Mass inflation as a recurring property of matter in astrophysical situations

S.V.M. Clube
Department of Physics
University of Oxford, UK

A minority view of the universe due to the author is discussed in the light of several recent developments. In particular, galactic signatures in the terrestrial record have now been established which are difficult to explain except in terms of a previously unrecognised family of fragile cometary bodies in spiral arms. The presence of these bodies coupled with an apparently major outflow in the Galaxy of its spiral arm and globular cluster systems seems to indicate a new kind of gravitational perturbation in the Galactic nucleus which is associated here with recurring mass inflation. These new effects provide *prima facie* evidence for the Lorentz-Dicke interpretation of physical phenomena, suggesting in turn that we may have been seriously misled as to the fundamental nature of the cosmological redshift.

Introduction

The observable universe is divided by astrophysicists and geophysicists into a hierarchy of subordinate regimes rather like a Russian doll. Most of these regimes are characterised by discrete bodies and a volume of space in which these bodies interact. At the highest level, a cosmological environment is recognised in which clusters of galaxies (and even larger configurations) move around and interact. Next, there is an intergalactic environment containing galaxies that orbit within individual groups or clusters. This is followed by an interstellar environment containing stars and other material aggregates that orbit within individual galaxies. Then we come to the interplanetary environment containing planets and other smaller bodies that orbit in the vicinity of individual stars. The surface of our planet may be thought of as an intercontinental environment containing continental masses that drift around beneath a medium composed of oceanwater and atmosphere. Below there is a particular convection cell of the Earth's mantle on which our observing platform, a particular continental mass, floats. And finally, there is the terrestrial core.

Whilst each of these physical regimes is commonly perceived as being in some kind of dynamic equilibrium coupled with its surroundings, periodic and/or stochastic perturbations may also be envisaged. And insofar as it is conceivable that these perturbations are transmitted through the various levels of the hierarchy, it is possible that the terrestrial surface may carry an imprint of their temporal sequence. It follows that perturbation signatures in the terrestrial record are capable in principle of having some bearing on our perception of cosmic and terrestrial processes. The significance of the terrestrial record in this respect is not yet settled however. On the other hand, there have been several recent developments in our understanding of these various regimes which may now open the way to a fundamental change in our cosmological viewpoint based ultimately on the terrestrial record.

Interplanetary Environment[1]

The most crucial development in this respect is the space-age discovery, still largely unremarked by most astrophysicists and geophysicists, of a population of dark bodies (diameters ~ 1–10 km) in Earth-crossing orbits. These are now known to be present in sufficient numbers to be in general accord with the cratering flux on the planetary surfaces during the last 3.9 billion years. An associated development has been the discovery of a substantial population of dust particles (the zodiacal cloud) in the same general region of interplanetary space. Both populations are recognized as being too large to be generated by the systems which at first sight are their most likely sources, namely main-belt asteroids and/or short-period comets. This has long been an acute problem so far as the dynamical equilibrium of the interplanetary environment is concerned, particularly as the short-period comet population is also overabundant in relation to the flux of long-period comets from the Oort cloud. Both excess populations in Earth-crossing orbits (*i.e.,* dark bodies, dust particles) including the excess of short-period comets may however be the natural product of occasional very large comets (diameter ~ 100 km) of extreme fragility, which break up into kilometre and sub-kilometre sized cometary bodies and rapidly reduce to dust. If this understanding of our interplanetary environment is correct, requiring its perturbation by very large comets from time to time, we might also expect to have evidence of the most recent and forthcoming very large comets. Such evidence is available in the form of a huge swarm of meteoroidal debris circulating at the core of the Taurid meteor complex which has apparently evolved from a very large comet (diameter ~ 100 km) during the last 10^4 yr; and in the form of a very large comet called Chiron (diameter ~ 200 km) whose current orbit under the influence of Saturn may in the near future (~ 5.10^4 yr) transfer to one under the influence of Jupiter.

The interval between these very large comets is typical of the characteristic interval ~ 10^5yr between those deflected into the short-period comet system from the Oort cloud. Thus the interplanetary environment may now be considered to contain a rapidly disintegrating giant comet for several 10^4 yr every 10^5 yr or so, though the frequency of these perturbations is evidently further modulated by such changes in the overall flux of long-period comets as may be imposed by the source function and gravitational perturbations of the Oort cloud. Neither of the latter are known with certainty at present although it has come to be assumed that the long-period comets observed at perihelion are outer fringe members (the Oort cloud) of an unseen, primordial cloud of comets surrounding the Sun which is perpetually stirred up by passing stars, interstellar clouds and galactic tides. The evidence supporting this belief does not exclude other possibilities however. Thus the Oort cloud may also be a recurring solar appendage arising through the capture of comets from star forming regions in spiral arms. Perturbations of the interplanetary environment induced by very large comets may be modulated therefore by an approximate double-period of ~ 250 Myr corresponding to the Sun's passage through successive pairs of spiral arm-interarm regions *and* approximate half- or quarter-periods (~ 30 Myr, ~ 15 Myr) corresponding to the Sun's vertical oscillation in the Galactic plane. These periodicities are respectively due to comet capture in spiral arms and the sampling of a variable galactic tide in the vicinity of spiral arms.

Interactions between the massive swarms of meteoroidal debris due to very large comets and the Earth may thus be expected to produce characteristic temporal signatures which are random, quasi-periodic and periodic. The characteristic timescales are ~ 0.1 Myr (chrons), ~62.5 Myr (super-chrons) and ~30 Myr/ ~15 Myr respectively. Since these interactions may also be expected to affect climate through dust-loadings of the atmosphere which cause global cooling, corresponding modulations of plate tectonics and core dynamics cannot be excluded. Thus the climate fluctuations produce corresponding displacements of oceanwater between the polar ice and equatorial bulge, thereby perturbing the angular momentum balance of the asthenosphere and inducing additional mantle flows. As a result of core-mantle coupling therefore a characteristic galactic signature is expected in the geomagnetic reversal frequency record. Although this chain of physical effects is evidently long, since the characteristic chron-superchron-periodic signature has been found in the geomagnetic record, there is now a comparatively well-founded empirical and theoretical basis for believing that we have arrived at a reasonably sound understanding of the relationship between the Earth and its more immediate cosmological environment.

This understanding is, of course, still controversial since it has far-reaching implications both in astrophysics and geophysics which have yet to be fully explored. Furthermore it has rather serious implications so far as the short term variability (~ 10^2-10^3yr) of the terrestrial environment is concerned, affecting our perception of the history of civilization. Nevertheless, there is no alternative explanation of the chron-superchron-periodic signature in the geomagnetic reversal record, and its possible galactic implications should therefore be taken seriously.

The Interstellar Environment[2]

Fundamentally, this line of enquiry cannot be sustained unless there is a clear physical basis for believing very large, fragile (*i.e.,* highly devolatilised) comets are present in great numbers in spiral arms.

Here the situation has long been that astrophysicists envisage for spiral arms a rather weak pressure responsible for initiating the collapse of interstellar material forming stars. Thus the moderately tenuous gas and dust which cools in the wake of spiral density wave shocks is expected to undergo rapid spherical collapse into stars as its intrinsic angular momentum (unavoidable in a differentially rotating galactic disc) is carried away by disconnected magnetic fields. There is residual angular momentum however which is responsible for generating around each protostar an essentially flat nebula of gas and dust. This is the formation region for planets, as well as comets and asteroids. Comets, which contain a high proportion of volatiles, are thus assumed now to be preferentially accreted only in the outer regions of gravitationally bound nebulae and are unlikely to be present either as very large bodies or in great numbers throughout spiral arms. Current astrophysical doctrine does not therefore appear to provide a satisfactory basis for the line of thinking developed above.

The question arises then whether spiral arms should be looked upon as due to the repeated formation of rapidly cooling outflows from the nuclear region of a galaxy, possibly caused by the recurrent injection of high temperature plasma (jets) into the galactic plane from short-lived circumnuclear discs. Such outflows, having within them very little differential angular momentum to resist gravitational collapse, must nevertheless be presumed to have overall specific angular momentum comparable to the galaxy as a whole. But if they are derived from essentially bound circumnuclear discs, albeit ones that are short-lived, such outflows would seem to occur as a result of the growth (inflation) and decline (deflation) of some kind of temporary mass in the galactic nucleus. While this may be seen as a potential difficulty for the outflow scheme, the overall picture does have general support from the gaseous discs pervading galaxies which are penetrated by systems of very hot bubbles and fountains in approximate pressure balance with cold, dense regions of gas and dust, all broadly associated with starforming regions in spiral arms. The current mythology, of course, is that the hot bubbles are a post-star formation phase associated with a primordially *cold* state of the spiral arms. However, a pre-star formation phase associated with primordially *hot* spiral arms (which subsequently cool and collapse) is an equally plausible interpretation of the observations facts and cannot be excluded. Thus we may envisage a scenario in which spiral arm material collapses under a pressure that is generated by the jets in the displaced cooler material of the surrounding thick disc. Under these conditions, given a differentially non-rotating medium injected into the galactic disc, we may expect in spiral arms an abundance of hot though rapidly cooling condensations down to the size of very large comets (*i.e.,* with devolatilized cores), themselves the likely building blocks of larger aggregates which subsequently produce planets and stars. On this basis at least, a galacto-terrestrial relationship of the kind discussed above cannot be ruled out.

However the alternative picture is only plausibly upheld if spiral arm systems, particularly that of our Galaxy, do in fact participate in some kind of (outward) flow relative to the underlying disc. Once again of course such an idea is contrary to received opinion, but there is a good deal of evidence in favour of outward flow which is mostly swept under the carpet at present. Thus, at the beginning of this century, it was well known that there are at least two significant stellar streams in the solar neighbourhood, and while it has been customary to interpret this fact since the 1920's as evidence for a general velocity ellipsoid in the solar neighbourhood, the possibility of a serious error cannot be excluded. Indeed, an interpretation of the two streams is also admitted in terms of a younger (spiral arm) population of stars and gas which, in addition to its rotation about the

Galactic Centre, is moving outwards in the Galaxy near the Sun at ~ 40 kms^{-1}. A ready enough demonstration of the likely validity of this proposal is available in the *asymmetric* expansion of the gaseous spiral arm system at the centre of our Galaxy since the latter can also be regarded as having a more plausible interpretation (at least so far as the general symmetry of spiral nebulae is concerned) in terms of a *symmetric* central outflow and a true outward motion of the local standard of rest (coincident with the local spiral arm system) of around 40 kms^{-1}. Moreover, it is known that the seemingly massive nucleus Sgr A* of our Galaxy is also immersed in an electron-positron annihilation region, a hot circumnuclear disc and a cold circumnuclear gas cloud (Sgr A west), all of which rotate with the Galaxy and have a central velocity relative to the local standard of rest of 40 kms^{-1}. Indeed the accumulated kinematic evidence is probably beyond the stage where a likely outward motion of the spiral arm system in the solar neighbourhood can be gainfully denied. Further investigation reveals in fact that the central region of the globular cluster system of our Galaxy is also characterised by a large scale outward radial motion which is difficult to understand except in terms of an extreme gravitational perturbation at the Galactic centre, also likely to have been associated with the ejection of the 3 kpc spiral arm system itself. Thus, contrary to the currently received view, both the spiral arm and globular cluster systems of our Galaxy may now be understood in the context of recurrent activity in galactic nuclei, according to which we might suppose that the successive superstars that form in the centres of normal galaxies reach a late stage in their evolution which is associated with temporary mass inflation. The effect this is to cause the temporary collapse of the central regions of the galactic disc and surrounding halo followed by their release. As a result of the strong compression into a compact circumnuclear disc, the former is released as spiral arms.

The Intergalactic Environment[3]

These considerations indicate that by persistently ignoring the galacto-terrestrial relationship, very large comets with fragile cores and spiral outflows that are primordially hot, perhaps on the grounds that we do not expect so many surprises in a single Russian doll, we have failed also to recognise a potentially significant physical state of matter that is most apparent during the end-stages of stellar evolution. While these overlooked factors undoubtedly have many facets that have yet to be explored in detail, the reduction of a catalogue of misunderstandings to a single physical effect which arises at the end-stage of stellar evolution, an area of astrophysics still with many unresolved questions, does have the considerable advantage of reducing much complex phenomenology to a simple physical question. That is, we wish to know whether naturally formed aggregates of matter capable of evolving and generating within themselves states of extreme gravitational potential (*e.g.* stars) may also be expected to assume hypermassive states. It has in fact already been shown by Dicke that a property of matter of this kind is appropriate for weak gravity fields provided we adopt Lorentzian theory: we may refer therefore to a Lorentz-Dicke theory of matter. According to this theory, rest mass (m) and luminal motion (c) together experience inflation $= m_0 \exp\,(-3j/c_0^2)$) and deflation ($c = c_0 \exp\,(2j/c_0^2)$) respectively in a gravitational field of (newtonian) potential j. Thus event horizons do not arise in this theory and it is to be expected that highly collapsed stars and superstars will approach more the behaviour of naked hypermassive singularities (subject to a finite limiting density) than that of black holes.

It follows that the extreme redshifts of quasars, treated as short-lived highly evolved superstars in galactic nuclei, may be due in part to gravitational redshifts whilst the extreme superluminal motion of some quasars, treated as ordinary relativistic motion in a binding gravitational field of comparative proximity, is likely to be illusory due to the adopted cosmological distances. The use of a conventional upper limit of $\sim 10^{12} M_\odot$ for any galactic mass to eliminate the possibility of high gravitational redshifts in quasars is thus seen to have been a theory dependent argument which had no over-riding justification. Likewise there is no firm basis for supposing all quasar redshifts are necessarily cosmological *i.e.,* that they are indicative of great distance (early epoch) in a supposedly expanding universe. Indeed the fundamental inference, given that we invoke Lorentz-Dicke theory, must be that the universe is stationary and that we have been misled as to the true nature of the cosmological redshift (see later).

Combining the above considerations therefore with the cosmological evidence, we envisage a stationary universe of essentially cannibalised galaxies, repeatedly forming temporarily hypermassive superstars in their nuclei, whose effect overall is to account for the presence of dark matter, high velocity flows and the structure of larger scale formations in the universe (*superclusters and voids*); and whose effect internally is to account for the violent relaxation and recurring spirality of individual galaxies. The fact that it is possible in principle to explain dark matter on extragalactic scales in terms of on-going though intermittent properties of normal galactic matter removes any necessity for new material components of the universe and a mass inflationary stage during its formation.

Cosmological redshifts[4]

If the Lorentz-Dicke theory is fundamentally correct, it is necessary to reconsider where our understanding of cosmological redshifts is likely to be mistaken. It will be recalled that the starting point of twentieth century physics was the applicability of Maxwell's equation regardless of absolute motion through space. Lorentz transformations were thus appropriate in describing the space/time relationships between relatively moving systems. To account for these, Lorentz suggested a physical contraction of moving bodies in the direction of motion and a redefinition of their physical time as a `local time'. These postulates pre-supposed the existence of a material aether; thus an inertially massive, locally non-gravitating medium was envisaged whose various transitions of state (into visible matter) were associated with a locally disturbed aether (*i.e.,* in the field surrounding visible matter). The concept of local time was also taken to imply a particular way of visualizing visible matter, involving a structurally stationary aether in which the moving visible matter reflected essentially instantaneous distributions of a moving field sequentially generating creation-annihilation events in the aether. Creation-annihilation events were not a well attested feature of physics at this time and it seems that the new mode of thinking merely helped to accelerate the demise of the aether: thus matter conceived of in these terms appeared less fundamental than the moving field. At the same time, while radiative processes were necessarily quantized at the point of emission and reception, the Lorentzian picture also required the transmission of energy by electromagnetic waves. Nevertheless, all these effects were discussed by Einstein as a consequence of fundamentally different ideas. He defined space-time frameworks of equal status for relatively moving systems based on the absolute constancy of luminal motion, thereby removing any necessity for an underlying material aether and requiring radiation to be transmitted by massless photons. The Einstein picture was more or less immediately preferred since it was conceptually simpler and appeared to get around the nineteenth century problem of constructing a suitable physical model of the aether by eliminating it altogether.

The implications of these theories for *cosmologically* transmitted electromagnetic radiation differ in principle however. Thus according to Lorentz theory, the electromagnetic wave is successively absorbed and re-emitted along the path by a medium carrying successive gravitational fields in relative motion, the effect being to impose a cumulative redshift as expressed by the quadratic component of successive relativistic doppler effects. In the Einstein theory on the other hand, the massless photon is only absorbed at the receiver and there is no known interaction along the path, the effect in a stationary universe being to produce no redshift. The discovery, confirmed around 1930, that a cosmological redshift nevertheless exists led to a crisis in Einsteinian physics which was only resolved by arbitrarily introducing an expanding space-time substratum, subsequently to be embellished by additional ideas associated with the concept of a big bang. The insistence on an Einsteinian picture at this juncture seems all the more remarkable now that it is possible in principle to comprehend a whole variety of otherwise unexplained astrophysical effects in terms of a simple extension of Lorentzian theory.

Conclusion

Whilst this particular combination of ideas is not yet sufficiently developed that the general framework discussed here qualifies to be described as a full-blown theory, there are certainly aspects of our physical, geophysical and astrophysical environments which are commonly overlooked and which might now cause one, with some justification, to have reservations concerning conventional cosmology. Indeed, conventional cosmology on its own account already involves a major inconsistency since there is no observed continuity between the primordial fireball and its supposedly subsequent material condensations. It seems probable then that uniform cosmic background radiations must arise through physical processes which are substantially unrelated to the gravitational fields borne by the aether (*e.g.* pair production with subsequent recombinations), in effect confirming the existence of a substantially uniform aether. Under these circumstances therefore, the great variety of `anomalous' cosmological phenomena discussed by Arp and others at this meeting should not in my opinion be seen as an excuse for `shooting the messenger'. Rather, they should be viewed as part of the continuing process of acquiring knowledge as we advance beyond our still very primitive understanding of the complex environment in which we live, even to the extent of revising some of our most fundamental assumptions in physics. If these speculations have any validity, perhaps physicists in particular should be wary of consorting only with cosmologists—mundane bodies like comets also have a significant tale to tell.

Notes and references

1. Terrestrial catastrophism and its underlying motivating force have been extensively discussed in, for example, Clube S.V.M. (editor) *Catastrophes and Evolution* (CUP 1989); Clube S.V.M. & Napier W.M. *The Cosmic Winter* (Basil Blackwell 1990); and Bailey M.E.; Clube S.V.M. & Napier W.M. *The Origin of Comets* (Pergamon 1990).
2. The idea that the local spiral system is undergoing rapid expansion as part of a recurring process of violent relaxation in galaxies was first explored in Clube S.V.M. *Mon.Not.R.Astr.Soc*. **161**, 445 (1973), *Vistas in Astr*. **22**, 77 (1978) and Bailey M.E. & Clube S.V.M. *Nature* **275**, 278 (1978). See Clube S.V.M. & Waddington W.G. *Mon.Not.R.Astr.Soc*. **23**, 7P (1989) for recent evidence and references.
3. The idea that hypermassive superstars in galactic nuclei are a consequence of mass inflationary effects predicted and quantified by Lorentz-Dicke theory was first considered in Clube S.V.M. *Mon.Not.R.Astr.Soc.* **193**, 385 (1980).

See also Dicke R.H. *Evidence for gravitational theories* (ed. Moller, C., Adademic Press), 1 (1962).

4. Whilst not necessarily excluding possible modifications of G.R. that are capable of encompassing the considerations of this section, the varied developments of Lorentz theory during the present century are regarded as more relevant *e.g.* see Duffy M.C. *Physical interpretations of relativity theory* (ed. Duffy M.C.), 136 (1990).