

A RECIPE FOR JUMP-LIKE PROGRESS IN SCIENCE – ILLUSTRATED BY 6 EXAMPLES

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Abstract

Does there exist a method to boost scientific and humanitarian progress? Six cases in point are offered. The featured protagonists are: Zwicky, Einstein, Conrad, Reichardt, Szilard and Everett. The six breakthroughs offered are: (1) stationary cosmology (combined with a promising terrestrial fusion technology); (2) global-*c* general relativity; (3) well-stirred life; (4) *Pandaka-pygmaea* based brain science; (5) an interactively reared wiser biological intelligence; (6) an experiment proving personalized assignment of the physical world.

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Introduction

Jump-like progress happens only rarely in science. One element is the community aspect. For example, the historical city of Prague has an incredible “genius loci” with a great number of discoveries made there by many important scientists leaving unforgettable traces. During his reign, emperor Rudolf II attracted a great many prominent minds to Prague. Tycho Brahe, Niels Henrik Abel, Johannes Kepler, Bernard Bolzano, Auguste Cauchy Christian Doppler, Ernst Mach and Albert Einstein followed in line. Kepler formulated here the first two of his three laws of planetary motion using Tycho Brahe’s observations. Nowhere differentiable continuous functions were invented there by Bolzano in the book ‘Paradoxes of Infinity’ of 1851, with Weierstrass continuing a decade later. And Christian Doppler lectured on his new effect and Albert Einstein started general relativity here while Karel Capek simultaneously coined the word “robot” and Kafka saw

the reality of the rarely opened door. In the same vein, Oxford, Cambridge, Heidelberg and nowadays Princeton, MIT, Berkeley, CalTech likewise enabled visionary scientific ideas to be captured ahead of their time through a hard-to-define cooperative effect. In the following, it is not this general spirit of the right place at the right time that is to be highlighted. Rather, a universal method is suggested to exist, illustrated by six examples. The latter are either finished or about to be implemented. The common denominator is that a maverick insight which is already famous – or infamous – is looked at from a new angle. This recipe does not depend on the genius loci in principle – which fact makes it easy to transplant.

(i) Serendipity captured (in the footsteps of Zwicky)

A totally unexpected empirical phenomenon that is seen for the first time can trigger a major jump of the imagination. This fate struck Fritz Zwicky [1929a]. His colleague Edwin Hubble had just offered his famous linear distance-dependent redshift law in the sky by extrapolating boldly from a ridiculously small sample of measurements [Hubble, 1929] while standing on the shoulders of Vesto M. Slipher, George E. Lemaitre and Milton Humason. Hubble's empirical conjecture brought Zwicky to immediately envision a distance-proportional braking of low-mass fast particles (photons) passing through high-mass attractive particles (galaxies) that are in motion themselves, a fact Zwicky did not mention yet. Zwicky thereby anticipated a feature of a new statistical mechanics based on attractive rather than repulsive particle potentials which was to be glimpsed next 74 years later [Rossler et al., 2003]. What one learns is that a revolutionary empirical finding, Hubble's law of a distance-proportional redshift (which later would prove valid over orders-of-magnitude larger distances), was immediately appreciated and given a hypothetical causal explanation by Zwicky. This envisioned explanation was postulate-free – unlike the earlier expansion postulate due to Friedmann and Lemaitre that later came to be named “Big Bang” by Fred Hoyle.

The gravitational many-body paradigm of Zwicky would be a flop for three quarters of a century after opinion-leader Sir Arthur Eddington had immediately pointed to an error in Zwicky's paper, a fact made public instantaneously by Zwicky himself [1929b]. The whole globe would thereafter be laughing about Zwicky's “tired light” idea as his detractors would call it. The mentioned re-discovery of the idea 74 years later was more lucky. It eventually led to the discovery of a new fundamental sub-discipline of deterministic statistical mechanics valid under attractive rather than repulsive conditions: “Cryodynamics,” sister discipline to Thermodynamics [Rossler, 2011, 2013]. A first textbook is waiting to be written by a specialist

in deterministic statistical mechanics in the footsteps of Yakov Sinai [Sinai, 1963, 1970]; cf. [Rossler, 2013].

The delay that followed Zwicky's breakthrough is about to end with a revenge by now. This is due to an independent implication of cryodynamics which concerns, not the skies but the earth below. "Paradoxical cooling" by hotter attractive particles (electrons) injected concentrically, can predictably control previously uncontrollable plasma instabilities before they touch the wall of a Tokamak fusion reactor [Rossler et al., 2012, 2013]. To facilitate the elaboration of this potentially future-deciding technological step, a *European Institute for Cryodynamics and its Applications* has been proposed to the European Research Council as a modern pendant to the "Physikalisch-Technische Reichsanstalt." The latter was established in 1887 in Berlin in order to boost the at the time dimly predictable global electrification [Huebener, Lübbig, 2010]. The technological future of cryodynamics is bound to be comparable with the shining past of thermodynamics.

(ii) A drawback turned around (in the footsteps of Einstein)

An effective stumbling block that was encountered on a maverick road of scientific progress can be turned into a bonanza in the end. General relativity provides a case in point. The famous "equivalence principle" between gravitational acceleration and ordinary kinematic acceleration, spotted by Einstein in 1907 [Einstein, 1907], lies at the root of general relativity as is well known. This "happiest thought of my life" as Einstein would always call it states that in free fall, one is weightless – such that the laws of special relativity described two years before by himself hold the key to understanding gravity. The final conclusions drawn from this epoch-making insight in the next eight years are beset by a minuscule unfinished point. Einstein in 1907 correctly deduced from the equivalence principle the fact that downstairs in gravity, a transversally moving light ray must be "creeping" when watched from above. However, the conclusion thereby forcing itself upon Einstein – that the speed of light c was reduced downstairs – turns out to be inapplicable in retrospect. The real explanation of this important "Einstein creeping" is an (optically masked) *size increase* present downstairs. This fact, which is quite difficult to spot in the context of the equivalence principle proper because it requires the use of Einstein's later-introduced "light clock" (cf. [Rossler, Frohlich, 2013]), was spotted for sure only many decades later – after the same space-dilation had turned up as a surprise implication of a totally independent physical discipline, quantum electrodynamics, in a sort of pre-established harmony [Rossler, 2014].

At the time of the emergence of quantum electrodynamics in the second half of the 20th century, however, the mentioned drawback in gravitation theory so reluctantly accepted by Einstein in 1907 (that c ceased to be a global constant in nature) had become so deeply ingrained in follow-up work as to be virtually immune to repair. The shock of the lost global constancy of c of 1905, encountered in 1907, had stopped Einstein from working on gravitation for three years – until his good friend Paul Ehrenfest would lure him back in Prague with his own, formally “non-gravitational,” paradigm of the rotating disk. By carefully working around the encountered obstacle, Einstein was then able to erect the lasting edifice of general relativity. However, the finalized Einstein equation still contains an only locally (but not globally) constant speed of light c as is well known if rarely mentioned. The *global c*, spotted so belatedly [Rossler, 2014], fortunately calls for nothing else but a “re-scaling” in order for one to arrive at the physically correct “volume-conserving” final form of the Einstein equation. However, this goal has so far been achieved only for a subcase, the Schwarzschild solution [Rossler, 2012a]. The full job is not only maximally demanding, technically speaking, but also maximally discouraging morally due to its implied consequences. Many cherished features of general relativity – including the possibility of Hawking radiation for example – automatically lose their physical validity in the presence of *c-global*. Most alarmingly, the famous expanding solutions to the Einstein equation which underly the different Big Bang formalisms are all gone. This fact is virtually unacceptable to the advanced relativistic and cosmological community to date (were there not cryodynamics as mentioned).

In this hard-to-transport context, it comes as a pleasant surprise that as soon as the expansion postulate is dropped, twenty-three other postulates unnoticeably accrued over eight decades in necessary support of the Big Bang scenario turn out to be invalid – each for an independent reason [Rossler, 2012b]. This fact forms a big surprise of its own. The ensuing radically simpler, both temporally and spatially vastly enlarged cosmological scenario currently has no chance to find acceptance by the astrophysical community (Matthias Bartelmann, personal communication 2013). This is the fate which revolutions and *nonsense* both share. Is it not overconfident to hark back so deep into the past against the grain of a decades-old global consensus crowned by several Nobel prizes? (To witness: the famous “cosmic” background radiation loses its cosmological distance, and the celebrated “pennant” on the Hubble line ceases to reflect a mysterious “accelerated expansion” fueled by a mysterious “dark energy” while being a predictable implication of the fractality of a stationary cosmos [Rossler, 2006].)

A fearless way is the royal road in science. “Hypotheses non fingo” (I do not conjure up hypotheses) said Newton in the footsteps of Occam. Since the cosmological profession is currently about to wake up to the new situation (double abandonment of the Big Bang in the wake of cryodynamics and *c*-global), it is perhaps rewarding to throw a glance at four *further* examples in which a leap-like “secondary progress” comes attached to an already won “aha-insight.”

(iii) Lucky extrapolation (in the footsteps of Conrad)

In conversation, Michael Conrad once took up the idea of a reaction-kinetic explanation of biogenesis of a few years before [Rossler, 1971]. He saw that the simplified description offered there in terms of purely time-dependent variables can be taken literally. The *Conrad experiment* costs comparatively little in terms of money but requires a lot of trust in mathematical reasoning. A “well-stirred form of life” was predicted by him to emerge *in reality*, after months or years (or decades?) of letting the famous oscillatory Belousov-Zhabotinsky reaction [Zhabotinsky, 1964] run in a continuous stirred tank reactor (CSTR). That is to say, the 6 external ingredients of this oscillatory (and as it later turned out [Schmitz et al., 1977; Rossler, Wegmann, 1978] chaotic) reaction are continuously supplied in the presence of an overflow. This set-up is easy to implement in any chemistry lab (Michael Conrad, personal communication 1974).

In light of the dearth of empirical approaches to biogenesis so far – like missions to the ice-covered but internally hot moons *Europa* and *Enceladus*, or to the inner layers of Jupiter or Saturn for which a non-water based form of life was predicted [Rossler, 2000], or eventually to the closest neutron star with its predicted nuclear-chemical life forms [Forward, 1980] – the Conrad experiment is maximally attractive. Everyone is invited to place a bet on its outcome since it can be started immediately at many places.

(iv) Copycatting (in homage to Reichardt)

The “Pandaka-Pygmaea Institute” is a proposal [Rossler, 2008; Seaman, Rossler, 2011] already implicit in an Abstract published in 1990 [Rossler et al., 1990]. The proposal is modeled after the life of Werner Reichardt who at age 27 consciously devoted his life to the housefly – as he confided to the first author when the latter was 27. The fish *Pandakapygmaea* is the smallest animal at 0.9 cm which features a full-fledged vertebrate brain -- no larger than the brain of a big fly. The choice is especially lucky because Pandaka possesses a close relative, *Gobiusniger*, a fish which at 20 centimeters body length ranges with its own brain size “half-way” between Pandaka’s and the human brain in logarithmic units.

The exhaustive study of our smallest close relative, *Pandakapygmaea*, regarding wiring, neurotransmitters and behavior, by deploying the full arsenal of advanced modern methods will automatically cause a jump in the biological understanding of the human brain, with major medical implications. The “bottom-up” approach of the proposed PPI (Pandakapygmaea Institute) can then be compared to the equally promising top-down approach provided by the “brain equation” of combinatorial mathematics [Rossler, 2014b], compare also [Zelinka, 2001], [Zelinka et al., 2010].

(v) Generalizing (in the footsteps of Szilard)

“To generalize” means to take an observation and transport it to a wider or new context. The “White Elephant Experiment” transplants the causal therapy of congenital smile-blindness (“autism”), offered to human children [Rossler, 1975], onto a biological intelligence superior to the human brain in terms of the complexity of its hardware. The method consists in copying the decisive human functional trait [Rossler, 1975]: The caretaker of the young bonding mirror-competent individual must, (1) feel strongly rewarded herself by the expression of happiness shown by the beloved adoptee and, (2) reward the latter whenever feeling acutely delighted herself by what he is momentarily doing or not doing, through her actively producing the species-specific bonding sound in strict proportion to her own momentarily felt delight. This scenario functionally reproduces the “smile coupling” which physiologically exists between a human mother and her toddler. Hereby, point (2) which closes a positive feedback loop is decisive. This *symmetric type* of social coupling between two mirror-competent brains generates a unique epigenetic instability – the personogenetic function change – which is a unique biological characteristic of the human species (*Pongogoneotrophicus*) in which it arose through an evolutionary accident called “Huxley ritualization” [Rossler, 2004].

This experiment if successful transforms into reality a suggestion made by physicist Leo Szilard [1947] in the aftermath of the bomb (for which he bore the foremost responsibility despite his unsuccessful attempt to prevent it from being dropped). An intelligence wiser than the human one [Salk, 1983] is of vital importance on Hawking’s planet. Note that Stephen Hawking reminds the world of the necessity of “space colonization soon” in view of the manifest propensity for self-destruction inherent in human society [Hawking, Hawking, 2007].

(vi) Bisociation (in the footsteps of John Stewart Bell)

The notion of “bisociation” – bringing together two formerly unrelated insights – lies at the root of creativity according to Arthur Koestler [1964]. The Einstein-Belle experiment [Rossler, 1990] is a case in point. It was

apparently first spotted by Susan Feingold in unpublished 1978 notes (cf. [Peres, 1984]). It “bisociates” the Bell nonlocality [Bell, 1964] of the Einstein-Podolsky-Rosen gedanken experiment [Einstein et al., 1935], famously tested by Aspect [Aspect et al., 1982], on the one hand, with the space-like causal separation discovered by Einstein 30 years before [Einstein, 1905] on the other; cf. [Rossler, 1992]. The combined experiment by now is for 13 years under construction by the European Space Agency (ESA), and more recently apparently also by the Chinese Space Administration (CNSA). Zeilinger and his former co-worker Jian-Wei Pan are the protagonists. The problem is that the “quantum satellite” is not finished (Anton Zeilinger, personal communication 2013 to O.E.R.).

No one doubts that the Bell correlations will survive under the condition of a relativistic causal separation between the two measuring stations (one on the ground, the other fast receding in the satellite when it has just passed overhead). There is no alternative outcome in sight. However, this finding once it will be held in hand necessarily amounts to a major crisis in physics. This is because in that case, only one of two conclusions remains possible:

Conclusion (a): The commutator relations of quantum mechanics are empirically violated for the first time in history – which fact amounts to the end of quantum mechanics. This is in accordance with Einstein’s original (if politely expressed) intention of 1935 [Einstein et al., 1935]. For two non-commuting measurements of the same superposition-type quantum state have by then been successfully obtained: one on the ground, one in the satellite. Hence quantum mechanics is “completed” and hence dead.

Conclusion (b): In each frame, taken alone, everything is fine because the measurement done in it was the first. Therefore the measurement result obtained subsequently on the other side reflects as usual the fact that the superposition in the virgin quantum state at the source has already been reduced by the first side. There is no difference at all to the so far conducted single-frame experiments: The “Bell correlations” are empirically observed in the frame in question. However, in this case the *other* frame is automatically “underprivileged” – it cannot make the analogous claim. Yet the other frame is the first frame, on its own side! Therefore, a contradiction-in-terms has been reached by the predicted experimental outcome (survival of the Bell correlations): Logic is dead.

There is one way out left in case (b): That the “worlds” on the two sides (ground and satellite, respectively) are mutually opaque. Then, quantum mechanics survives. Indeed if for each of the two sides a different pair of measurement results exists which is opaque to the other side, then everything is fine as far as the survival of quantum mechanics is concerned. This is what Everett [1957] formally described as an allowed

second version of quantum mechanics besides Bohr's Copenhagen version. (On closer reading he appears to have foreseen this experimental outcome on the last page of his paper.) The *Copenhagen interpretation* of quantum mechanics then has been empirically disproved as originally hoped-for by the unusually combative Einstein of 1935. However, the subsequent *Everett theory* of quantum mechanics survives. Thus, the survival of the Bell correlations under relativistic causal separation (say for us, the people on the ground) represents an empirical proof that more than one quantum world exists in nature [Rossler, 2011]. This anticipated outcome of the Zeilinger experiment [Rossler, 1990] goes undisputed.

John Bell was very much impressed in 1988 by this proposal made to him in person, replying spontaneously: "This idea is completely new to me." Later when he had been sent the manuscript triggered into existence by this positive response, with the kind request to submit it on behalf of the author, he wrote back in his unique style: "I do not share your enthusiasm for these ideas and do not want to share in the responsibility" – but: He had carefully corrected-through the manuscript with his red pen so that it could be submitted – as is mentioned in the printed version [Rossler, 1990], which he did not live to see.

The predicted survival of the Bell correlations in the Zeilinger experiment will amount to a revolution in physics – arguably the biggest one ever. It will totally change the attitude of humankind towards physical reality. So far, the two phenomena of the Now and of Color (and the other qualia) could be safely ignored by science since they fall outside science's relational scope. However, these two manifest miracles cease to stand alone once the Zeilinger experiment has yielded the outcome which no one doubts. This outcome will prove to the eye that the world of relations has the *same* private character as the world of the qualia – just as Everett [1957] predicted. The assigned physical world then manifestly acquires the character of a personalized gift ("spoken to us" in the words of Martin Buber). A swerve back to the origin of modern science in the pious spirit of René Descartes would be forced upon humanity. A compelling reason for ceasing all cruelty on the planet would be lying on humankind's table – once a manifestly personalized interference into everyone's life is the conclusion forced upon everyone by this in this case most important experiment of history. The readily spoken prayers of a child at the dinner table will lose their mildly naïve touch in the eyes of a witnessing adult.

Discussion

While "golden route towards discovery" would be too strong a label for the six proposals offered above, they prove that "creative suspicion" can be turned into a method. Such a suspicion according to Zwicky strikes you

“every two years.” In particular it is advisable to always be among the first to respond to every freshly opened-up route by “enlarging it” with a new question. The marked delays witnessed in each of the above 6 examples prove to the eye that the scientific community is currently not “tuned” towards responding to an unexpected jump-like progress. Max Planck made similar remarks a century ago.

An analogy to the famous *uncanny valley* of artificial intelligence spotted by Masahiro Mori (reduced appreciation of “almost perfect” pictorial renderings compared to both very crude and totally realistic ones) suggests itself. There obviously exists what can be called an *uncanny desert* around every jump-like progress in science. This desert must be traversed before acceptance can set in. It follows from this sobering insight that many “sleeping beauties” are bound to exist in science at this moment in time with not a few of them destined to be “kissed awake” since most of the deserts are never crossed. Due to this precariousness of every major scientific progress, part of the attention of every scientist ought to be geared towards spotting one or the other of these islands as a royal route for scientific innovation.

The above six examples of “previous serendipity exploited” demonstrate to the eye that “jump-like progress” is a part of the normal course of science. Such progress is greatly facilitated when embracing the most provocative question is no longer considered unprofessional behavior but rather is accepted as the defining attitude of science. The “spirit of the most risky enterprise” – not in terms of money but in terms of hopeful humility displayed – reigns superior in science. The majority of persons on our planet are still denied a decent life – with the curve of global progress recently inverted by the bio-gasoline catastrophe [Lagi et al., 2011]. All persons have the same inalienable rights according to the American constitution, Immanuel Kant [1797], Leo Szilard and Hugh Everett III. The “curmudgeon” Zwicky demonstrated it to the world that the dream of one’s being a loving provocation can be lived.

To conclude, someone who called his colleagues “spherical bastards” because they are bastards “no matter from what angle you look” paradoxically was featured above as a role model in science. Zwicky was incredibly charming and incredibly fertile – dispelling the fear, for example, that the sun by its becoming a red giant in 5 billion years’ time will eat the earth (since our descendants can shift the earth very slowly as he proved). He also sent the first terrestrial object into outer space as a token, just in case. And he discovered galactic clusters and baryonic dark matter (the only form that exists in the absence of cosmic expansion). And he conceived of neutron stars in general and painstakingly discovered the largest number of them in particular. At the same time, Zwicky displayed what is called “Swabian humor” which at the bottom of it is loving and constructive. So when he

asked a sophomore on the staircase of CalTech: “Who the hell are you?” Zwicky was the *Šweik of physics* – his mother came from Prague – and we all need him as our role model on the way towards a both sharper and more caring planet.

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