plasma, the first structures were proto-supercluster-voids. At 10^{12} s

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

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 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 also 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 $L_K \equiv [\nu^3/\varepsilon]^{1/4}$ and the viscous and turbulent Schwarz scales at the time of first structure nearly matched the horizon scale $L_H \equiv ct \approx 3 \times 10^{20}$ m, freezing in the density, strain-rate, and spin magnitudes and directions of the subsequent 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 1999). Thus, HGD explains galaxy spin alignments and close angular associations with quasars without assuming Arp intrinsic red shifts and AGN quasar ejections.

The quiet condition of the primordial gas is revealed by measurements of temperature fluctuations of the cosmic microwave background radiation that show an average $\delta T/T \approx 10^{-5}$ much too small for uninhibited strong turbulence to have existed at that time of plasma-gas transition (10^{13} s). Turbulent plasma motions were strongly damped by buoyancy forces at horizon scales after the first gravitational fragmentation time 10^{12} s. Viscous forces in the plasma are inadequate to explain the lack of primordial turbulence ($\nu \geq 10^{30}$ m^2 s^{-1} is required but, after 10^{12} s, $\nu \leq 4 \times 10^{26}$, Gibson 2000). Thus the observed lack of strong turbulence proves that large scale buoyancy forces and gravitational structure formation must have begun in the plasma epoch. The linear geometry and small 10^{20} m scales of proto-galaxy structures reflect the Kolmogorov scale and Nomura geometry of weak plasma turbulence at transition to gas (Gibson 2006; Gibson & Schild 2007; Nomura & Post 1998). Observations of CG and FG clusters (Mendes de Oliveira & Carrasco 2007) reveal proto-galaxy L_N sizes and linear geometries expected from turbulent plasma proto-galaxy-cluster fragmentation by the expansion of the universe.

– 8 –

3.   Stephan's Quintet: HGD interpretation of an HST image

Moles et al. 1997 summarize the data and dynamical status of SQ consistent with standard CDMHC cosmology, proposing that the nearby NGC 7320C with $cz = 6.0 \times 10^5$ m/s (matching that of NGC 7318B) has possibly collided several times with SQ members stripping their gas and central stars to form luminous wakes and to preserve their dynamical equilibrium, thus accounting for the fact that 43 of the 100 members of the Hickson 1982 catalog of compact groups contain discordant redshift members. However, Gallagher et al. 2001 show from their Hubble Space Telescope (HST) measurements that globular star clusters in SQ are not concentrated in the inner regions of the galaxies as observed in numerous merger remnants, but are spread over the SQ debris and surrounding area. We see no evidence of collisions or mergers in the HST images of SQ and suggest the luminous wakes are not gas stripped from galaxy cores by collisions but are new stars triggered into formation in the baryonic-dark-matter halo of the SQ cluster as member galaxies are gently stretched away by the expansion of space.

According to HGD, galaxy mergers and collisions do not strip gas but produce gas by evaporating the frozen hydrogen and helium of the planetary mass objects which dominate the baryonic mass of galaxies. The baryonic dark matter is comprised of proto-globular-star-cluster (PGC) clumps of planetary-mass primordial-fog-particles (PFPs) from hydro-gravitational-dynamics theory (Gibson 1996) and quasar microlensing observations (Schild 1996). Therefore from HGD the cores of SQ galaxies are deficient in gas and YGCs because they have not had mergers or collisions.

Following standard CDMHC cosmology and N-body computer models, galaxies and clusters of galaxies are formed by hierarchical collisionless clustering due to gravity starting with sub-galaxy mass CDM seeds condensed in the plasma epoch after the big bang. The Jeans 1902 gravitational condensation criterion rules out structures forming in ordinary baryonic matter. CDM seeds are diffusionally and tidally unstable from hydro-gravitational-dynamics theory and their clustering to form galaxies is contrary to observations (Sand et al. 2002). From HGD, both CDMHC cosmology and the Jeans 1902 criterion are fundamentally incorrect and misleading (Gibson 2000; Gibson 2006). CDM seeds cannot form because the CDM material is so weakly collisional. CDM seeds cannot merge because tidal forces would cause rapid fragmentation of the merging seeds to scales of the fundamental particles.

The unknown non-baryonic CDM material is enormously diffusive compared to the H and He ions of the primordial plasma and cannot condense or fragment gravitationally. However, we can be sure structure formation occurred in the plasma epoch because buoyancy within self gravitational structure is the only mechanism available to inhibit turbulence. Viscous forces were inadequate. Fully developed turbulence would have produced $\delta T/T \approx 0.1$

values much larger than the $\delta T/T \approx 0.00001$ values observed in numerous cosmic microwave background studies. From HGD, structure formation first occurred by gravitational fragmentation due to the expansion of space when viscous and weak turbulence forces of the primordial plasma matched gravitational forces at scales smaller than the horizon scale ct, where c is the speed of light and t is the time after the big bang. The growth of structure was arrested by non-baryonic matter filling the voids between baryonic fragments. This HGD-cosmology and its application to the interpretation of SQ is illustrated schematically in Figure 1ab.

In Fig. 1a at top left we see a fragmenting proto-supercluster (10^{46} kg) of the primordial plasma as it separates from other such fragments due to the rapid expansion of the universe at the time of first gravitational structure formation about 30,000 years (10^{12} s) after the big bang (Gibson 1996). The scale is near the horizon scale ct at that time 3×10^{20} m with baryonic density 2×10^{-17} kg/m^3 and non-baryonic density $\approx 10^{-15}$ kg/m^3 decreasing with time and the non-baryonic matter (probably neutrinos) diffuses to fill the voids and reduce the gravitational forces (Gibson 2000). In Fig. 1a center proto-cluster fragments form and separate, and on the right proto-galaxies fragment just before the cooling plasma turns to gas at 300,000 years (10^{13} s).

The proto-galaxies preserve the density and spin of the proto-supercluster as fossils of the primordial plasma turbulence (Gibson 1999). Their initial size is therefore about 3×10^{19} m as the plasma fragments with the inertial-vortex viscous scales and geometry of weak turbulence. The gas proto-galaxies fragment into Jeans-mass (10^{36} kg) proto-globular-cluster (PGC) dense clouds of (10^{24} kg) primordial-fog-particles (PFPs) that cool, freeze, and diffuse away from Nomura scale galaxy cores to form baryonic-dark-matter (BDM) halos around galaxies and galaxy-clusters such as SQ. The Jeans-mass is relevant, but not for the reasons given by Jeans (1902). Some galaxy-clusters can be very slow in their separation due to crowding and frictional forces of their BDM halos, as shown by the central galaxy cluster at the right of Fig. 1a. The BDM halo may reveal the history of galaxy mergers and separations because strong tidal forces and radiation by galaxy cores trigger the formation of stars and YGCs as they and their halos move through each other's BDM halos, leaving star wakes and dust wakes.

Fig. 1b shows schematically our interpretation of SQ based on HGD. The five galaxies are separated by distances inferred from Hubble's law and their red shifts times the horizon distance 10^{26} m due to the stretching of space along a thin tube of diameter $\approx 2 \times 10^{21}$ m oriented along the line of sight to the Trio. The distance to the line-of-sight tube entrance from earth is thus $\approx 2.7 \times 10^{23}$ m for NGC 7320, with the exit and Trio at $\approx 2.2 \times 10^{24}$ m. NGC 7320 appears larger than the Trio members because it is closer, consistent with the

fact that it contains numerous young-globular-clusters (YGCs) obvious in the HST images, but YGCs in the Trio are barely resolved (Gallagher et al. 2001). The tube in Fig. 1b is not to scale: the true aspect ratio is that of a sheet of paper or a very long stick of uncooked spaghetti. By perspective, about 1% of the front face of the tube covers the back face.

Figure 2 shows an HST image of Stephan's Quintet. The trail of luminous material extending southeast of NGC 7319 is interpreted from HGD as a star wake formed as one of the galaxy-fragments of the original cluster moves away through the baryonic-dark-matter (BDM) halo, triggering star formation until it exits at the halo boundary marked by a dashed line. Other star wakes in Fig. 2 are also marked by arrows. These star wakes are similar in origin to the filamentary galaxy VV29B of the Tadpole merger (Gibson & Schild 2003) and the "tidal tails" of the Mice and Antennae merging galaxies, except that in SQ all the galaxies are seen to separate through each other's halos rather than merge, contrary to the standard SQ (Moles et al. 1997) model.

Two dust trails are shown by arrows in the upper right of Fig. 2 that we interpret as star wakes of the separation of NGC 7318B from NGC 7318A. A similar dust trail is interpreted from its direction as a star wake of NGC 7331 produced in the NGC 7319 BDM halo as it moved out of the cluster. The luminous trail pointing toward NGC 7320C is confirmed by gas patterns (Gutierrez et al. 2002) observed from broadband R measurements that suggest NGC 7320 has the same origin near NGC 7319. An unidentified galaxy separated in the northern star forming region, leaving over a hundred YGCs (Gallagher et al. 2001) before exiting the BDM halo boundary (shown by the dashed line in the upper left of Fig. 2).

Details of the Hubble Space Telescope images of Stephan's Quintet (including Fig. 2) can be found at the website for the July 19, 2001 STScI-2001-22 press release (http://hubblesite.org/newscenter/archive/2001/22/image/a). The images are described as "Star Clusters Born in the Wreckage of Cosmic Collisions" reflecting the large number of YGCs detected (Gallagher et al. 2001) and the standard SQ model (Moles et al. 1997).

According to our HGD interpretation, none of the YGCs are due to galaxy collisions or mergers. All are formed in the BDM halos as the galaxies gently separate with small transverse velocity along lines of sight. There were no cosmic collisions and there is no wreckage. Numerous very well resolved YGCs can be seen in the NGC 7320 high resolution image with separations indicating numbers in the range $10^5 - 10^6$. This suggests a significant fraction of the dark baryonic matter in the halo of NGC 7320 has been triggered to form YGCs and stars as the galaxy separated through both the dense BDM halo of the SQ Trio and the BDM halo of its companion galaxy NGC 7331, also at $z = 0.0027$ (2.7×10^{23} m) separated northeast 3×10^{21} m. No such concentration of YGCs can be seen in the SQ Trio galaxies, consistent with our HGD interpretation that their distance is ≈ 8 times that

of NGC 7320 as shown in Fig. 1b.

4.   Stephan's Quintet: HGD interpretation of R and H_α maps

The present status of observations of Stephan's Quintet is well summarized by Gutierrez et al. 2002, including their deep broadband R and narrowband H_α maps shown in Figure 3. The R band map (their Fig. 1) with sensitivity 26 mag arcsec^{-2} extends to a wide range that includes NGC 7320C with the other SQ member galaxies. A clear H_α bridge is shown with red shift $z = 0.022$ corresponding to that of the SQ Trio to a sharp interface with $z = 0.0027$ material in NGC 7320, consistent with our interpretation that the bridge was formed in the BDM halo of the SQ Trio by NGC 7320 as it emerged and separated by the expansion of the universe along the line of sight, as shown by the dashed arrow in Fig. 2.

The solid arrow shown in Fig. 3 toward NGC 7320C suggests its emergence from the SQ Trio BDM halo leaving the star wake shown by a corresponding arrow in Fig. 2. The mechanism of star wake production is that the frozen PFPs are in meta-stable equilibrium within their PGCs. Radiation from a passing galaxy causes evaporation of gas and tidal forces which together increase the rate of accretion of the PFPs to form larger planets and finally stars. The size of the stars and their lifetimes depends on the turbulence levels produced in the gas according to HGD, Eq. (4). Large turbulence levels produce large, short lived stars. The dust lane between NGC 7318A and its twin NGC 7318B suggests large turbulence levels produced large stars and dust through supernovas. A similar dust lane from NGC 7219 is in the general direction of NGC 7331 and its companions, as indicated by the arrow in Fig. 2.

5.   Conclusions

We conclude that Stephan's Quintet compact galaxy cluster (HCG92) with its highly anomalous redshifts is better described by hydro-gravitational-dynamics (HGD) theory and cosmology (Gibson 1996) than by the CDMHCC or the Arp AGN-ejected-galaxy intrinsic-redshift scenarios. According to HGD-cosmology, all the SQ galaxies formed in a linear cluster by gravitational fragmentation of the primordial plasma just before photon decoupling and transition to gas 300,000 years after the big bang. None of the galaxies show evidence of collisions or mergers. Such close alignments are improbable by chance. They remained stuck together for 12.9 billion years until 220 million years ago when the uniform expansion of space in the universe finally overcame gravitation and the viscous frictional forces of the cluster baryonic-dark-matter halo. The BDM halo consists of proto-globular-star-cluster (PGC)

– 12 –

clumps of frozen primordial planets (PFPs) with a large kinematic viscosity (Gibson 2006) because PGCs become weakly collisional as their planets freeze.

The nature of the baryonic-dark-matter halo is explained by HGD and supported by the SQ observations. At the plasma-gas transition the small, dense, proto-galaxy plasma-clouds turned to gas. From HGD (Gibson 1996) the gas fragmented at the Jeans scale to form PGC (10^{36} kg) clumps of (10^{24} kg) primordial-fog-particles (PFP planets), as shown in Fig. 1b, consistent with the conclusion (Schild 1996) from quasar microlensing observations that the lens galaxy mass is dominated by "rogue planets likely to be the missing mass".

Some of the PFPs near the proto-galaxy centers accreted to form stars and the luminous galaxy cores. Most PFPs condensed and froze as the universe expanded and cooled so their PGCs remained dark and gradually diffused away from the galaxy cores to form BDM galaxy halos, and some diffused further to form cluster baryonic-dark-matter (BDM) halos. The Stephan Quintet cluster BDM halo boundaries are revealed by the separation of the SQ galaxies as star wakes, as shown in Fig. 2. The SQ BDM halo radius is only $\approx 2 \times 10^{21}$ m, compared with the BDM halo radius of the Tadpole galaxy $\approx 5 \times 10^{21}$ m as shown by HST/ACS images with the star wake of the merging galaxy (Gibson & Schild 2003).

Our HGD interpretation of SQ solves the long standing mystery of its anomalous red shifts (Burbidge and Burbidge 1961). Rather than an explosive expansion or intrinsic red shifts of the SQ galaxies ejected by the same parent (Arp 1973) we suggest that a uniform expansion of the universe stretched the SQ galaxies along a line of sight because of perspective and small transverse velocities resulting from BDM halo gas friction and their sticky beginnings, as shown in Fig. 1b. The common point of origin of the SQ galaxies is confirmed by gas trails in recent R and H_α maps, as shown in Fig. 3 (Gutierrez et al. 2002). Highly discordant red shifts often observed for aligned quasars and AGN galaxies (Hoyle et al. 2000) are thus explained using the conventional physics of HGD.

From the present study, the interpretation of compact groups [CG] and fossil groups [FG] of galaxies as mergers (Mendes de Oliveira & Carrasco 2007) should be reversed. These are not merging but separating galaxy clusters.

REFERENCES

Aharonian et al. 2006, Nature, 440, 1018

Arp, H. 1973, ApJ, 183, 411

Arp, H. 1998, ApJ, 496, 661

– 13 –

Burbidge, E. M., & Burbidge, G. R. 1961, ApJ, 134, 244

Burbidge, G. R. 2003, ApJ, 586, L119

Bershadskii, A., and K.R. Sreenivasan, 2002, Phys. Lett. A, 299, 149

Gallagher, S. C., Charlton, J. C., Hunsberger, S. D., Zaritsky, D., & Whitmore, B. C. 2001, AJ, 122, 163

Gibson, C. H. 1996, Appl. Mech. Rev., 49, 299, astro-ph/9904260

Gibson, C. H. 1999, J. of Mar. Systems, 21, 147, astro-ph/9904237

Gibson, C. H. 2000, J. Fluids Eng., 122, 830, astro-ph/0003352.

Gibson, C. H. 2001, Proc. ICME 2001, Vol. 1, BUET, 1, astro-ph/0110012

Gibson, C. H. 2006, J. Appl. Fluid Mech. (in press 2008, 2(1), 1-8, www.jafmonline.net), astro-ph/0606073v3

Gibson, C. H. 2004, Flow, Turbulence and Combustion, 72, 161179

Gibson, C. H. 2005, Combust. Sci. and Tech., 177, 1049-1071

Gibson, C. H. 2006, astro-ph/0606073

Gibson, C. H. & Schild, R. E. 2003, astro-ph/0210583v2

Gibson, C. H. & Schild, R. E. 2007, astro-ph/0701474

Gutierrez, C. M., Lopez-Corredoira, M., Prada, F. & Eliche, M. C. 2002, ApJ, 579, 592

Hickson, P. 1982, ApJ, 255, 382

Hoyle, F., Burbidge, G., & Narlikar, J. V. 2000, A Different Approach to Cosmology, Cambridge U. Press

Jeans, J. H. 1902, Phil. Trans. R. Soc. Lond. A, 199, 1

Mendes de Olivieira, C. & Carrasco, E. R. 2007, arXiv:0710.3347v1[astro-ph], accepted ApJL

Moles, M., Sulentic, J. W., & Marquez, I. 1997, ApJ, 485, L69

Nomura, K. K. & Post, G. K. 1998, JFM, 377, 65-97

Schild, R. 1996, ApJ, 464, 125

– 14 –

Sand, D. J., Treu, T, & Ellis, R. S. 2002, ApJ, 574, L129

_____

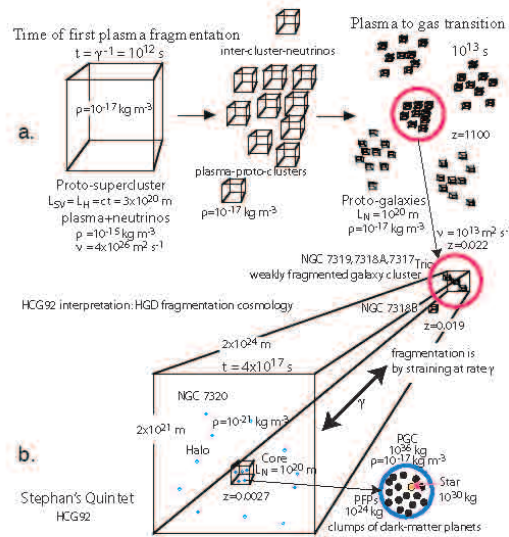This preprint was prepared with the AAS LATEX macros v5.2.

Fig. 1.— a. According to hydro-gravitational-dynamics (Gibson 1996), proto-superclusters (left) fragment to proto-clusters (center) which fragment to form proto-galaxies during the super-viscous plasma epoch (Gibson 2000). Compact galaxy clusters such as Stephan's Quintet occur in this cosmology when dispersal of the cluster by the expansion of the universe is delayed by frictional forces; eg., the central cluster of galaxies on the right. b. Galaxies of the fragmented SQ cluster remain along a line of sight to the SQ Trio because of their small transverse velocities, reflecting their sticky beginnings.
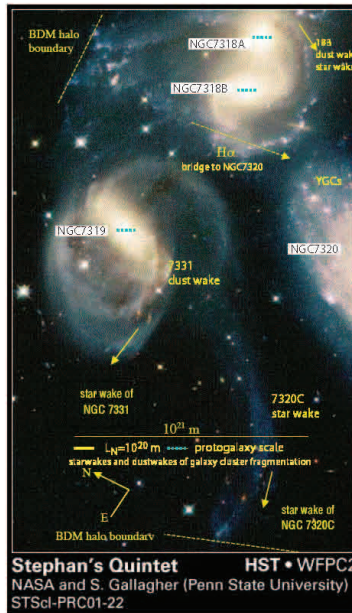
– 16 –

Fig. 2.— 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 Trio cluster baryonic-dark-matter (BDM) halo of PGCs and PFPs, triggering star formation. Star wakes of mergers and collisions are not observed. The H_α gas bridge proves NGC7320 is not a chance intruder. BDM haloes form by diffusion of PGC clumps of dark matter planets from Nomura scale L_N galaxy cores that reflect the size of plasma protogalaxies (Fig. 1a). YGCs can be resolved in NGC7320 because it is closer than the Trio, contrary to the Arp hypothesis that SQ galaxies are near and ejected by parent NGC7331 with intrinsic redshifts (Arp 1973; Arp 1998).
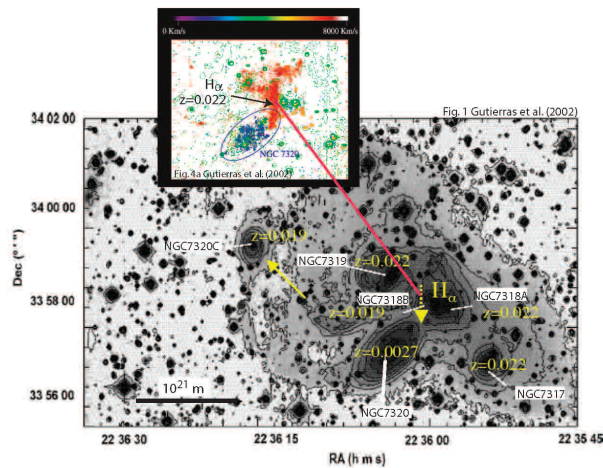
– 17 –

Fig. 3.— Contour R map of SQ (Gutierrez et al. 2002) showing connections between SQ galaxies and NGC 7320C to the East (left), and NGC 7320 to the South (bottom). The H_α bridge is at the red shift 0.022 of the SQ Trio, and shows a sharp transition to $z = 0.0027$ for NGC 7320 (Gutierrez et al. 2002) consistent with HGD cosmology where fragmented SQ galaxies are gently stretched into a thin pencil by the expansion of the universe, Fig. 1b.

The length of the Stephan Quintet "pencil" is ~ 100 times longer than that of the Hannawi et al. (2015) Quasar Quartet "pencil"; that is ~ 10^24 meters compared to ~ 10^22 meters. The Quasar Quartet is a very bright early version of the Stephan Quintet. With time the expansion of the universe will stretch the fossil turbulence vortex line to scales much larger than the galaxies. Such chain galaxy clusters support HGD cosmology, and falsify all aspects of LCDMHC. In LCDMHC, galaxies are the last objects to form. In HGD, they are the first. CHG