Journal of Cosmology (2011), Vol. 17, No. 18, pp 7531-7552

Clumps of hydrogenous planetoids as the dark matter of galaxies

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Received ______________________; accepted ______________________

ABSTRACT

Hydrodynamic gravitational condensation theory and quasar-microlensing observations lead to the conclusion that the baryonic mass of most galaxies is dominated by dense clumps of hydrogenous planetoids. Star microlensing collaborations fail to detect planetoids as the dominant dark matter component of the inner Galaxy halo (within ≈ 30 kpc) by an unjustified uniform-number-density assumption that underestimates the average value. At plasma neutralization and photon decoupling, existing proto-galaxies should fragment at both proto-globular-cluster (PGC) $\approx 10^5 M_\odot$ and terrestrial-mass scales $\approx 10^{-6} M_\odot$, from Gibson's 1996 hydro-gravitational theory. Schild's 1996 interpretation was that the mass of the lens galaxy is dominated by "rogue planets ... likely to be the missing mass", from measured twinkling frequencies of the lensed quasar Q0957+561 A,B images and their time-delayed difference. Schild's findings of a 1.1 year image time delay with dominant planetoid image-twinkling-period are confirmed herein by three observatories.

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

1. Introduction

We discuss an accumulation of observational evidence and theoretical predictions supporting the conclusions that the masses of galaxies within about 10^{21} m (30 kpc) of their central cores are dominated by Proto-Globular-star-Cluster (PGC) mass (10^{35} kg $-$ $10^5 M_\odot$) clumps of planetary mass (10^{24} kg $-$ $10^{-6} M_\odot$) objects formed from primordial hydrogen-helium gas soon after its transition from plasma 300 000 years after the Big Bang. The planetoids are termed "rogue planets" by Schild 1996 and "primordial fog particles" (PFPs) by Gibson 1996.

The most convincing observational evidence comes from light curves of gravitationally lensed quasars. A few quasars have galaxies precisely along their lines of sight. The overall mass distributions of such galaxies serve as lenses that distort space and cause the quasar to appear as two or more brightened, twinkling, images. The dominant mass component of the lens galaxy determines the dominant twinkle period (or equivalently, the peak frequency of the microlensing light curve spectrum) of the quasar-image light curves, from Einstein's gravitational equations, as various objects pass in front of the quasar at their estimated transverse velocity. The smaller the object mass, the shorter the period of brightening or darkening (the twinkle period). Keel 1982 was the first to use such evidence to conclude that the masses of galaxies are not dominated by their stars or by other objects with stellar mass. Refsdal and Stabell 1993 noted, from fluctuations of the four images of the "Einstein cross" quasar Q2237, that the mass of the lensing quasar was possibly dominated by objects as small as 10^{23} kg ($10^{-7} M_\odot$), although without image delay corrections for intrinsic quasar variability this conclusion was considered tentative.

From a fifteen year record of observations of both A and B images of the first lensed quasar detected (Q0957+561 A,B), Schild 1996 and Schild and Thomson 1997 determined the dominant twinkling frequency of the difference between the A and B brightness curves, corrected for an estimated 404 ± 26 day time delay of image B (now 416.3 ± 1.7, Pelt et al. 1998) to eliminate brightness variations intrinsic to the quasar. Schild 1996 concluded from the time-delay corrected brightness difference curve, the microlensing record, that the mass of the lensing galaxy of Q0957 is dominated by component objects with planetary mass. A precise quasar lens time delay is required to distinguish between intrinsic brightness changes of the quasar and microlensing events caused by the galaxy mass components, since typical event times were found to be only 10 to 100 days. The time delay was controversial for a number of years, but is now confirmed by several observers (§2) supporting the Schild 1996 conclusion that the lens galaxy mass is dominated by "rogue planets ... likely to be the missing mass". Although star-microlensing collaborations fail to detect planetoids as the halo missing mass and claim to exclude them (§3), their search focused on larger mass dark matter candidate objects (brown dwarfs).

In the following section we present records from three observatories (§2) confirming the existence of rapid quasar microlensing events, and confirming that the events tend to occur in clumps. The missing mass of the galaxy therefore consists of primordial planetoidal objects that have not yet accreted to form stars. Clumping of such objects is to be expected as a consequence of the accretional process, with the intermittency of planetoid number density increasing with the mass range. However, tight clumping or any clumping within the clumps of planetoids poses a measurement problem for their detection by the star-microlensing collaborations (§3), which have not yet detected any planetoidal component in the halo mass of the Milky Way Galaxy, contrary to the quasar-microlensing observations of planetoids in other galaxies.

Independently and simultaneously with the Schild 1996 observations and conclusions, Gibson 1996 predicted that the mass of all galaxies should be dominated by globular-cluster-mass clumps of planetoids based on a new (non-Jeans) gravitational condensation theory, discussed in the (§4). Details and refinements of the new theory are given by Gibson and Schild 2000a, Gibson 1999, and Gibson 2000ab. We summarize our conclusions in §5.

2. A quasar-microlensing event recorded at three observatories

A heightened interest in the Q0957 gravitational lens system resulted from a prediction by Kundic et al. 1995 that a rapid decline in the quasar's brightness should be seen in Feb.—Mar. 1996 in the second arriving B image, based upon observation of the event in the first arriving A image in December 1994. Because the time delay was still controversial, with values of 1.1-years (Schild 1990, Pelt et al. 1994) and 1.4-years (Lehar et al. 1992, Press et al. 1992), it appeared that observations during February and May 1996 would settle the time delay issue. Thus at least 3 observatories undertook monitoring programs to observe the predicted event.

At Mount Hopkins, the 15 year monitoring program on the 1.2 m telescope continued, with observations made by scheduled observers on 109 nights. Four observations were made each night with a Kron-Cousins R filter, and the observations averaged together for a published nightly mean brightness value. The quasar brightness was referenced to 5 nearby stars whose brightnesses were checked relative to each other to ensure stability of the magnitude zero point. The data are plotted in Figures 1 and 2 of this report, and data for the first season showing the brightness drop in the first-arriving A component have been published by Schild and Thomson 1997.

The Princeton data were obtained by Kundic et al. 1995 using the 3.5m Apache Point telescope with g and r filters on the Gunn photometric system. Their data are not published, but data for the first season were posted on a World-Wide-Web site listed in the Kundic report. We have converted these data to a standard R filter using the relations given in Kent 1985. When we compare the Princeton results to Mt. Hopkins data for the same dates, we find an rms residual of 0.029 mag for component A and 0.18 mag for component B. Unexpectedly, we find the origin of this disagreement not to be so much in random errors as in a systematic drift in the apparent zero points in the course of the observing season. Data for the second observing season have not been presented in tabular form, but a plot of the data posted at the Princeton WWW site has allowed us to compare the results. We have taken the Princeton data plot, separated the two colors of data, and rescaled data for the Mt. Hopkins and Canary Island (Oscoz et al. 1996) groups to make the comparisons in Figures 1 and 2.

The Canary Island data are posted at the WWW site given in the report by Oscoz et al. 1996. They were obtained with the 0.8m telescope using standard R filters and local comparison stars. Because data were obtained in response to the Princeton challenge of Kundic et al. 1995, the Canary Island group reports data for the second season only. We have compared their data with the Mt. Hopkins data with the assumption that any Canary Island datum taken within 24 hours of a Mt. Hopkins observation had agreeing dates, and the rms deviations of the two data sets for our 15 agreeing dates is 0.013 mag for image A and 0.016 mag for B. The error estimates listed at the WWW web site are considerably larger, averaging 0.022 for A and 0.020 for B. Because the Canary Island—Mt. Hopkins comparison must have some error contribution from Mt. Hopkins, it is clear that the posted Canary Island error estimates are too large by a factor of approximately 2. In our plots of the Canary Island data, Figure 2, we have used the original posted error estimates.

We show in Figure 1 a comparison of the available photometries for the first observing season. In the upper plot, the Mt. Hopkins data are shown with a magnitude scale and zero point for a standard R filter. The Princeton data have been shown with an arbitrary offset of 0.2 mag. These magnitudes are determined from a transformation from the Princeton

Gunn g,r photometric system, using the transformation equations determined by Kent 1985. Error bars are shown strictly according to the estimates of the authors. The data are superimposed in the bottom panel of Figure 1, and the error bars are suppressed for clarity. It may be seen that the data agree about as well as predicted from the errors. One artifact that may be noticed is that there appear to be several points, mostly in the Princeton data, markedly below the mean trend. It is surprising that these discrepant points are in the sense of brightness deficiency, because the two principal error sources, cosmic rays and merging of the two quasar images due to bad seeing effects, both tend to make the images brighter. The A component data in the lower panel will be compared to the observations of image B in Figure 3.

In Figure 2 we show 3 data sets in the upper panel, with their associated error bars. However as noted previously, we do not actually have the tabulated data for the Princeton team, and we have scaled the results of Mt. Hopkins and the Canary Island groups to the Princeton data as posted in a plot released by the Princeton team. Thus the plotted magnitudes are on the Gunn photometric system, which differs from standard R by a zero point offset and a color term of 0.15 mag. In other words, R = r - 0.15(g-r) + Const. Since image B varied only from 1.071 to 1.142, a variation of 0.07 mag, we conclude that the scatter introduced into the comparison of r and R magnitudes has a full amplitude of 0.01 magnitudes, or a scatter of at most 0.005 magnitudes around a mean offset. Thus we have simply combined the Princeton r magnitudes with an arbitrary zero point offset in the comparison with the Mt. Hopkins and Canary Island R magnitudes in the bottom panel of Figure 2.

We find in Figure 2 (bottom) good evidence that the brightness drop predicted by Kundic et al. 1995 did indeed occur at around Julian Date 2450130. The brightness in the R band did indeed drop almost 0.1 magnitudes, and time delays of 423 days (Oscoz et al. 1997) and 416 days (Kundic et al. 1997) are determined. However, a remarkable thing happened at the end of this event, or immediately afterward; a strong microlensing event was observed, principally in the Mt. Hopkins data. The event may be seen as a strong downward spike centered on J.D. 2450151. Although the event was primarily seen in the Mt. Hopkins data, the brightness did not recover to the expected level for another 30 days, and for the remainder of this discussion, we refer to this event as the 3-observatory microlens.

A much better perspective on the 3-observatory microlens comes from inspection of Figure 3, where we plot data for both observing seasons combined with the 416-day time delay of Kundic et al. 1997. In this plot the open and filled symbols refer to the first and second observing seasons, exactly as in Figures 1 and 2. We consider that from J.D. 2450151 to 2450180 the data records are sufficiently discrepant to conclude that a microlensing event of 30 to 40 days duration and asymmetrical profile occurred. It is of course possible that more than one event was occurring at this time. It is likely that another event was seen at 2450220 ± 10 days, again seen by 3 observatories. A few other significant discrepancies may be recognized in this fascinating combined data record, and it is not surprising that the time delay has been so difficult to determine because of the influence of this complex pattern of microlensing. On the other hand, with the time delay now measured, the microlensing provides a powerful probe of the mass distribution of objects in the lens galaxy, and perhaps elsewhere (Schild 1996). The mass of the object causing the 35 day duration microlensing event at J.D. 2450151 is $1 \times 10^{-6} M_{\odot} = 2 \times 10^{24}$ kg.

We now pose the question of the significance level of the detection of microlensing. We avoid questions of *a posteriori* statistics by phrasing a test as follows. A dramatic microlensing event was seen covering dates J.D. 2450150-70. During the previous year, a brightness record was obtained that covered the same time interval. If we average and smooth the brightness record for the previous year, at what level of statistical significance can we say each observatory noted a departure in the second year? Posed this way, we can easily determine that each of the three observatories observed a departure attributed to microlensing of at least 10 σ, where the standard deviation σ has been estimated for the individual data points of each observatory. Thus we conclude that each of three observatories has obtained as at least a 10 σ result that the second arriving image has brightness departures attributed to microlensing, because they were not seen in the first arriving image.

3. Comparison with star microlensing searches

The search for MAssive Compact Halo Object (MACHO) particles in the Halo of our Galaxy by microlensing stars of the Large Magellanic Cloud (LMC) has resulted in negative but controversial results. The classic Alcock et al. (1995abcde) papers of the MACHO collaboration report lens masses $m \leq 0.1 M_{\odot}$, for which event times $t_{sm} \approx 130\sqrt{m/M_{\odot}}$ (days) are several months. Star-microlensing events by objects with PFP mass $10^{-6} M_{\odot}$ last only 0.13 days (3 hours), and are therefore difficult to detect in the original program which only obtained a single image frame of each field in a night. The corresponding Q0957 quasar-microlensing time $t_{qm} \approx 3 \times 10^{4}\sqrt{m/M_{\odot}}$ (days) is 30 days.

Alcock et al. 1996 report that for a limited subsample of their data, where several exposures of rapid succession were considered, the low detection rates indicate non-detection of sufficient mass to make PFP's the entire mass of a standard spheroidal dark matter Halo. Renault et al. 1998 reach the same conclusion from a more intensive search of a smaller area. The combined MACHO and EROS (Expérience de Recherche d'Objets Sombres) collaborations (Alcock et al. 1998) focus on small-planetary-mass objects such as PFPs in excluding a population with mass $M_p = (10^{-7} - 10^{-3}) M_{\odot}$ as more than 25% of the missing halo mass within 50 kpc of the Galaxy center (the distance to the LMC), or $M_p = (3.7 \times 10^{-7} - 4.5 \times 10^{-5})M_\odot$ having more than 10%. Here it is important to recognize that the star microlensing projects have not detected the baryonic dark matter, but have only rejected their own model of the dark matter and its distribution. Their assumption that the objects are homogeneously distributed is most unlikely for a small-mass population such as PFPs which are hydrogenous and primordial, and consequently distributed as a complex array of nested clumps due to their nonlinear gravitational-accretion-cascade for a wide range of mass to form stars. For small M_p values, the number density n_p is likely to become a lognormal random variable with intermittency factor $I_p \equiv \sigma^2_{ln[n_p]} \approx 0.5ln[M_\odot/M_p] = 8.1$ (Gibson and Schild 2000b), where σ^2_X denotes the variance of random variable X. For a lognormal random variable, the mean to mode ratio is $exp[3I_p/2] = 1.8 \times 10^5$ for $I_p = 8.1$. A small number of independent samples of n_p gives an estimate of the mode (the most probable value) of a random variable, which is what is estimated by MACHO/EROS n_p measurements since the LMC occupies only about 0.04% of the sky and the rapid sampling required for a small object search comprised only about 0.2% of their records. An exclusion of $10^{-7}M_\odot$ objects as $\leq 0.1M_{halo}$ from an estimate of the mode of n_p is thus not conclusive, since the mean PFP halo mass could be $\geq 1.8 \times 10^4 M_{halo}$ from such measurements even if the closely packed star samples are considered independent. Consequently, we suggest that the Alcock et al. 1998 and Renault et al. 1998 interpretations of MACHO/EROS statistics as an exclusion of planetoids comprising the Halo mass are highly model dependent and as yet inconclusive.

4. Theory

Many astrophysical and cosmological models of structure formation (Padmanabhan 1993, Peebles 1993, Kolb and Turner 1994, Silk 1989, Weinberg 1972, Rees 1976) are based on the gravitational instability criterion of Jeans 1902. By this criterion, for a homogeneous gas of density ρ and sound speed V_S, the smallest possible scale of gravitational condensation is $L_J \equiv V_S/(G\rho)^{1/2}$, where G is Newton's gravitational constant. The validity of Jeans's theory has been questioned by Gibson (1996, 1997ab, 1998, 1999, 2000ab). Why should the speed of sound V_S be relevant to gravitational instability? Why are viscous forces and the inertial-vortex forces of turbulent flows neglected? What about magnetic forces and molecular diffusivity? The new theory shows that fluid mechanically determined Schwarz length scale criteria L_{SX} apply rather than L_J, Gibson 1996. Condensation and void formation are possible at lengths matching the largest of the Schwarz scales L_{SX}, where L_{SX} are derived by balancing gravitational forces with viscous, inertial-vortex, or magnetic forces of the fluid, or (for the super-diffusive non-baryonic dark matter) by balancing the diffusion velocity and gravitational velocity of the density field, Gibson 1999, 2000a. The subscript X denotes V, T, M or D, respectively. The Jeans theory and its corollary misconceptions "pressure support" and "thermal support" are most misleading when applied to the hot, quiet, early universe, when $L_J \gg L_{SV} \approx L_{SV}$ for the baryonic matter.

According to the Gibson 1996-2000 hydro-gravitational theory, the Jeans scale L_J was irrelevant at the time of first gravitational structure formation $t \approx 10^{12}$ s in the plasma epoch when $V_S = c/3^{1/2}$ was large and $L_{SV} \approx L_{ST} \ll ct \ll L_J$, giving proto-supercluster to proto-galaxy mass objects ($10^{16} M_{\odot}$). Recent cosmic microwave background observations of $\delta T/T$ show a sub-horizon spectral peak consistent with these first structures but inconsistent with sonic interpretations of current cosmologies. L_J sets the formation size and mass of proto-globular-starclusters (PGCs) for $t \approx 10^{13}$ s at the beginning of the gas epoch, but L_J should not be used as a criterion to exclude the simultaneous formation of smaller gassy hydrogenous planetoids (PFPs) at the viscous and weak turbulence Schwarz scales, where $L_{SV} \approx L_{ST} \ll L_J$. Our claim is that an important error of current cosmological models is to assume that the Jeans 1902 criterion may be used under all or any circumstances to exclude the gravitational formation of objects or voids. Although it is generally recognized that either powerful turbulence or strong magnetic forces can prevent star formation at L_J scales (Chandrasekhar 1951); for example, in dense molecular clouds produced by supernovas where L_{ST} and $L_{SM} \gg L_J$, cases of the early universe where $L_{SX} \ll L_J$ have been misinterpreted or overlooked.

Jeans neglected viscous and inertial-vortex forces in the conservation of momentum equation with gravity. He assumed the pressure depends only on the density. Either of these unjustified assumptions reduce the fluid mechanical problem to one of gravitational acoustics. Jeans also neglected particle and gravitational diffusive terms in the conservation of mass equation, providing another important source of error. As shown in Gibson 1996, the Jeans assumptions are inadequate to describe the highly nonlinear process of gravitational structure formation. The linearized Euler equation Jeans assumed is rarely reliable in any fluid mechanical context, particularly to describe rapidly expanding flows such as that of the early universe where viscous or buoyancy forces are required to suppress turbulence.

Strong turbulence was not present at the time of plasma to neutral gas transition, from measurements of the cosmic microwave background (CMB) radiation that show $\delta T/T$ values of only 10^{-5}, three or more orders of magnitude less than values expected if the flow were strongly turbulent. It follows that either the Reynolds number or Froude number or both must have been subcritical in the plasma epoch before 300 000 years to suppress turbulence to the small levels indicated by the CMB, Gibson 2000ab. Gibson 1999 estimates the photon viscosity of the plasma at the time of first structure formation was $5\,10^{26}$ $\mathrm{m}^2\,\mathrm{s}^{-1}$, giving an horizon Reynolds number slightly above critical and a viscous Schwarz scale mass ρL_{SV}^3 of 10^{46} kg, the observed mass of a galaxy supercluster, where $L_{SV} \equiv (\nu\gamma/\rho G)^{1/2}$ is the viscous Schwarz scale, ν is the kinematic viscosity, $\gamma \approx 1/t$ is the rate-of-strain of the fluid, and ρ is the density. The time t when the horizon mass $\rho(t)L_H^3$ increases to 10^{46} kg is about 10^{12} s, where $\rho(t)$ is derived from Einstein's equation, Gibson 1997b.

As the universe expanded and cooled the average density decreased and the viscous condensation scale increased slowly, giving a decrease in the condensation mass to galactic values of about 10^{42} kg by the time of plasma-gas transition at 10^{13} s (300 000 years). The formation of proto-supercluster and proto-galaxy structures during the plasma epoch is a source of buoyancy forces and subcritical Froude numbers that can partly explain the CMB indications of suppressed turbulence. Because the gravitational free fall time $\tau_G \equiv (\rho G)^{-1/2}$ at each fragmentation stage in the plasma epoch exceeds the universe age t, no large increase in density could occur in these structures, although voids could form between them. The baryonic density of about 10^{-17} kg m^{-3} estimated at $t \approx 10^{12}$ s is close to the average density of globular star clusters, and is taken to be a fossil of this time of first fragmentation in the universe.

Because of their relatively small mass and rapidity of formation (a few thousand years) from the primordial gas, the L_{SV} scale gas planetoids formed within PGCs are termed "primordial fog particles," or PFPs. PFP formation represents the first gravitational condensation of the universe, when mass density ρ first increased due to gravity after 300 000 years of decreasing. Previous structure formations in the plasma epoch were fragmentations by void formation because gravitational free fall times $\tau_G \equiv (\rho G)^{-1/2}$ required for densities to significantly increase were longer than the age of the universe at neutralization. Proto-superclusters and proto-galaxies densities have monotonically decreased ever since, from an initial value of 10^{-15} (including the nonbaryonic component) at $t \approx 10^{12}$ s, to present values of about 10^{-23} and 10^{-21} kg m^{-3}, respectively, as the "flat" universe has expanded to its present average density $\rho \approx 10^{-26}$ kg m^{-3}.

A thermal-acoustic-gravitational instability occurred at the time of neutral gas formation, causing fragmentation of the proto-galaxy gas blobs at the Jeans scale $L_J \approx 10^4 L_{SV}$, simultaneous to the fragmentation at L_{SV} scales to form PFPs. From the ideal gas equation $p/\rho = RT \approx {V_S}^2$ it follows that changes in the density ρ are exactly compensated by changes in the pressure p if the temperature T is constant, where R is the gas constant of the hydrogen-helium mixture. Thus, radiative heat transfer cannot inhibit void formation at scales $L_{IC} \equiv (RT/\rho G)^{1/2} = L_J$, where L_{IC} is termed the initial condensation scale (Gibson and Schild 2000a). For the primordial gas temperature $T = 3\,000$ K and primordial gas density $\rho \approx 10^{-17}$ kg m^{-3}, the initial fragmentation mass was $\rho L_{IC}^3 \approx 10^{35}$ kg, the mass of a typical globular cluster of stars, with internal fragmentation into a trillion PFPs.

Observations that globular clusters typically contain a million small, ancient, stars have often been cited as evidence of the validity of Jeans's theory, but we see that this thermal-acoustic-gravitational instability has nothing to do with the linear perturbation stability analysis of Jeans 1902. Instead, the L_{IC} scale sets the mass of increasingly isolated, $10^5 M_\odot$ clouds or clumps of PFPs in the expanding proto-galaxy to that of a proto-globular-cluster, or PGC. Relative motions of the 10^{12} PFPs within the 10^5 PGCs of a proto-galaxy would have been strongly inhibited by drag forces of their gassy environment during their τ_G condensation periods lasting millions of years. Their accretion to form globular cluster stars must have been equally gentle, as evidenced by a remarkable spherical symmetry which Jeans likened to "fuzzy cricket balls", compared to the chaotic conditions and geometries of present strongly turbulent star forming regions. Old globular star clusters provide fossil evidence of the high density and weak turbulence existing at their time of formation. Young globular star clusters with the same mass and density, Ashman and Zepf 1998, support the present hypothesis that all luminous globular star clusters form, when tidal forces trigger accretion, from the abundance of dark PGC clumps of hydrogenous planetoids permeating all galaxies.

Where are these hundreds of thousands of PGC clumps of PFPs formed in each proto-galaxy at the plasma-gas transition? A full review of the evidence is beyond the scope of the present paper. To summarize the model, most PGCs are apparently intact but dark, and reside where they were formed, in galaxy inner-halos and cores. Some PGCs have collided with each other or have been otherwise agitated to activate a full formation of stars; for example, in the 200 observed globular clusters of the Milky Way or the 10 000 in M87. Some have been disrupted and their PFPs re-evaporated or dispersed, possibly by repeated encounters to form the galaxy disk and core and the dominant mass component of interstellar medium in these luminous spiral galaxy regions. Some may have formed the so-called super-star clusters detected near galaxy cores, with $10^4 M_\odot$ mass, many large ($\approx 100 M_\odot$) stars, and huge average densities (10^{-15} kg m^{-3}) requiring a compaction process. What provides the material of construction for the 700 young globular star clusters detected in the bright arms of interacting "antennae" galaxies NGC 4038/4039, Whitmore and Schweizer 1995? Their typical PGC mass, density, and size suggest the bright young PGs form from dark PGCs brought out of cold storage by tidal forces of the galaxy encounter. Random gas clouds would have random smaller densities and masses. Why have PGC densities remained constant? Because the temperature of the universe fell below the 13 K freezing point of their gasses only after about a billion years, the evolution of PFPs in clusters has been gassy, complex, and collisional. Even after freezing to their present mode as rogue Jovian planets they are much more subject to re-evaporation to gas than stars, with consequent drag forces that damp "virial" velocities, and hence are less likely to be expelled from their PGC clusters by collisionless processes than stars from star clusters as discussed by Binney and Tremaine 1987.

Thus, although many questions remain, we have good reason to expect that most of the baryonic matter of a galaxy consists of dark clumps of hydrogenous planetoids, as observed by Schild 1996 and predicted by Gibson 1996.

5. Conclusions

Quasar-microlensing evidence that lens galaxy masses may be dominated by point-mass objects of planetary mass has been reviewed, and it is found that this possibility is not excluded by the present lack of star-microlensing evidence. The assumption of a uniform-number-density of the hypothetical population of planetoids as the halo dark matter of the galaxy is unjustified and unexpected since such a population should be hydrogenous and primordial as the material of construction of galactic stars that are observed and since any accretion process over a million-fold mass range is likely to produce a highly non-uniform number density distribution for the planetoids within a proto-globular-cluster, even if PGCs were found on the plane of a star-microlensing field.

Because quasar images are guided by the mass of the lens galaxy, twinkling at the dominant point-mass-frequency is assured. Clumping of clumps, and subsequent clumping of point masses within the clumps, should cause interference and multiple point-mass-lensing with occasional isolated events, as observed, and render the planetoids functionally invisible to sparse star-microlensing samples, Gibson and Schild 2000b.

The Schild 1996 inference of planetoids as the missing matter of the Q0957+561 A,B lensed quasar and his estimated 1.1 year time delay of the images are confirmed by three observatories, and supported by the Gibson 1996 nonlinear-hydrodynamic-gravitational condensation theory that independently predicted this result. Furthermore, the Gibson 1996 theory predicts the planetoids should be sequestered in proto-globular-clusters, which can explain the lack of star-microlensing evidence of their existence, along with the probability of strong internal intermittency and clumping of the planetoids within the PGCs due to their accretional cascade.

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Figure 1. Data for the A (northern) gravitational lens image, recorded in the October 1994 - June 1995 observing season. In the upper panel, brightness estimates with error bars are shown as triangles for the Schild and Thomson (1997) data, and as circles for the Kundic et al. (1995) data. The R magnitude scale is for the Schild and Thomson data and the Kundic et al. data is arbitrarily offset 0.2 mag to permit comparison. In the lower panel, the data are shown superimposed and without error bars, to show the generally good agreement, especially around the date of the large quasar brightness drop at 2449715. In Figures 1, 2, and 3 the most significant 2 digits of the Julian date have been suppressed for clarity.

Figure 2. Data for the B (southern) component recorded in the Nov. 1995−June 1996 observing season. In the upper panel, filled squares with error bars are from Oscoz et al. 1996, Triangles are from Schild and Thomson (1997), and circles are from the WWW plot at the site reported by Kundic et al. (1995). In the lower panel, data from the three observatories are plotted without error bars. Generally good agreement is shown in the comparison, and distinct brightness trends are seen in all three data sets.

Figure 3. Data from the lower panels of Figures 1 and 2 are shown superimposed with the same symbol definitions as previously, and for a 416 day time delay. It may immediately be seen that there is generally good agreement, and that the second arriving B image (solid symbols) generally follows the pattern of fluctuation exhibited the year before in the first-arriving A image (open symbols). However there are important differences; around Julian Date 2450150-70 a strong brightness drop occurred that had not been seen in the first arriving A image. Similarly, around J.D. 2450220 the records differ systematically by several percent.

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