The Distribution of Baryonic Matter in the Universe

The mass of the universe, its density, composition, state, and distribution have all been central issues in cosmological research. Total mass as having anything other than an infinite value would seem to presume a finite universe. On the other hand, mass density of the universe has significance with regard to the possibility of its eventual collapse that was addressed by Newton, Einstein, and Hawking, to name but a few of the scientists concerned with this topic over the centuries. A 'critical' density $\rho_c = 3\ H_o^2/8\ \pi\ G$ is defined as that which precludes collapse if observed redshift H_o implies universal expansion. The role of thermodynamics, as against expansion, in fending off gravitational collapse has not garnered the equal attention of these scientists.

The composition of what matter there is has become a consuming obsession with cosmologists in recent decades. Of primary concern to these researchers is the percentages of dark matter, dark energy, and the diminutive portion of baryonic (luminous) matter. Earlier that diminutive portion was a concern with regard to so-called 'missing matter' – missing in the sense of too little to preclude infinite expansion. More recently, whether dark matter is cold or hot, in units small or large, consumes the work of many investigators. We will address the issues for which the concept of dark matter was introduced elsewhere on this site. Before the advent of such extreme concern about dark 'stuff', the origin and percentages of helium and other of the baryonic elements in the periodic table were issues of interest that have largely been resolved. Peculiarities of the mass to luminosity ratios of stellar entities, galaxies, galactic clusters, and 'filament' structures is of continuing interest with regard to identifying the role and distribution of supposed dark matter.

Restricting one's research to baryonic matter, that has thermodynamic as well as gravitational interaction possibility aspects, focuses one's attention on the state of the baryonic matter in and around the predominant structures of the universe. The state of matter – whether primarily molecular as we encounter in our earthly environment, disassociated neutral atoms at higher temperatures, or ionic plasma at extremes of temperature – is of increasing interest. The vast majority of the baryonic matter in the universe is now accepted as existing in the latter state. Recognition that gravitation is not the only, nor necessarily most important, interaction of baryonic matter elevates the significance of the distribution of matter into structures within the universe.

concepts and misconceptions of eventual collapse or continued expansion

Newton concluded that a finite universe would collapse under its own weight, but an infinite one would not. Einstein, Hawking, and others of some distinction have disagreed, a disagreement that led Einstein to doubt the applicability of Poisson's universally accepted equation to uniformly distributed mass in even an infinite universe. Hubble's discovery, interpreted as having confirmed recessional galaxy velocities, provided an escape for Einstein. He could then espouse legitimacy of his interpretation of Poisson's unaltered equation as possibly producing the accelerated collapse of an infinite or any other universe based on there having been a big bang. That may be a little simplified, but that's the gist.

Naively, I think, Einstein and Hawking envisioned an infinite, uniformly dense universe as an indefinitely enlarged spherical region of uniform density. Then using Poisson's equation, they demonstrated that such a universe would collapse unless sufficiently exploding. Their depiction is a totally invalid model of an infinite universe. Despite his restored acquiescence to the legitimacy of Poisson's equation, this notion has not been relinquished by cosmologists. It was incorrect – not just in adding, before ultimately rejecting, an unjustified term to Poisson's equation, but much more significantly in the characterization of an indefinitely extended sphere as a valid model of an infinite universe. Any three-dimensional model of the universe, whether finite or infinite, as embraced by an infinitely enlarged sphere of a given density implies an illogical external surface of the universe at which any collapse must inevitably begin. It's like Columbus worrying about sailing off the edge of the earth when there is no edge. In this simplistic characterization, we would be at the non-Copernican center of the universe as it collapses around us.

Alleviating unjustified aspects of the depiction is quite straight-forward. Gravitational collapse of a spherical region begins at the outside surface and works its way in. But there is no 'outside' of the universe. However many shells you imagine in modeling an infinite onion, there will always be more than that many more shells outside of that or you have an invalid model of an infinite onion. There is an *axiom of specification* to avoid such gibberish.

It is Einstein's and Hawking's model, not the application of Poisson's equation, that is incorrect. However large the three-dimensional sphere one chooses (refer to the one on the left in figure 1), there is an equally large sphere adjacent to it, which is still a part of an infinite universe. All the rest of a uniformly dense universe (both inside and outside the larger sphere) is completely symmetric with regard to the point in question, so all gravitational forces cancel at every such point on the surface of the smaller (or any) sphere that Einstein and Hawking used to model their infinite universe. There is no universal collapse of a uniformly dense infinite universe. Period.

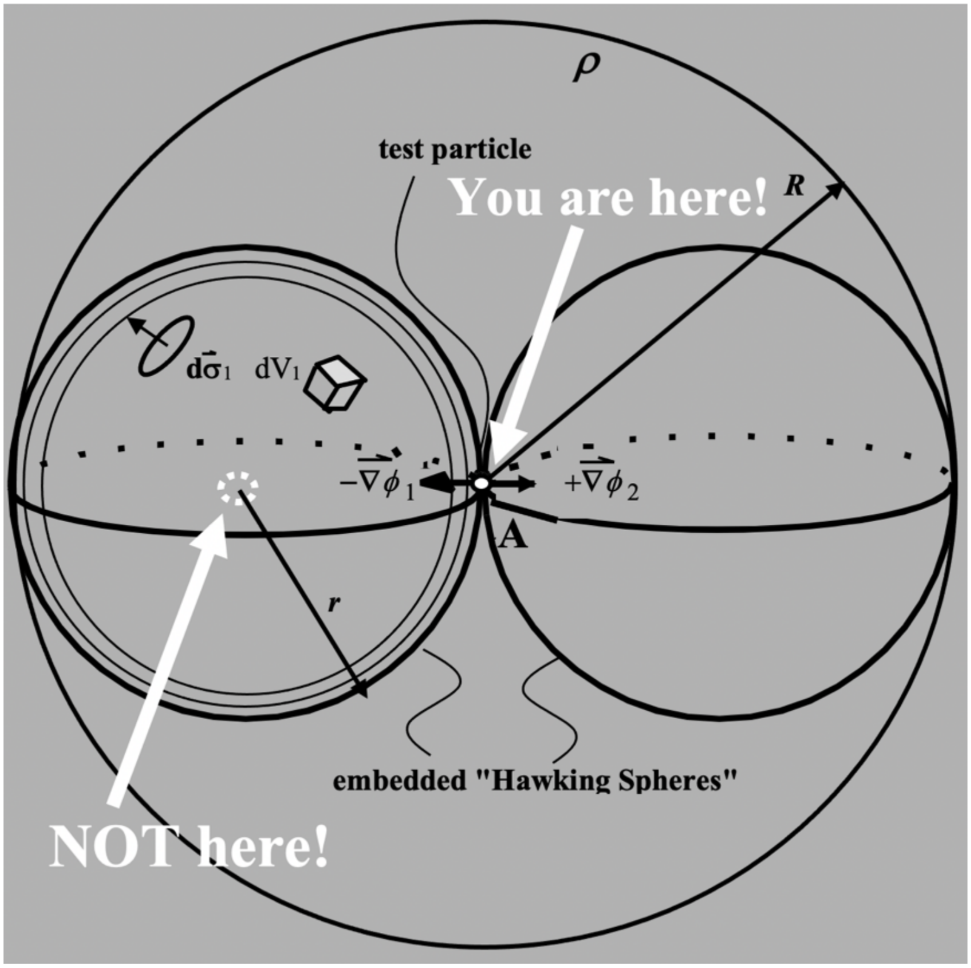

Figure 1: Using the Poisson equation to model a stable uniform density infinite universe

If the left-hand sphere were somehow to have been filled with a higher total density of matter without affecting the surrounding uniform density, it and regions surrounding it would begin to collapse inward forcing a larger and larger exception to uniformity. If instead, that sphere had been empty without affecting the surrounding uniformity, then the hole would expand indefinitely outward. This is due to outward gravitational force on the particles at the boundary that would collapse into the smaller spheres external to the former sphere, increasing the size of the deficit sphere. But in a stationary state universe there would always be a level at which the universe can be considered uniformly dense and at that level no net collapse occurs.

Of course, uniformity at the detailed local level of our universe is unrealistic to say the least. Randomly induced variations are inevitable in realistic dynamic models of the universe; they would produce clumps and holes but maintain overall uniformity. Einstein's equally egregious error was depicting an exclusively gravitational universe. Any adequate model of a universe at a temperature above absolute zero must include thermodynamic considerations with its ideal gas law for which a stable uniform mass density would be associated with uniform average temperature and pressure. In the (only realistic) situation of higher temperatures and pressure in a denser clump, pressure would limit infalling matter from its outer regions, stability ultimately resulting. A void would be filled in by diffusion due to pressure from the outside until a spherical declivity was filled in enough to counter the outward gravitational force. Unless matter were to have been inserted or extracted from the general uniformity, hydrostatic equilibrium would be maintained with uniformity established at a higher level of granularity – the larger sphere in figure 1. In either of these cases, there will be a gravitational clumping toward the center of a left-most spherical region surrounded by a less dense region out to where the uniform density of the universe is realized at the interface to the sphere of counter gravitational force. This is shown in figure 2.

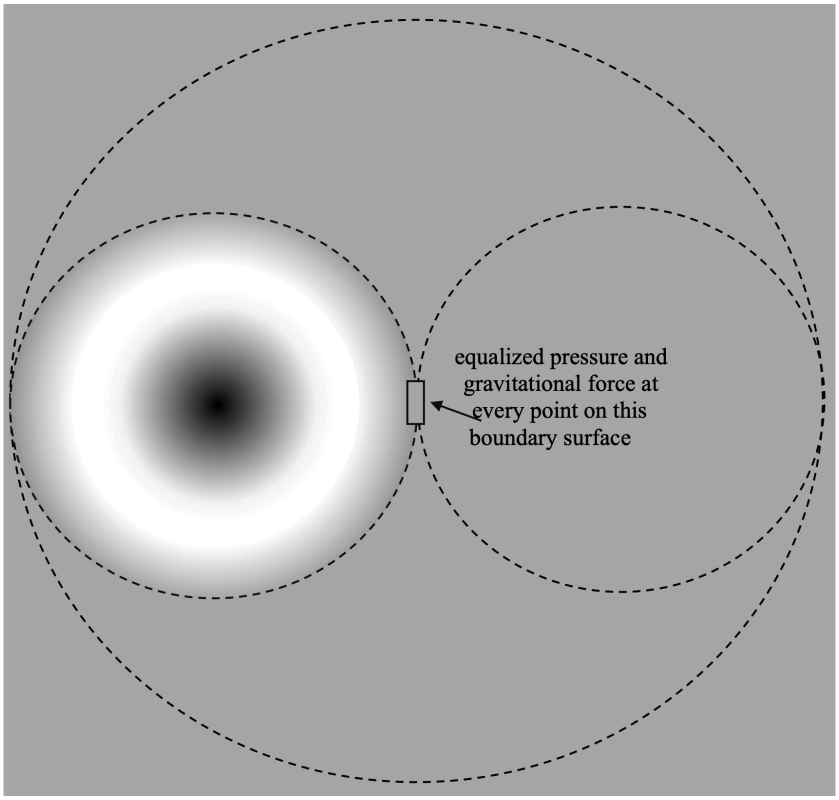

Figure 2: Poisson equation applied to stationary state model of varied uniform density

This will occur because all symmetrically organized forces external to the two smaller spherical regions nullify each other. The typical hydrostatic functionalities of density, temperature, and pressure shown in figure 3 will ensue. Variable density regions will expand and be extended until average density is equilibrated to the average uniform density and pressure values with cancelation of forces at the boundaries of the deviation. The average of temperature and pressure will follow the mass density. equalizing pressure and gravitational force at every point on this boundary surface between over densities where the Poisson equation applies to a stationary state model of varied uniform density applies.

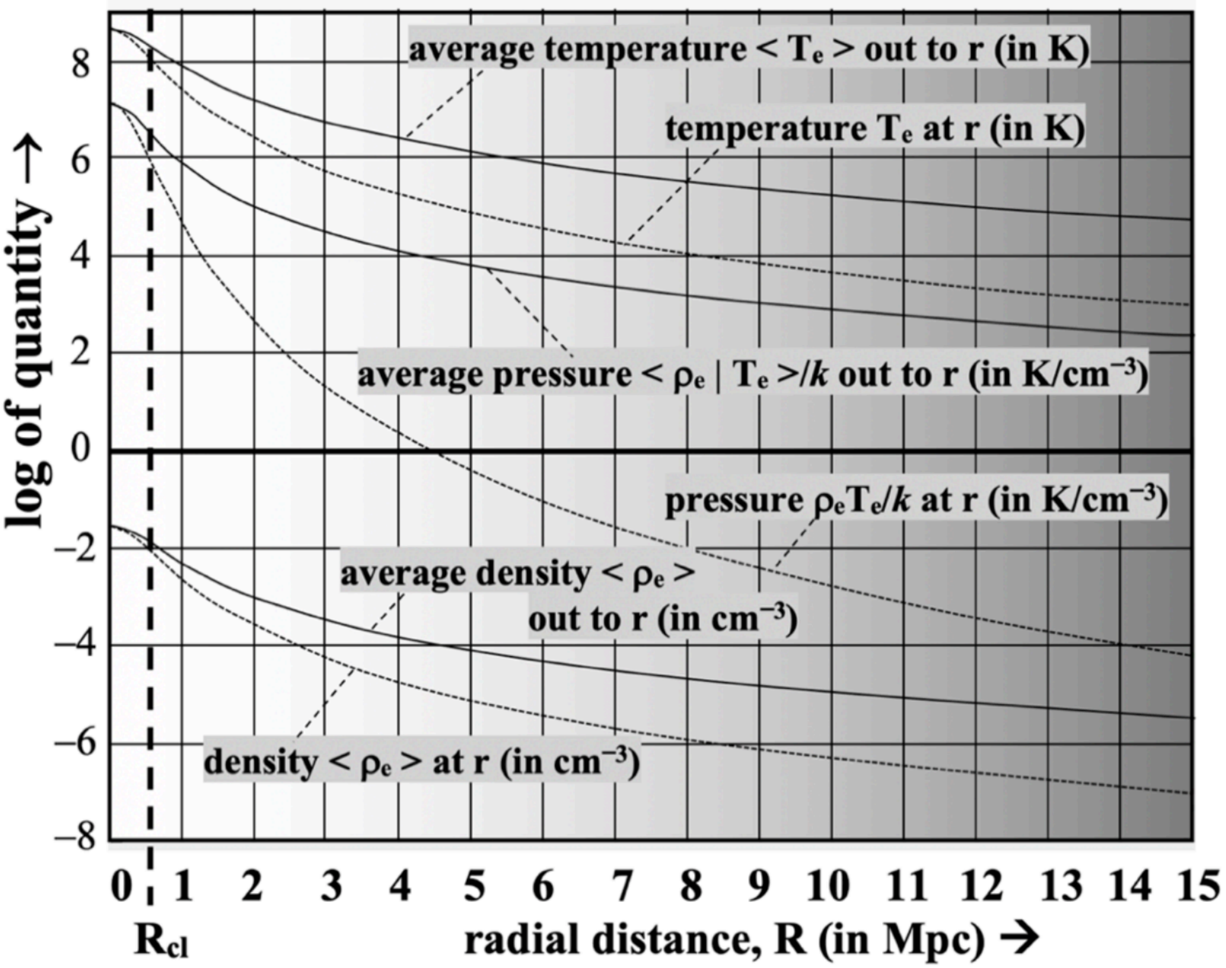

Figure 3: Typical temperature, density, and pressure of intergalactic plasma gases in a galaxy cluster cell as functions of the distance from the centers of the cell

Of course dark matter, as defined by virtue of its non-luminous nature, would not experience thermodynamic effects unless some form of 'dark thermodynamics' were invented. The mapping of dark matter effects correlates its supposed existence with its baryonic counterpart. This close association would have to be attributed to gravitational attachment in which case we have a rather tail wags dog relationship. Thermodynamic considerations produce baryonic matter distribution that must then subsume the much greater dark matter mass into an unholy relationship that would considerably mute thermodynamic effects one would think. This is another inconsistency that is resolved by the plasma scattering model of cosmological redshift addressed elsewhere on this site.