

December 4th, 1953
Wailuku, Maui
Territory of Hawaii
U. S. A.

Mr. Percy A. Campbell
San Diego, California

Dear Mr. Campbell:

Recently a copy of your article entitled "Science of the Universe" came into my possession via NBS where I used to work. Unfortunately the envelope was destroyed so I do not have your exact address. I hope this letter finds you.

The contents of your article I found very interesting and in substantial agreement with my own ideas. Some years ago I worked out a mechanism whereby a moving charged particle could extract energy from a light photon and thereby reduce its apparent wavelength. This process has been demonstrated in the laboratory at centimeter wavelengths, so it will work. The great unknown is the magnitude of the parameters available in intergalactic space. Thus it is not possible to give a quantitative yes or no to the idea at the present state of knowledge. I still think the idea is much more sound than those of our explosive friends.

There is no statement where your article was reprinted from so I cannot follow up your other references. In any case I would appreciate receiving copies of your "Conservation of the Cosmos" and "Upswing of the Universe", if any are still available or references to same in the literature.

Very truly yours,

Grote Reber

SCIENCE of the UNIVERSE

“The sum total of all sums total is eternal.”

— LUCRETIUS, *On the Nature of Things*

Is the universe a manufactured article? finite in extent? finite in duration? and at present running down? Upon all these counts the argument of the present paper is to the contrary. Let us take up these points in reverse order.

The idea that the universe is running down has its roots in the 2nd law of thermodynamics, which is a law which amounts to saying that the continuing operations of the universe keep lowering the availability factor of its energy, leading eventually to a “heat-death” of the universe (a total loss of temperature differences). The samples taken of the universe to substantiate this law are however limited in extent, the altogether main portion of the universe, that of the interstellar spaces and the altogether overwhelming spatial regions between the galaxies themselves, being left out of the sampling tests altogether. Yet, according to Millikan’s estimate (since 1935) there is, in these vast regions, not only the sum total of the radiant energy of space, but 30 to 300 times as much as that belonging to the universal cosmic-ray system. Moreover, this cosmic-ray energy is of the highest possible availability, no other sort of energy approaching it in that respect. Here then is a situation which is clearly of the utmost significance to cosmology, but of which the 2nd law of thermodynamics knows nothing. It is safe to say that this modern-day discovery outlaws this 2nd law as a proved general law for the universe. Indeed, the present writer has already, in two papers, *Conservation of the Cosmos*, and *Upswing of the Universe*, elaborated the theory that the cosmic rays do in fact overrule this 2nd law in its universal application. Instead of a universe that is running down, according to that law, the cosmic rays put in their bid for a permanently conserved universe—and, win. Let us review this situation.

Thus far physicists and astronomers have been content to allow this altogether main supply of available energy of the universe—the cosmic rays—to lie fallow, with the exception (almost) of only that bit of it which enters the atmosphere of the earth and is trapped in their Geiger counters. Undoubtedly, the energy of the cosmic-ray system has its part to play in the universe, a part commensurate in importance with the altogether overwhelmingness of its amount and availability factor. Only in the role of mainspring of nature or of the universe is this importance achieved. Let us discuss it upon that basis. The mainspring hypothesis bases itself upon two factors. (1) The slow acquisition, by the cosmic-ray particles, of the whole energy-fund of the radiant energy which finds its way into interstellar and intergalactic spaces. (2) The utilization of this energy, thus acquired, to break down diffuse interstellar and intergalactic matter (dust and gases) to the basic condition of hydrogen gas.

Along with these two basic factors, we have the two supplementary factors whereby the hydrogen, thus manufactured in general space, be-

comes consolidated eventually into stars and star systems, and the further factor whereby these stars themselves finally become dissipated in space as diffuse dust and gases. Helping the consolidation process, in hydrogen fields, is the mutual gravitational attractions of the hydrogen atoms and molecules, and the pressure exerted from without upon them by photons, and also by the cosmic-ray particles. The eventual dispersion of the matter of stars is brought about by their mutual collisions, as well as by other means, as revealed by the dispersion of matter from novae.

These two basic factors of cosmic evolution, together with the two supplementary factors, assure the universe of a perpetual conservational round of existence. Diffuse hydrogen gas may be taken to be the basic condition of matter. Matter departs from this basic condition only to return to it eventually. In the interval, matter assumes the massive condition of stars. In this condition the 2nd law of thermodynamics comes into play. Matter runs down in condition—from the high-energy hydrogen state to the various heavier, more complex atoms of diminished energy content, viz., helium, carbon, oxygen, iron, etc. The energy difference escapes as radiation. But finally this run-down matter becomes dissipated widely in space. Thereupon the high-speed cosmic-ray particles take charge of this diffuse matter and gradually reinstate it to the high-energy condition of diffuse hydrogen. This completes the evolutionary cycle of matter (and energy) and assures to nature in general unqualified conservation. The availability factor of the energy of the cosmos, as well as the amount of that energy, suffers no net loss, taken in the large. There is no running down of the universe, only a temporary running down of matter in the bulk form, as in the earth, the sun, and the stars.

Now let us return to our two basic conservation principles, both involving the extraordinary cosmic-ray particles. That these particles constitute a universal cosmic gas is the plain lesson taught by the long line of experiments which has already been made upon them. The constituent particles are various—mainly protons, with a sprinkling of heavier atomic nuclei. (Electrons also no doubt are present, but are mostly deflected away from the earth by magnetic action.) These cosmic-ray particles are endowed with the greatest amount of energy (relative to their masses) of any particles known to exist. That is, their kinetic speeds approach closely to that of light. The experience with these particles in the earth's atmosphere proves that they have a shattering collisional effect upon all heavy complex atoms, breaking them down towards the basic hydrogen condition. Given plenty of astronomical time, it is evident that the general result is a widespread manufacture of high-energy hydrogen out of the diffuse spatial material of more complex atomic composition, and of lower energy content. This manufacturing process transfers energy from the high-speed cosmic-ray particles to the manufactured hydrogen. Thus the cosmic-ray system of particles must constantly be losing some of its total energy. On the other hand, it is wholly unlikely that this unique universal system of particles is merely a passing component of the universe. This calls for a continuous replenishment of the total store of energy possessed by the cosmic-ray system, (as well as a replenishment of its diminishing store of particles). There is one and evidently only one *at all adequate* energy source for this replenishment. That source is the general radiant energy of space (the photons). Now do the photons gradually lose their energies in the course of astronomical time? They certainly do. So well is this a

known fact that this gradual loss of energy has been given a name — “the nebular red shift of light.” Light from all of the extremely remote nebulae shows a marked red shift, proving that the photons do, very gradually, part with their energies, since red-light photons (light-quanta) possess less energy than do photons of shorter wave lengths (yellow, blue, etc.). However, this red-shift phenomenon has long tempted astronomers to imagine that the universe is in process of general expansion, the well-known Doppler effect being thus invoked to put the whole universe “on the skids.” Well, to save the universe from this suicidal debacle is clearly a must of common-sense cosmology. Three vital matters are at stake. (1) The universe must be preserved. (2) The cosmic-ray system must be maintained. (3) The energy of radiation must be utilized, not wasted. Turning away, therefore, from the fatal theory of the expanding (exploding) universe, we return to the extraordinary cosmic-ray system for a solution of this 3-way problem.

This solution of the matter is simply to the effect that a light-quantum (photon), colliding with a cosmic-ray particle, unloads some of its energy upon that particle, causing it to travel a bit faster. This energy transfer is irreversible. Photons never absorb energy from the particles, that is, the light-shift is always a red shift, never a violet shift. At any single collision a photon loses but a small portion of its energy because of the relatively extreme smallness of the particle (always of subatomic size). But a photon coming from a far nebula (at a distance of one-hundred million light-years) nevertheless collides with so many of the cosmic-ray particles that the integral red shift is significant, and, of measurable amount, appearing as such upon spectroscopic plates in large telescopes. This explanation accounts, without any *ad hoc* assumption, for the fact that the red shift is found to vary in degree proportionally with the total time the nebular light has taken to make the journey to the earth. Naturally, the total number of collisions varies directly as the time of this transit. The fact of the exceeding rarity of the universal cosmic-ray *gas* adds greatly to the mean time-interval between collisions.

This explanation of the cause of the red shift of nebular light, and of the source of the cosmic-ray energy, together with the cosmic-ray manufacture of hydrogen in space, and the massing of this hydrogen into stars, which eventually have their run-down material dissipated out into space again (following the leave-taking of the radiation), permits us to fit the various workings of the cosmos together like a picture puzzle, and to have as a result a cosmos which lasts — a cosmos which stays cosmic — a cosmos which conserves itself inalienably. In this way we give the cosmos full credit for being a cosmos. We give it full credit for being a self-conserving system. It pays dearly for its life insurance, its insurance against *depreciation*. It sacrifices all of its energy of radiation to the cosmic-ray system for that purpose, and, it gets in return, full coverage. In this way, the cosmic-ray system definitely acts the role of the mainspring of the cosmos. In that office it clashes with the 2nd law of thermodynamics. It accepts the energy of the photons at a low level of availability, and, in so doing, gives it status as kinetic energy of very high availability indeed. In effect, the cosmic-ray system is an availability pump for energy. Actually, what happens is that the energy acquired gets a pickaback ride upon particles which already possess kinetic energy in very high degree — a pyramiding effect. Its availability factor therefore is correspondingly enhanced, and the deadly grip of the 2nd law upon the cosmos is loosened.

In the depths of space the universe cashes in on its life insurance. The result is a full rejuvenation of matter. Thanks to the extraordinary cosmic-ray particles, the universe is saved from senescence. The 2nd law of thermodynamics is never allowed to write *finis* to the universe in the form of "universal darkness and decay."

Well, once the cosmos is posited to be a cosmos in fact, we are left no alternative but to grant it all that it may require along that line. We have already given a *cosmic* answer to the question as to the age of the universe, looking backward and forward. The cosmos, being a self-conserving system (considered in the large), is not now running down, nor has it been doing so in the past. Cosmic time therefore is not a thing with limits, either past or future. It had no beginning, nor will it have an end. Birth and death are not "vital statistics" belonging to the cosmos as such. Thus the universe is altogether infinite in the matter of time. In the matter of space it can be no other than infinite also. A spatial limit of any kind would be a bound to its cosmic character. Thus the universe is of infinite, limitless extent. These corollaries of our proposition that the universe is indeed cosmic, with all of the requisites thereof, does of course throw out the supposition that it is a manufactured article. That is an idea which runs counter to the whole proposition that the cosmos is inalienably a cosmos. In an inalienable cosmos, self-evolution is the inalienable order of existence—momentarily, and, eternally.

This cosmic conception of the universe has of course the subconception that it is self-existing, which is the very opposite thing from saying that it once upon a time created itself out of nothing, or somehow emerged from a universe of nothingness which might be supposed to have preceded it. Talking about nothingness is the silly trick of trying to talk of that of which, by definition, there is nothing to say. The universe had no such blankety-blank origin. The cosmic universe exists because existence is its very nature, and nonexistence not a possible alternative. The universe which can and does now exist is no other than the universe which always has existed. No less, it is the universe which always will exist. It simply is—evolutionally! There is no getting outside of or beyond that fact of its existence. A universe with that basis of natural necessity is invulnerable. It has no Achilles' heel of weakness. It itself monopolizes all possibility.

As for the real stuff of the universe—that can only be infinite space itself. Matter, electricity, and radiant energy are but different modes of spatial manifestation. Matter is best understood as a spatial excess—too much spatial stuff to fit into the normal Euclidean pattern. Electricity (positive and negative) is an overamount and an associated underamount thereof (or *vice versa*). Radiant energy is a wave form and wave activity thereof. This gives us the general conclusion that the cosmos is only phenomenalized space. Mathematically uniform space gives us Euclidean geometry, an abstraction. Phenomenalized space, space existing somewhat out of its true Euclidean norm, and therefore in endless phenomenal mutation about that norm, gives us the universe that is. The universe is space-stuff, in infinite amount, existing eternally, in a cosmic (phenomenal) condition.

San Diego, California
October 31, 1953

PERCY A. CAMPBELL
Author of "Our Natural Universe"
(October, 1950) — Etc., Etc.