



PII: S0960-0779(98)00118-5

Almost-Black-Holes: an Old–New Paradigm

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(Accepted 14 May 1997)

Abstract—The so-called Schwarzschild factor, which determines the relativistic redshift of almost-black-holes, is used to establish an analogy between redshift phenomena on three different mass levels: neutron stars, quasars and cosmos. Secondly, a topological argument of the surgery type is introduced to suggest the existence of a distance-dependent redshift law in almost-black-holes. Thirdly, an ‘embedding’ of the Friedmann ‘big bang’ solution into a more robust Schwarzschild neighborhood is proposed and discussed from the viewpoint of its internal stability. © 1998 Elsevier Science Ltd. All rights reserved

1. INTRODUCTION

The concept of observer-covariance as introduced by Einstein in 1905 has a precursor in a paper of the 18th-century physicist Roger Joseph Boscovich, entitled “On space and time as they are recognized by us” [1]. Boscovich made an interesting claim: a breathing world (‘expanding or contracting in a matter of days’) would appear non-breathing to an internal observer. This little-known cosmological proposition seems to call for a re-evaluation of cosmological redshift in ‘non-breathing’ terms.

The reddening of galaxies in close proportion to their distances (the Hubble law) is a well-established fact of nature. Finding an alternative interpretation to the standard ‘big bang’ interpretation is notoriously difficult. Therefore it is perhaps a good strategy at first to confine one’s interest to the most prominent ‘beacons’ in the sky, the so-called quasars or quasi-stellar radio sources. If quasar redshift turned out to be compatible with a non-recessional origin, light would be thrown also on cosmological redshift itself.

2. THE RELATIVISTIC REDSHIFT LAW

The relativistic redshift law is an implication of Schwarzschild’s rotation-symmetric constant-density solution to Einstein’s field equations of general relativity [2]. The law was used by Zeldovich and Podurets [3] to draw attention to the fact that black-hole redshift (which is total) has a precursor which is non-total. Such sub-maximal redshifts are a characteristic of what may

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be called ‘almost-black-holes’. The radius of such objects is somewhat ‘too large’ to cause their complete optical disappearance. More important, perhaps, the range of diameters for which the ‘almost’ phenomenon occurs increases linearly with the adjacent Schwarzschild radius itself.

Specifically, the redshift z depends on a single parameter K according to a simple, monotonically increasing hyperbolic law:

$$z = \frac{\Delta\lambda}{\lambda} = (1 - K)^{-1/2} - 1. \quad (1)$$

One sees that z becomes infinite as K approaches unity from below. The parameter K is a ratio implicit in the Schwarzschild metric: the quotient between the object’s Schwarzschild radius and its actual radius,

$$K = \frac{r_s}{r}. \quad (2)$$

The Schwarzschild radius r_s itself is given by

$$r_s = \frac{2G}{c^2} M = \frac{M}{M_{\text{sun}}} r_{\text{sun}} = \frac{M}{M_{\text{sun}}} 3 \text{ km}, \quad (3)$$

where M is the object’s mass and M_{sun} is the mass of the sun and $r_{\text{sun}} = 2.96 \text{ km}$ is the sun’s Schwarzschild radius.

By substituting from equation (3) into equation (2), one arrives at a more intuitive formulation of K :

$$K = \frac{M}{M_{\text{sun}}} ; \frac{r}{r_{\text{sun}}}. \quad (4)$$

Equation (4) shows that K becomes unity (and hence z infinite) if M is equal to the sun’s mass and r is simultaneously equal to the sun’s Schwarzschild radius. However, this is only one possibility in an infinite family. The same result applies whenever M is an arbitrary multiple of M_{sun} and r is the same multiple of r_{sun} .

One sees that not only the Schwarzschild radius itself scales linearly with mass—a fact which, as is well known, allows for arbitrarily ‘dilute’ black holes—but so does the surrounding range of ‘almost-black-hole’ radii. Hence the larger a ‘dilute’ black hole, the larger also the surrounding set of radii for an almost-black-hole.

This means that, whenever a larger mass scale becomes of interest for some reason, the probability of one’s finding a nontrivial relativistic redshift associated with an object in this mass range is proportionally enhanced. This result defies common sense which believes that ‘relativistic redshift’ has something to do with the local curvature of space. It comes as a surprise that the ‘flatter’, more linear, spacetime becomes due to a dilution-in-space of all masses, the greater the risk of a curvature-induced redshift becomes.

3. THE SIGNIFICANCE OF THE SCHWARZSCHILD FACTOR

The Schwarzschild factor K determines the ‘gravitational redshift’ of any (more or less isolated) object in space as we saw. Adjacent sources of masses negligible compared with that of the almost-black-hole itself, that are either light-emitting or light-absorbing, obey the same law as a function of their own distance (r) from the center.

Historically, the first major application of the Einstein–Schwarzschild redshift law is Oppenheimer and Snyder’s observation [4] that a star with the mass of the sun would be hard-pressed

indeed to acquire the sun's Schwarzschild radius in an implosion. For the density of nuclear matter (10^{14} g/cm³) would be reached before the Schwarzschild radius is. Any further compression is therefore out of the question. However, a star with a mass only three times larger is no longer subject to the same barrier when likewise subjected to a supernova implosion. The quadratic decrease of critical density with mass is responsible for the fact that the density of nuclear matter is now no longer reached ahead of the Schwarzschild radius, so that ordinary physical forces can no longer halt the implosion. While a calculation of the forces which apply inside the Schwarzschild radius remains problematical up to this day, the idea of 'black-hole collapse' was born.

A look at the structure of equation (4) shows that the 'dilution trick' employed by Oppenheimer and Snyder can be reiterated. All forces in the neighborhood of the Schwarzschild radius—like the tidal forces experienced by an object about to 'plunge through'—can be diluted further and further to a virtually arbitrary extent (because of their decreasing quadratically with the Schwarzschild radius). Simultaneously, the adjacent co-extended 'redshift-laden' r values for almost-black-holes show the same good-natured behavior. Both facts taken together are bound to play a major role in 'natural applications'.

4. QUASARS VIEWED AS ALMOST-BLACK-HOLES

Zeldovich and Podurets [3] pointed to equation (1) with quasars in mind. Quasars had just been discovered by Sandage and Schmidt [5, 6] as optically small ('quasi-stellar') strongly redshifted sources. They are in addition, as is well known, characterized by a broad (mostly non-thermal) spectrum and a number of further non-mandatory features, such as jet formation, strong radio, x-ray and gamma emission and a marked variability (with a mean half-period of up to a year). Today, quasars are believed to be 'active galactic nuclei' ([6a], see [7]).

There exists a continuous transition range towards less and less bright and more and more rapidly varying sources (down to the order of an hour) that are called 'BL-Lac objects' (see [8]). Redshifted Seyfert galaxies also often contain an active galactic nucleus [8]. A typical modern interpretation of quasars stipulates that they are 'objects of some 10^{10} solar masses crammed into a volume with a diameter of about one parsec' [9].

Heuristic insertion of those two parameter values ($M = 10^{10}$ solar masses and $r = 1$ light year or 10^{13} km) into equation (4) reveals that only a miniscule relativistic redshift is implied by this current quasar model. However, there is a remedy. All it takes to enter the nontrivial scaling range (once r is fixed by the time constant of variability) is to crank up M by a factor of 10^2 . Insertion of $M = 10^{12}$ solar masses along with $r = 10^{13}$ km into equation (4) yields

$$K = 0.3 \quad (5)$$

and, using equation (1), a redshift $z = 0.2$. The redshift of the first identified quasar (3C273) was 0.16 [6]. If mass had been increased only three times more, to 3 times 10^{12} solar masses, K would approach unity and z infinity. Note that quasars with redshifts of up to about 5 are known [8].

The proposed 'mass correction for quasars' by two orders of magnitude is not entirely implausible, given the fact that the standard picture assumes a very broad range (10^6 to 10^{10} solar masses [8]) already. Such a wide range of empirically acceptable values usually admits of a comparably large 'fringe zone'. The proposed value of 10^{12} solar masses would still fit into the fringe zone.

The value of 10^{10} solar masses, given as the only estimate by Voigt [9], is equivalent to 10 per cent of the mass of the Milky Way galaxy (about 10^{11} solar masses). A giant elliptical galaxy may reach 10^{14} solar masses [10]. Thus, the proposal made above boils down to the hypothesis that the active galactic nuclei of giant elliptical galaxies may reach the same relative size as is the accepted standard for less massive galaxies—1% or 10^{12} solar masses.

5. TWO PROBLEMS: AVAILABLE TIME AND STABILITY

The main problem is time. Eventually, galactic nuclei of the predicted size (10^{12} solar masses) are bound to form in giant elliptical galaxies anyhow. However, Novikov estimates that the time scale until all galaxies have decayed to a single black hole each is 10^{19} years [11]. If this estimate were the only guide, the proposal made above would be in serious trouble. Fortunately, though, galactic nuclei of the predicted size can be generated by the very processes that gave rise to the smaller nuclei found in smaller galaxies. (Andromeda is believed to have a nucleus of 10^9 solar masses [10]; the Milky Way galaxy has one of 2.5 million solar masses [13].) Since giant ellipticals are believed to have come about through a process called 'galactic cannibalism', see [8], it appears conceivable that some of them may at present already have collected a sufficient amount of core material (10^{12} solar masses) from their cannibalized smaller cousins. The time scale would then be comparable to that needed by smaller galaxies to accrue their own nuclei. The time window allotted by the big bang hypothesis (10^{10} years) is therefore not necessarily at variance with the proposal made above concerning the mass of quasar-type nuclei.

The second fundamental problem is stability. 'Relativistic star clusters' are stable in the sense of forming a Newtonian 'equilibrium' only up to intrinsic redshifts of about $z = 0.5$ [3], corresponding to a K of about 0.55. In other words, when the radius of the star cluster has shrunk below a value of about twice the Schwarzschild radius, an instability against 'collisionless radial vibrations' sets in (see [7], p. 687).

According to this estimate, quasars with a redshift larger than 0.5 should be rather shortlived since the Newtonian radial instability causes an irreversible approach toward the Schwarzschild horizon [3]. The final stage—the falling over the cliff so to speak—takes 10^{-5} seconds times the mass of the black hole measured in units of the sun's mass [7]. Thus, to 'blink out', a mass of 10^{12} solar masses will need 10^7 seconds or roughly a year. The duration of the 'semiclassical collapse' which precedes this nonclassical collapse will be considerably longer, however. A quasar decay stretching over centuries or millennia is, therefore, not excluded by the Zeldovich–Podurets instability. Such time scales are also not excluded by phenomenology, since some quasars seem to have lost brightness over the course of almost a century (to judge from comparison with old photographic plates [12]).

This apparent confirmation of the proposal made is no reason for complacency, however. There remains a second quantitative problem to consider. If large-redshift quasars were so shortlived as to be visible only for millennia (a negligible span on cosmological time scales), their abundance in the sky would be hard to understand. Therefore, search for further loopholes in the Zeldovich–Podurets limit is called for.

To derive their $z = 0.5$ limit, Zeldovich and Podurets [3] presupposed that the star cluster possesses the radial density of a Newtonian star cluster. This assumption can be relaxed. There are two possibilities—a less dense central region and a more dense one. The former case applies when for some reason the center is 'swept clean'. This could happen, for example, if a large accretion disk surrounding a moderately massive central black hole had formed inside a cluster. Such a situation has recently been photographed in the core of an active elliptical galaxy (NGC4261, [10]), although on a much too large scale (the accretion disk is 400 light years in diameter). Whether or not central dilution can indeed allow for a prolonged semiclassical survival of relativistic redshifts greater than 0.5 is open.

The second possibility, of an enhanced central density, again presupposes the presence of an internal black hole. (The alternative—a self-similarly increasing internal density without formation of a black hole—appears more contrived although strong redshifts can be obtained in this fashion.) The larger a central black hole, the less 'voracious' it in general becomes (so that the second possibility gains in plausibility). However, there are 'bumps' in the curve. The black hole in the Milky Way Galaxy (2.5×10^6 solar masses [13]) is quiet while that in Andromeda (10^9

solar masses [10]) is violently active. Whether the presence of a black hole that makes up a sizable fraction of the volume of an almost-black-hole may act as a stabilizing factor for the surrounding strongly redshifted cluster is open. To find out numerically whether there exist such conditions, especially in the presence of rotation, requires celestial molecular-dynamics simulations of hybrid type that are not yet available.

A third possibility, worth considering finally, is the ‘burning log’ analogy. A ‘burning zone’ with a large redshift may surround a continually growing giant black hole for an extended period of time as a ‘quasi-equilibrium’. A not too high density in the surrounding cluster may be conducive, and so may be rotation. A growth zone characterized by high-energy phenomena is needed anyhow for a realistic quasar model. Again, only certain regions of parameter space can be hoped to be appropriate. This third hypothesis again seems like begging the future (when relativistic molecular-dynamics simulations will be available). However, in this case, macroscopic dissipative approximations also have a chance.

This is because the third hypothesis belongs into a different ball park, so to speak. It amounts to a new type of ‘dissipative structure’ (in the sense of Prigogine and Nicolis [14]) postulated for relativistic star clusters. The latter no doubt are complex enough to admit such phenomena. So far, only the standard equilibrium of statistical mechanics has been invoked in the analysis of their stability it appears. The consideration of dynamically maintained (flux-type) steady states constitutes a necessary second step before Zeldovich’s quasar model can be laid to rest on theoretical grounds for time scales much larger than millennia (at stake here).

Eventually, more complicated attractors may become of interest as well, given the empirical presence of recurrent phenomena on two time scales (months; centuries) already mentioned.

6. DISTANCE-DEPENDENT REDSHIFT INSIDE ALMOST-BLACK-HOLES?

Star clusters of the almost-black-hole type are intriguing, not only for ‘applied’ reasons but also in a more abstract context. The fact that they are much easier to understand than genuine black holes renders them a useful tool when a more direct attack on the properties of the latter is out of the question. A case in point is the fact already mentioned that almost-black-holes may contain ‘interior black holes’, a property unlikely to be inherited by black holes proper.

A second feature along these lines could be the presence of an internal distance-dependent redshift law. The farther two stars are apart in a relativistic cluster, the more they appear to be subject to a mutual redshift because the rest of the cluster acts like a dress that screens the one from the other’s view.

This proposal can be made more intuitive by resorting to a topological argument of the surgery type. It may be called the ‘pair-of-braces trick’ in honor of a bygone fashion period in which men’s trousers were suspended with a pair of rubber strips (‘braces’) fixed with buttons to the waistband. These rubber bands could be elongated with the thumb to make an elegant snapping sound when released – a children’s delight. In the same vein, an outer star of the relativistic star cloud can be pictured in the mind as being lifted out of the cloud, only to be put back again (without the snapping sound).

As the star is slowly moved up away from the rest of the cloud, it does not take a long stretch until the cloud assumes almost the same overall redshift to our star as it would when viewed from far apart. (About a light year suffices.) Then, as the star is slowly moved all the way back to its original place, its former neighbors eventually become part of their original linear ($z = 0$) neighborhood again. Not so for the more distant neighbors, however. While they too resume their former relative positions of 2 light years apart (rather than 3), there is no reason apparent why their redshifts should go down all the way toward zero, too. (Starting from a redshift of 0.15

at a distance of 3 light years, something like 0.1 would be expected at a distance of 2, rather than exactly 0, one feels.)

The argument just presented is purely qualitative—applying as an ‘integral’ over all possible topological shapes of the cloud as it were. It is only for some very special shapes (such as perfect rotation symmetry) that the argument becomes problematical (at first sight) on quantitative grounds. For the surface of the cloud then forms an ‘equicurvature region’ in analogy to the ‘equipotential region’ which forms in a sphere of electrically charged particles under similar conditions. However, in curved spacetime, the analogy to a static potential indeed breaks down it appears. Two points which have the same gravitational potential compared to a third (the center, say) are no longer necessarily potential-free relative to each other.

The following analogy from special relativity is helpful. Two spaceships that depart in opposite directions are mutually redshifted even though their home base appears equally redshifted to both. Similarly, two spaceships that are accelerated in opposite directions can be mutually redshifted. Think of each as trying in vain to escape from the gravitational tug of a heavy star in opposite directions, for example. The analogy can be checked by means of the equivalence principle, using the method of isochrones (work in preparation). Eventually, when the requisite acceleration becomes maximal (close to the surface of a black hole), mutual redshift also shared become maximal. In the case of an almost-black-hole, the mutual redshift of course will stay bounded.

The advantage of the almost-black-hole paradigm is that the cloud is transparent. The phenomenon can therefore be watched in principle. How does the night sky look in our star cloud? Suppose we have landed on a planet that orbits an outer Sun-like star at a distance of 8 light minutes (as we do in our own galaxy). The mean distance to the next star in the cluster (10^{12} stars packed into a volume 2 light years in diameter) is 2 light years over 10^4 or about 2 light hours. Hence the night sky is still characterized by a decrease in brightness by a factor of about 200 (120 minutes over 8 minutes, squared), much as holds true on Uranus where the sun is only the brightest star in the sky. Olber’s paradox—a blazing night sky—thus is avoided for two reasons in the cloud: (a) the small finite diameter of the cloud, and (b) the distance-dependent redshift, predicted above.

7. A COSMOLOGICAL ANALOG

The almost-black-hole just considered had a density 24 orders of magnitude lower than that of a supernova-induced almost-black-hole (neutron star). A similar reduction in density can be achieved once more if we take the next ‘mass leap’, up from the galactic scale to that of the cosmos. We thus are free to insert the mass and the radius of the cosmos into equation (4).

The currently accepted mass of the cosmos is about 10^{22} solar masses (corresponding to 10^{11} galaxies like the Milky Way) [8]. Hereby the mass of the recently discovered (still ‘unignited’) blue dark galaxies [15] is not yet included. The currently accepted radius (‘age’) of the cosmos is about 10 billion (10^{10}) light years or 10^{23} km. Insertion of these two numbers for M and v into equation (4) yields

$$K = 0.3, \tag{6}$$

once more. Thus the very situation described above for the inhabitants of a solar system that is part of a relativistic star cluster is re-encountered here for the inhabitants of an arbitrary solar system in the cosmos: A distance-dependent redshift law can be predicted.

There are several differences between the internal redshift law, proposed above to exist inside an almost-black-hole, and that found empirically in the cosmos (Hubble’s law). Firstly, the redshift law inside an almost-black-hole is bounded. A boundedness has yet to be ruled out for

the cosmological redshift of ordinary galaxies. Secondly, almost-black-holes are non-closed by definition. Hence if the cosmos were an almost-black-hole, at least some 'scattering light' would have to exist inside (possibly in the form of an isotropic background radiation). Thirdly, the redshift law stipulated above appears to be nonlinear (work in preparation). Fourthly, it holds true only for more or less 'outer' positions in the almost-black-hole and hence is not universally valid as would be demanded by the cosmological principle.

Still, juggling with the parameters of equation (4) is again an option. The total mass of the visible cosmos may easily be three times larger than assumed above. In that case, z_{\max} would once more approach infinity. The above surgery-type argument (cutting off a star and sewing it on again) does not lose any of its significance under this condition. On the contrary: the closer the cloud comes to forming a black hole, the more the difference between 'outer' and 'inner' positions loses its meaning since a fully fledged black hole ceases to have a 'periphery' [7].

Thus it appears that the above distance-dependent redshift law becomes both unbounded and universal—close to the limit at which an almost-black-hole with the mass and radius of the cosmos becomes critical (starts nonclassical collapse).

How important is the assumption of criticality? As long as this limit has not yet been reached, the time scale for the existence of such a cosmos is much longer than after non-classical collapse has set in. The above desideratum of having some 'leeway' over and above the current time scale of 10^{10} years in order to allow for the ready formation of supermassive galactic nuclei could be met under this condition.

However, if we seriously opt for criticality, the leeway disappears. Once collapse has set in, no more than about 10^{10} years— 10^{10} times the collapse duration of the above relativistic star cluster which had a 10^{10} times lower mass as mentioned—would be available. The numerical coincidence with the prediction made by the Friedmannian big bang scenario comes as a surprise. Is the current discussion of criticality in the Friedmann model to be re-encountered in the context of the more general Schwarzschild model (except for a change in sign)? The only major difference would be that the 'big crunch' would already have started in case criticality holds true.

This conclusion presupposes, however, that we already live on the inside of a giant black hole without realizing it. The very advantage of the almost-black-hole paradigm—that the unsolved mysteries of the interior solution of Schwarzschild's can be shunned—is thereby forfeited. The properties of dilute isotropic black holes are currently open (John Wheeler, personal communication, 1976). Fortunately, it appears that we can stay on the safe other side and still get some meaningful answers.

8. DISCUSSION

A number of qualitative implications of Schwarzschild's exterior solution have been re-considered with a view to Boscovich's suggestion that an interior observer of a cosmos which is 'breathing' is unable to sense the breathing.

Paradoxically, a breathing-type solution was thereby re-encountered, albeit of the Schwarzschild type. Hence the whole carefully selected roundabout route—to take only a 'grazing look' at the Einstein–Rosen bridge (as Misner *et al.* [7] call the complete Schwarzschild solution)—was to no avail it appears. Or is there, nevertheless, a remaining way to secure a stationary spacetime as far as an internal observer is concerned, without putting up with steady creation as Bondi *et al.* [16] found themselves forced to do?

The following answer in the positive suggests itself: A near-closed almost-black-hole of the mass of the cosmos contracts in a manner which is undetectable from the inside-up until criticality is reached and forever.

The first part ('up until') makes sense once one is already close to the horizon. This near-criticality had to be assumed above on empirical grounds (homogeneous background; unbounded redshift). The final approach to the horizon then does not involve any dramatic local changes any more and may therefore indeed be unnoticeable from within.

The second part ('forever') is startling. To see what is meant, a glance at the interior solution becomes necessary at last. However, as soon as one even tentatively embraces the idea of living inside a black hole, one is almost trapped. For it now seems to make much more sense to go on asking the same type of question, posed above for almost-black-holes, in the context of the real stuff: Does a dilute black hole of the mass of the cosmos contract in a way which is undetectable from the inside? This conjecture was indeed favored by the authors—until they stumbled across a picture in the 'gravitation bible': Fig. 32.1 of [7].

The picture is a qualitative drawing derived from many quantitative calculations of the two Schwarzschild solutions. Its hallmark is that it even includes the light cones, calculated as they hold true around an inward-plunging trajectory in both its outside portion and its inside portion. The point: Time goes forward (upward) on the outside (in a direction perpendicular to the radius as one would expect) but it goes inward, in the direction of the radius, on the inside.

This switch is well known in principle. It reflects the 'signature inversion' (radius becomes time, time becomes radius) shown by the Schwarzschild metric in the transition from the exterior to the interior solution (see [17]). However, once the same fact has been translated into the behavior of co-moving light cones, as Misner *et al.* have succeeded in doing, it suddenly becomes possible to relate to it and to picture in one's mind what happens: The interior singularity is time-like, not space-like. (A sentence to this effect is also to be found in [7].)

Indeed at the end (at r —speak time—equal to zero), the volume (at t —speak radius—equal to 35.1 M) is nonzero, so the quoted Figure proves. Thus, the internal singularity, which is usually said to crush everything which has fallen in out of existence, acts in a rather counterintuitive manner: it is only time (r) that gets crushed, not space (t). After hitting zero, time (r) re-emerges in the opposite direction (further down in the Figure) to hit the circumference ($r = 2M$) again at the very moment ($r = 2M =$ horizon) at which the departure took place.

The fact that eventually (in part IV of the Synge diagram), one is back in ordinary spacetime—at the very moment at which one left it, but in a 'mirror universe' in which time points the other way—is well known. Nevertheless, the '90-degree turn' of the light cone, taken in the Schwarzschild coordinates r and t , appears to have gone unnoticed in the following sense: It implies that the inner solution has no connection to the outer solution, in terms of an ongoing evolution.

Two points neighboring in space on the outside become two points neighboring in time on the inside. Hence whatever tantalizing things may go on inside, they have no contact to what goes on outside. Like a plant and a melody, they remain unconnected, even if their identities could be demonstrated mathematically. There indeed exist special 'adapted' coordinates (due to Eddington and Finkelstein, and Novikov, Kruskal and Szekeres, respectively), shown in the same Figure in parts (b) and (c), which do provide such a smooth connection. However, this is no counterargument since the trajectories in question are not a flow (in the sense of dynamical systems theory) but are allowed to cross: they may cross in space (on the outside) and in time (on the inside). Therefore, evolution indeed continues directly on the outside in an identical if time-reversed fashion.

If this interpretation is correct, there is no way to find out about the inner plunge, from the outside. Evolution goes on as normal on the outside, until time stands still and reverses course. This last event is unnoticeable, too. Hence Boscovich was right and we are finished.

However, a frightening aspect remains to be mentioned: a new type of death is implicit. A similar fact was seen by Boltzmann. If all particle motions in the cosmos came to a sudden standstill (due to their colliding simultaneously head-on in many places in the right concerted

fashion), in a so-called ‘all-momenta-equal-to-zero’ state, and then reversed, this state could also not be found out from the inside, and there would also be no warning signs. Nevertheless evolution would have come to an end.

The difference is that the Boltzmann phenomenon occurs in classical spacetime where it is infinitely improbable (requiring a ‘conspiracy’ that would take an at least infinitely long time to materialize spontaneously in a gas), while a black hole is a realistic object. Previously, there was no reason to worry; now there is. For the idea of the universe being close to forming a black hole is very realistic provided it is correct.

Our journey devoted to searching for the impossibility of an internally detectable breathing has thus led us back to the concept of a ‘breathing universe’ once more, albeit as a temporal rather than spatial state of affairs. Nevertheless Boscovich’s claim turns out to be heeded after all.

The concept of a standstill that is unnoticeable from the inside was recently also made use of in the mathematical context of finding a convergent power-series solution for the three-body problem. Even in the presence of an impending collision, Quin-Dong Wang was able to continue as is well known [18]. Outside the context of mathematics, the same notion rather reminds one of the biblical (and eastern) assertion that death is nothing to be tasted. The prison—and the escape tactics—thereby acquire a whole new perspective which to pursue, however, would lead us beyond our present context.

Let us finally summarize some empirical questions which are suggested as predictions by the ‘almost’ approach:

1. Is there a ‘cascade’ of lawfully decreasing redshifts observable in quasar light? This would be expected if the zone of origin comprised a volume of the small size predicted. Sources of secondary radiation, as well as absorbing clouds, surrounding the relativistic star cluster should decrease in their redshifts in a ‘rich’ (yearly-ring-like or Forrest-like) manner. This is apparently the case [10, 19].
2. Is the active galactic nucleus, in those cases in which the surrounding galaxy is visible, more strongly redshifted than the surroundings? In particular, do the visible jets ejected by quasars show a smaller (‘purely cosmological’) redshift? In this context, the fact that in a nearby radio galaxy (Cygnus A), the jets are known to be ‘blueshifted’ [8] comes to mind as a possible special case.
3. Are elliptical galaxies of sufficient size the natural hosts and precursors of quasars? Would Centaurus A, one of the closest active elliptical galaxies, represent a possible early stage in quasar evolution?
4. Is there a typical life cycle for galaxies, just as there is for stars? Specifically, do galaxies start out as dust spheres, to become dust disks that are ‘unignited’ at first [15], to end up eventually in the stomach of a giant elliptical if lucky? A Hertzsprung–Russel-like diagram could then perhaps be drawn on a phenomenological basis once more as a function of some age-related parameter (like intrinsic luminosity) [19a].
5. Is the cosmological redshift determined by means of non-lensed spiral galaxies, bounded?
6. Is the structure of the cosmos qualitatively still the same at large distances? This appears to be the case according to recent catalog of 168 large-distance galaxies [20].
7. Is there empirical evidence for the ‘mutual-redshift conjecture’ of Section 6 besides the Hubble law itself? An experiment to find out could be done by measuring the redshift of starlight grazing the sun.

To conclude, a unified view of relativistic redshift phenomena has been suggested. Supermassive quasar models in the spirit of Zeldovich deserve a second look it appears. Macroscopic dissipative structures play a role in relativistic many-body dynamics. A microscopic simulation method has

to be developed. The 'big bang' can possibly be embedded in a family of neighboring, almost-black-hole solutions. A new implication of the exterior solution—mutual redshift—has been conjectured. So has been a new type of death without mortality and corpse. The goal of arriving at a non-expanding steady-state picture of the cosmos is still a powerful incentive for asking new questions. Qualitative topological thinking may bring the two nonlinear fields of spacetime theory on the one hand and chaos, solitons and fractals on the other closer together.

Acknowledgements—We thank Hermann Bondi, John Wheeler, Ilya Prigogine, John Argyris, Art Winfree, Ichiro Tsuda, Doyne Farmer, Piet Hut, Herbert Pfister, Jurgen Parisi and Jurgen Eichenbrenner for discussions. For J.O.R.

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