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Static Cosmology from Chaos-Borne Hubble Law

Otto E. Rossler[*]
Division of Theoretical Chemistry, University of Tubingen, 72076 Tübingen, EUROPE
(Received 24 August 2004, 09 February 2005)

A distance-proportional light-ray expansion in the cosmos was empirically discovered by Slipher and Hubble in the early 20th century, as is well known. A recent classical-mechanical finding, Fermi deceleration, implies a classical light-ray expansion and Hubble-like law. The magnitude of the effect appears to be competitive with the space-expansion paradigm of the big-bang cosmology. Therefore some old and new questions concerning the size and the age of the cosmos arise. An early result of Mandelbrot's - fractality of the cosmos - offers itself as a corollary. So does a Hawking-type hypothesis of void-induced particle acceleration. A current empirical quandary - existence of "too old" early galaxies - supports the prediction of a much larger and older cosmos. So does Riccardo Giacconi's preliminary finding of ultra-high-redshift x-ray point sources. The proposed new synthesis sees itself in the tradition of the Peebles school.

PACS numbers: 98.80-k,47.52.+j
Keywords: light-ray expansion, billiard, fractal dimension, chaos

1. Introduction

Recently the idea arose that it may be necessary to distinguish between "light-ray expansion" and "space expansion" in cosmology. The reason: a classical-mechanics based distance-proportional light-ray expansion was found to exist. Light rays traversing the cosmos have to negotiate galaxy clusters that are in random motion with up to 1 percent the speed of light. This is "the principle of the stirred lenses' soup" [1]. The name makes more sense in German because "lenses" is the same word as "lentils" in that language and the term "lentils' soup" is the canonical translation of the "red-pottage" of the Hebrew bible for which Esau sold his birthright to Jacob.

As a direct consequence of the stirring, light rays traversing the cosmos suffer a distance-proportional redshift [1,2]. This new "tired light " (cf. [3] for this term) mechanism is a special case of "Fermi deceleration," it turns out. Fermi deceleration was discovered and named by Loskutov and his co-workers in the context of chaotic billiards. A fast-moving ordinary billiard that is subjected to random, mostly grazing-type collisions with slow-moving high-mass boundaries suffers a distance-proportional loss of momentum [4]. The repelling, grazing-type boundaries of Loskutov *et al.* can be replaced by attracting high-mass point centers - with similar slightly-curved ("grazing-type") interactions being implied [2]. Hence the attracting centers can be galaxies or clusters of galaxies, and the billiard can be a light ray. The strength of the distance-proportional effect depends only on the density, mass and speed of the attracting centers.

2. Chaos and Mandelbrot

The strength of the new effect appears to be neither too large nor too small to account for the empirical Hubble law [1]. If this preliminary result is taken at face value, the implied lack of cosmic expansion re-opens the question of the size and the age of the cosmos.

The radius of the cosmos is, as is well known, subject to a general-relativistic size-limitation if the mass density is assumed to be uniform, which is the assumption which comes to mind first. In this case, not too much will be changed by the

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[*] Also at International Institute for Advanced Studies, Windsor, Ontario, CANADA

above classical explanation of the Hubble law compared to the standard model. The cosmos can still be a pulsatile cosmos, for example, albeit so on a much longer time scale.

If the assumption of a uniform mass density is dropped, however, a second qualitative possibility opens itself up: The general-relativistic upper bound is now no longer necessarily finite. This infinite stationary solution to the Einstein equations (the "fourth" - after Schwarzschild's, Friedmann's and Kerr's) was discovered by Benoit Mandelbrot in 1975 [5]. If the assumed fractal dimensionality of the mass distribution is unity - so that twice as large a radius contains not eight times, but only twice as much mass (as would occur in an ultralight Swiss cheese with holes even in the walls of the holes) -, the Schwarzschild radius which limits the size of a stationary cosmos becomes infinite. This is because twice as much mass by definition has twice-as-large a Schwarzschild radius - and so on for the next doubling of the radius, and so forth up to infinity. Therefore, an exactly 1-D Mandelbrot cosmos is both stationary and unbounded.

3. Peebles and Mandelbrot

Jim Peebles almost immediately discovered that the empirical fractal dimensionality of the distribution of galaxies in outer space is of the order of 1.2 up to large distances [6]. This and subsequently obtained analogous data can now be re-evaluated if the expansion hypothesis (which entered into their calculation) is abandoned. For the originally made assumption of a mounting "lack of volume" (as the remaining distance to the primordial fireball starts to shrink down to zero) ceases to apply. Therefore the previously found convergence of the fractal dimensionality toward a value closer and closer to three (uniform density) as the observational radius approaches the allowed maximum radius, is unlikely to continue. Hence it makes sense to hypothetically extend the empirical validity of the Peebles phenomenon of a near-unity fractal dimensionality to larger and larger distances - possibly over the whole visible cosmos.

However, Peebles adds a second empirical counterargument to the continued-fractality conjecture: decreasing lacunarity for very large distances. The term "lacunarity" was actually introduced by Mandelbrot and shown to have nothing to do with the fractal dimensionality in principle [7]. Peebles rather than quoting this obviously defensive argument, simply shows a picture of the glaring equidistribution of sources valid for very distant quasars [8]: A breakdown of any fractal pattern at very large distances in favor of equidistribution is clearly visible to the eye.

Unexpectedly though, the above "light-ray-expansion rather than space-expansion" scenario makes exactly the same prediction. For the hereby presupposed large number of intervening lenses [2] are bound to eventually "homogenize" any pre-existing large-scale lacunarity. Therefore, the glaring breakdown of Mandelbrot's defense argument is magically suspended. In addition, a new testable prediction arises: There should be a manifest increase of the "non-uniqueness index" (percentage of multiple-image objects) with distance for the farthest quasars. If this prediction - which is not very easy to check since properties other than the redshift value alone need to be taken into regard in a painstaking comparative analysis over larger and larger angles - bears out, once more an impenetrable crystal sphere will be smashed.

The "crystal sphere" of Ptolemy was believed to let shine through its fixed holes (for the fixed stars) the light from a metaphysical outer domain. It was still upheld by Copernicus, Kepler and Galilei, as is not very well known, and was only shattered by Bruno (Christophe Letellier, personal communication 2003).

4. A Brunian cosmos put to test

The self-consistent empirical prediction of a near-unity fractal dimensionality up to the largest distances was (according to Mandelbrot [7]) first made by Fournier [9]. If it survives further scrutiny as suggested above, a cosmos in the sense of Giordano Bruno - "unbounded in both space and time" - will become an option again.

It is clearly too early to say whether this extremal possibility has any chance to be supported by the data. For as we saw, both elements assumed above (numerical re-derivation of the Hubble parameter from the random motions of galaxy clusters in the absence of expansion; persistent near-unity fractal dimensionality up to very large distances in the presence of cosmic shear) are valid only up to an unknown factor of order unity. Nevertheless the new qualitative picture can already be subjected to a plausibility test.

The reason lies in the fact that the other accepted pillars of the big bang paradigm will no doubt spell the end of so far-reaching a hypothesis. Unexpectedly, this is does not seem to be the case. The first point to check is the cosmic background radiation. The latter is the strongest ally of the space-expansion hypothesis. Surprisingly, the CBR naturally falls back into its former role of "mean cosmic temperature."

Assis [10] recently gave a brief historical account of the more than a century old prediction of a mean cosmic temperature of 5.5 K existing. The latter only fell into oblivion when George Gamow arrived at a (less accurate) analogous prediction from the basis of a radically different scenario (the hot big-bang hypothesis). The subsequently actually observed black-body radiation of Wilson and Penzias was always interpreted as a confirmation of Gamow's prediction - and hence in the context of space expansion. In the context of the light-ray expansion paradigm, however, the same empirical radiation now conforms less naturally with the original prediction of a uniform cosmic temperature first introduced by Guillaume in 1896 (cf. [10]). In this case, the same radiation paradoxically loses the status of a cosmic "background" radiation, acquiring a more local status.

Note that if the radiation perceived here had originated maximally far away, it would (because of the light-ray expansion) have been redshifted by the very same amount as in the space expansion paradigm - so that its place of origin would have to be just as hot as in the space-expansion scenario.

Therefore, the CBR must in the new scenario automatically assume the role of a "canonic background radiation." As such it would, despite the fact that the mean cosmic temperature would be universal as mentioned, only represent the "room temperature" of the particular cosmic chamber which we live in. In other words, thermal equilibration of plasma and dust (and possibly even larger particles like iron whiskers ejected by supernovae), present in the local supercluster, would now be the origin of the observed background radiation.

The "thermalization problem of microscopic matter in the cosmos" was, not coincidentally, already addressed by Peebles [11] again. He found that on a cosmic scale, this potential explanation of the background radiation could be ruled out for the following reason: The mean dust level in the cosmos would then be too high to account for the observed, only moderate, frequency-dependent dimming for distant radiation. If, as in the present scenario, the observed equilibration takes place over cosmologically speaking negligible distances only, the other "rooms" and especially the voids in between would not have to possess the same mean dust density. Hence Peebles' thermal-equilibration hypothesis suddenly makes eminent sense.

To check on the new short-distance interpretation, one could compare the large-angle honeycomb structures of the WMAP with integrated radiation profiles specially collected over finite distances in the same directions. The more conspicuous high-frequency angular perturbations also detected, which are traditionally interpreted as quantum fluctuations in the primordial-fireball, have also been brought in connection with moving-lense effects in the past [12,13]. They would in the present context rather reflect plasma and gas etc. streamings in the local "room." The existence of even higher-frequency perturbations could be predicted. Note that the empirical verification of even the slightest change in the fine-grained background would topple the current (far-distance) interpretation.

On the other end of the scale, the systematic proper-motion effect discovered by Conklin [14] - the lowest-frequency global component of the CBR - would no longer reflect an "absolute" motion against the whole cosmos, but only one against the local room. Therefore, it would become urgent to at last identify different submotions in this lowest frequency range.

The three other pillars of the big bang paradigm - primordial nucleosynthesis, inflation and accelerated expansion - each possess a lesser weight in comparison. They could therefore be made wait in line until the exact size of the lightray-expansion-based (sub-) Hubble constant has been determined. The latter, being the same in both directions of time, would cause a mess in cosmology unless it were not either 0 or 100 percent. This explains the optimism concerning a 100 percent outcome displayed above.

Nevertheless the youngest addition among the three - the last one - can already be dealt with in the context of the present paradigm. It is based on the surprise "discovery of the year 1998" which consisted in a surprise nonlinear excessive dimming at Hubble redshifts around and beyond unity. This frequency-independent large-distance dimming possibly conforms with an accepted fact, the Peebles-Tolman dimming law. According to this law, cosmic dimming goes not with the first power of the frequency (as one might naively expect), but rather with the fourth power - that is, with (1+z)-4 [15]. The latter law was predicted by Tolman and later by Peebles for the space-expansion scenario; but it remains qualitatively in charge under a condition of light-path (rather than space) expansion. In a comment made in the year 1999, it was not yet clear whether the supernova observations which revealed the excess dimming had indeed explicitly included the Peebles-Tolman law [16]. The new light-ray expansion scenario now predictably supports an even higher exponent than 4 (owing to the chaos-theoretic Sinai divergence that is implied by the cosmic shear). Thus, the scheduled supernova project [17] would acquire an new added motivation.

5. Two intrinsic counterarguments

So far only some relative merits and pitfalls of the lightray-specific alternative to space expansion were focused on. However, there exists a second class of counterarguments that are not relative but absolute, for they are intrinsic to the new picture if the latter is taken seriously on a heuristic basis. They offer an even better chance at falsification.

The first such intrinsic counterargument is the far-from-equilibrium nature of the observable part of the cosmos. The glaring absence of the by assumption "far-from-equilibrium" nature of the big bang scenario makes itself felt. While the true nature of this assumption is rarely addressed (in an oscillatory cosmos, eventually a "second-order equilibrium" shold develop; Frank Kuske, personal communication 2005), in the present context the problem clearly cannot be kept under the carpet.

Even though this problem was not yet an issue in Bruno's time, it became notorious in the 19th century when Boltzmann proposed in an anthropic fashion that the visible cosmos was a far-from-equilibrium fluctuation pocket of finite extension in an infinite cosmos at equilibrium. While still a possibility to take seriously, Boltzmann's solution clearly looks a bit too heavy to swallow to date. Indeed one of the reasons the non-stationary post-Slipher [18] cosmologies enjoyed rapid acceptance in the 20th century may have to do with the very awkwardness of this - otherwise apparently irrefutable - assumption.

Actually, the assumption is perhaps no longer necessary to date. The heuristically revived Brunian eternity was unexpectedly supported above by a lucky coincidence (Mandelbrot's fourth solution). The heuristically revived Brunian eternity is - possibly - aided by an equally lucky coincidence. The latter, however, has only the status of a hypothesis at the time being. The hypothesis refers to a gravitational effect first stumbled upon but skipped by Einstein. In 1912, Einstein [19] pondered the case of a massive particle inside a Newtonian void (that is, a gravitating mass which consists of a constant-width spherical shell). Newton had shown that there is no gravity present inside, but the advent of special relativity called for a re-appraisal. Einstein found that a sudden linear acceleration, applied to the shell, is bound to drag the internal particle along a bit (and vice versa). For some reason, however, he did not remark on the simpler case of an initially non-zero relative velocity between the two bodies. If this footnote is added on to date in the hope that Einstein' s silence was not a reflection of his having already ruled out all this, one comes up with the prediction that the moving particle inside suffers a forward acceleration [20].

The hypothesis is easily falsifiable since it is based on special relativity alone. The latter predicts that the effective energy content of the masses in front of the internal moving particle is increased by the longitudinal Doppler factor while the effective energy in the rear is decreased by the same factor. This prediction is derived from the well-known fact that any impinging electromagnetic radiation is changed by this factor. This latter result can be extended to other types of radiation (like gravitational waves), although this has yet to be shown formally. It follows that the effective mass (wall thickness) in front and in the back of the particle are different - so that a net gravity applies in first order proportion to the particle's speed.

This prediction comes close in spirit to an acceleration postulated in an ad hoc manner by Fermi [21] in order to explain the phenomenon of corpuscular cosmic rays. However, unlike the accelerating billiard phenomenon also discovered by Loskutov and named after Fermi (recurrent non-grazing-type collisions of a billiard with moving boundaries [4]), which Loskutov had discovered before Fermi deceleration, the present acceleration is confined to material particles and does not extend to photons.

The hypothetical void-induced particle acceleration now implies that gravitational energy can be recycled into kinetic energy - much as a Carnot-cycle recycles heat. The mechanism thus mimics Hawking radiation [22] while lacking the property of being confined to the neighborhood of a black-hole's horizon. Both principles would indeed cooperate in the evaporation of black holes. The present mechanism would be both more general and more frail since the mediating particles (gravitons?) have yet to be defined. Thus, all that can be said at the time being is that "a Hawking-like mechanism" is needed as a remedy.

The second intrinsic problem to Brunicity consists in the fact that not all matter has long ago disappeared in eons-old black holes (a point once more already addressed by Peebles [15]). This second "far-from-equilibrium phenomenon" can again be hypothetically solved by the very "Hawking-like mechanism" already introduced in the context of the first.

6. Two empirical facts

Can the preceding, purely theoretical predictions be added some empirical flesh? More specifically, is there any direct empirical evidence in their favor? Two recent facts - or almost-facts - come to mind.

First, the bigger if less certain item: Very faint distant x-ray point sources are likely to possess redshifts in excess of 30. This empirical conjecture is based on two findings: (1) The current sensitivity of x-ray telescopes is 1000 times greater than that of light telescopes [23]. Hence these orbiting telescopes could in principle look "30 times deeper" (squareroot of 1000) into space than their light-based cousins do. (2) X-ray point sources continue to pour in at the lowest brightnesses [23]. Both facts taken together imply if the weakest point sources are the farthest that the latter possess redshifts in excess of 30. This empirical conjecture will when confirmed amount to a catastrophe for the big-bang paradigm since the latter leaves no room for redshifts in excess of about 10 for massive sources. Giacconi's conjecture (as the two points taken together may be called) moreover comes equipped with a matching third point: (3) Direct x-ray redshift measurements are already in progress [23]. This self-falsifying nature makes it particularly welcome.

Second, a harder but less extremal fact along the same lines: the recent optical discovery of strongly redshifted mature galaxies some 12 billion light years away when the cosmos was allegedly still very young. This finding has modern cosmology in its first full-fledged crisis after three quarters of a century [24-26]. Almost any way out appears acceptable at the time being. The above scenario would hence be a possibility worth exploring even if it had not been arrived at independently.

7. Discussion

A single surprise finding - a classical cooling mechanism for light - allows a whole new view on the Hubble law. This fact if correct necessarily affects any future cosmology. While the most straightforward solution would be a "division of labor" between two Hubble-like laws different in origin (one global-relativistic, the other much more local in kind), there also exists a certain hope that a monistic view will once more prevail.

The two critical elements of an "alternative synthesis" were presented: 1) Is a static post-Einstein cosmology possible? Answer: yes, as a Fournier-Mandelbrot cosmology. 2) Is the potentially infinite window in space and time thereby re-opened compatible with both long-term thermodynamics and long-term general-relativity? Answer: So only in a Hawking-like cycle between mass and kinetic energy.

Lacunarity, cosmic shear and Guillaume equilibration are crucial elements in the new picture. Very far-away gamma flashes should possess ultra-long equivalents in the ultraviolet range, for example (a point not made above). A crucial role will be played by the yet to be determined "very-large-distance dimming law."

The current paradigm has not very much to offer in its defense. Its strongest ally is the background radiation. It appears almost invincible. Even to look for short-distance corollaries sounds unreasonable in view of the well-known beautiful fine-tuning achieved with the big-bang picture. The predicted exponential increase with redshift of distant-quasar multiplicity (which could change this) will take years.

If thus nothing but a "draw" can be achieved on a short-term basis, what has been the real excuse for making so radical a proposal in the first place? The mere avoidance of a "mixed scenario" is obviously not enough. Simplicity desired by mortals is not always heeded by nature. There does exist an additional excuse which may be mentioned at the end. It consists in the counter-intuitive time-reversal invariance of the classical light-ray expansion. The expansion paradoxically holds true in both directions of time (as briefly mentioned). Although every redshifted (elongated) light ray is blueshifted (shrunk) under time reversal, an "average" (nonselected) path is again elongated in the other direction of time [1]. This is the first entropy-like phenomenon encountered in physics since the advent of thermodynamics in the 19-th century. This fact ensures Fermi deceleration a place in the history of physics. A mixture between 20-th century space-expansion (which is not time-reversal invariant) and 21-st century path-expansion (which is) would be maximally inelegant.

While this argument is purely esthetic, it is fully in line with the history of science. A cosmology whose actual features depend on chance (since several other combinations make just as much sense as far as the underlying principles are concerned) contradicts the scientific credo. The "hard road" of an attempted new simplicity was therefore chosen above. Even if none of the suggestions made will stand the test of time, the overall direction may be sound. Provided, of course, the new "second entropy" (or "slentropy" in honor of Slipher) is not a mirage.

Viewed against this background, Giacconi's outrageous conjecture is, perhaps, not so stupid after all.

8. An afterthought

Is any mature science so weak that an infinitesimal perturbation - an added classical Hubble law in the present case - can turn a 75-year old consensus on its head? Or were two perturbations acting together (Fermi deceleration, void-induced acceleration) needed for an infinitely improbable overoptimal jolt? Or - most likely - is there a major error in one of the two hypotheses?

Acknowledgments

Paper dedicated to Benoit Mandelbrot on the occasion of his 80th birthday. I thank Dieter Fröhlich, Normann Kleiner, Heinrich Kuypers, Alfred Klemm, Christophe Letellier, Bob Gilmore, Peter Weibel, Peter Plath, Vladimir Gontar, George Galeczki, André Assis, Joachim Peinke, Wolfgang Engelmann, Rudolf Huebener, Michael Scharle, Martin Pfaff, Hans Diebner, Florian Grond, Sebastian Fischer, Alfred Klemm, Iradj Rahimi-Laridjani, Jakob Nill, Jörg Frauendiener, Claus Kahlert, Dietrich Hoffmann, Christian Ochsenfeld, Roger Malina, George Lasker, Laurent Nottale, Mohamed El-Naschie, Jřgen Parisi, Bruno Eckhardt, Stefan Bombaci, Eva-Christina Zeller, Peter Bosetti, Andreas Schmidt, Andreas Reichelt, Thomas Tanner, Michael Ziller, Peter, Maria and Jacob Gogarten, Erwin Wendling, Dieter Laser, Siegfried Zielinski, Ulrich Hoyer, Wolf Koch, Frank Kuske, Ulrich Stolte, Martin Jung, Hajo Fuchs, Klaus Schönberger, Jeanette Fischer, Christoph Schuepp, Ren Stettler, Ramis Movassagh, Roland Maurmayr, Anthony Moore and George Krylov for discussions. For J.O.R.

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