From Webster's Collegiate Dictionary:

fiction:
1 a: something invented by the imagination or feigned; specifically: an invented story; b: fictitious literature (as novels or short stories); c: a work of fiction; especially: a novel

2 a : **an assumption of a possibility as a fact irrespective of the question of its truth,** a legal fiction
b : a useful illusion or pretense **<< *A Working Hypothesis* >>**

3 : the action of feigning or of creating with the imagination

heuristic:
: involving or serving as **an aid to learning, discovery**, or problem-solving by experimental and especially trial-and-error methods, heuristic techniques, a heuristic assumption; also

: of or relating to exploratory problem-solving techniques that utilize self-educating techniques (evaluation of feedback), to improve performance, a heuristic computer program

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Albert Einstein (1879-1955):
1921 Nobel Prize for Physics "*for your photoelectric law* and your work in the field of theoretical physics."

The prize was for the 1905 paper "*On a Heuristic Viewpoint Concerning the Production and Transformation of Light*"

How much Fiction is necessary in Science?

by
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Overview

I. "Nature is supreme - not our ideas".

II. Using what we know best to explain the remote and unknown - I call this the idea of "Locality".

III. By concentrating on specific phenomena we separate, and simplify them. This is the principle of "Specificity".

These and several others are ***strategic*** ideas for research. I will review their use for gaining wider views.

Strategic Ideas cannot be proven, but can shown to be plausible. They are part of **Meta-Science,** and are in this role axiomatic. This is the focus of my talk. The problem of fictions and their role in science is an application that I will demonstrate in:

Mach's Principle, is it scientific? The situation in **Cosmology** and in the **Quantum World.**

My conclusion is that what is loosely called philosophy **guides us,** but mostly as vague feelings. This influences our work, serves for **orientation and must be recognized as a great problem!**

How to avoid problems of unskilled thinking?

Descartes' famous *Discourse on Method (1637):*

1) One needs doubt and must seek consilience of all available information

2) "break down every problem in as many separate simple elements as might be possible"

These are the elements of the **analytical method**, to understand and to predict, in contrast to the **systems approach,** which looks at the total phenomena. Only the analytical method allowed the unprecedented success of modern science and technology. The systems approach can serve to augment it - it is corrective, but less productive.

William of Ockham (d. 1347) :

entia (principia) non sunt multiplicanda praeter necessitate, i.e., one must not introduce more concepts (abstract entities, details, elements, explanatory assumptions) than necessary.

The **"Razor"** is to cut off the unnecessary, the confusing, the unjustified, the sporadic. It is of inestimable importance for all analytical thinking.

We should lean on the side of few assumptions; not for economy, as Mach said, but for **robustness.**

Paracelsus:
(d. 1541)

sola dosis facit venenum
only the amount makes the poison

Do not overdose - **Anything**!
Even the best is harmful if used too much.

In Ancient Greece: (right) ***measure is best***.

μέτρον ἄριστον

In Economics: the *Law of Diminishing Returns.*

However, *an Overdose* goes beyond this;
the effect is not so much "fewer returns",
as that it becomes a **poison,**
harmful and in its effect, the opposite of what was desired.

We see uncounted examples of this principle in action. It has been recognized by many, but the overdose syndrome is everywhere - because it is in our culture.

Paradoxical Consequences of Excess.

Excessive concern with utility leads to waste and disaster in the **Paradox of Utility.**

Actions to liberate people by giving them more freedom, *if not checked by laws and traditions,* lead to an excess of freedom. This brings about a tyranny and became known as the **Paradox of Freedom**.

Similarly, too much tolerance leads to loss of tolerance in the **Paradox of Tolerance**. If we are tolerant with the intolerant they will, as soon as they can, suppress the tolerant. We must except from our tolerance those who, by acting and preaching intolerance, put themselves outside the community. (No rule can have total validity).

The **Paradox of Democracy** deals with the case when the majority, in the belief that they can decide anything may decide that a tyrant should rule, who promptly abolishes democracy.

Experience teaches that those who aim directly at happiness do not find it; but those who follow a purpose apart from happiness find it as a “fringe benefit.” This is the noted **Paradox of Hedonism.**

J. B. Conant in ***Two Modes of Thought*** (1964):

In science, we find two styles or preferences,

A) The empirical-inductive method of inquiry with emphasis on experience; and

B) The theoretical-deductive outlook based on assumed postulates.

Both are indispensable **in their combination**.

An excessive preference of style “B” leads to wild speculation - with bad effects. One loses all connection with the solid ground.

A sole reliance on “A” limits our efforts to what trade artisans can do.

It produces mere random trials unless Style “A” practitioners seek to widen the generalizations.

What is Truth?

Saint Thomas Aquinas (d. 1274):

veritas . . . . . est adequatio rei et intellectus.

Truth is **the match, the fair, or the sufficient representation of object by thought** (speech).

A statement that is not adequate, is simply not true. If object and statement do not sufficiently agree, we have to refine thinking (add details, qualifying factors, or change the *Paradigm*).

Perfect **representation** is not attainable (but it might between abstracts), but we must strive to approach it as much as possible.

If people are told that **truth** is not attainable, or *that one does not know what it is*, they will not even try.

The Aim of Pure Science:

Can we show that what we see or observe,
is as **necessary** as the basic logic-mathematical facts?

The Pythagorean theorem; or the fact that there are only five regular polyhedrons; or that the number of arrangements of things is limited to n-factorial (n!); - or in a different way - that a certain number will inevitably come up in a random lottery if we just wait long enough - these statements reflect necessities by their nature, i.e., **necessities which exist without dependence on anything else.**

A consequence of this ideal is that most science will have to be justified as Applied Science, or technology creation, with promises or commitment for useful results. This places a serious burden on the administrators:

From brilliant vision to a fraud is but one step!

Ask: How likely is this theory?

Assign a number for the likelihood l_k of each assumed component or constant (assuming they are independent).

Total probability $= \prod_{\text{All } k} l_k$

We should do this before making announcements of having found the theory that explains everything.

Ernst Mach (1838-1916)

Professor of Mathematics in Graz, Austria; later of Physics in Prague, of Philosophy in Vienna. Was home schooled; became famous because of:

Mach Number = speed/speed of sound
Mach's Bands - a discovery in Physiology
Mach's "Economy of Thought" criterion
Mach's Principle - one of our subjects today.

Mach had a decisive influence on Einstein; he was criticized by Lenin in *Materialism and Empirio-Criticism*

Positivist, Phenomenalist; his teachings inspired the later Vienna Circle of Logical Positivism.

Author: *Die Mechanik in ihrer Entwicklung, Erkenntnis und Irrtum (1905)*, and other works;

He was the source of many ideas. But two of them have been unfortunate: His Economy of Thought, and Mach's Principle (so named by Einstein). Both have produced major and persistent confusions.

Mach's Principle.

The Principle claims that it is necessary to assume that the most remote masses of the Universe provide the reference against which acceleration takes place. **A body in an empty Universe would not have inertia.**

This goes certainly against our principle of "locality" . What does the reference to the remote masses give us? Is it necessary to assume this? Can it be checked?

A common confusion arises because we need a reference to specify Orientation. But, do we need an external reference for the speed of rotation or for other accelerations? The answer is no!

We can measure the rotation with an optical gyro, as well as with a mechanical - they must respond to the same effect which is the transition from one inertial system to another one.

Mach's Principle:

For a body to go from one inertial system to another, requires acceleration. The accelerating force changes the state of the body's **energy**.

The energy level difference between different inertial systems is also being seen by a photon (Doppler Effect).

This is clearly a local affair - distant masses make no contribution.

Mach's Principle:

If true, a close connection would exist with the depths of the Universe. Gravitation and inertial would not remain exactly proportional with time.

The Eötvös-Dicke experiments have been negative at very high accuracy (10^{-12} ?).

We reject the Principle because:

It is too vague, and without mathematical formulation;

It is against experimental evidence at very high accuracy.

(Even solely as a heuristic viewpoint, the Tooth Fairy is more helpful.**)**

Stephen Hawking defines Cosmology as

The Study of the Universe as a Whole.

However, what is the Universe? We can ask:

1: What is the largest set of objects that can be observed?

2: What is the largest set of objects that are physically significant?

3: Is it justified to treat the Universe a whole?

4. Is it simple if viewed on a large scale?

5. The “Cosmological Principle”

The Redshift is defined as

$$z = \frac{\lambda_{obs} - \lambda_{em}}{\lambda_{em}} = \frac{\Delta\lambda}{\lambda_{em}} \quad \rightarrow \quad 1 + z = \frac{\lambda_{obs}}{\lambda_{em}}$$

Hubble Law:

$$v = \frac{dD}{dt} = H_0 \times D \; ; \quad H_0 = 70\text{km/s/Mpc} \pm 10; \quad h_0 = H_0/100$$

--------> $t_0 = -14$ Gyr for E-deS model

$$z = \frac{\Delta\lambda}{\lambda} \sim \frac{v}{c} \quad (\text{for } z < 0.1) = H \times D/c = D \times 2.4 \times 10^{-4}$$

-----> $D \sim z \times 4167$ Mpc

Relativistic Doppler:

$$\frac{\lambda_{obs}^2}{\lambda_{em}^2} = \frac{c + v}{c - v} \quad \text{-----> } \quad v = c \, \frac{(1+z)^2 - 1}{(1+z)^2 + 1}$$

$D = (t_{obs} - t_{em}) \times c$; Mass Density $\Omega_m = \rho_m/\rho_{crit}$

Why question the Hot Big Bang?

1) The time constraints. 14 Gyrs are insufficient for large structures to develop (by a factor of > ten).

2) How could any condensations develop? (a too large isotropy and uniformity of the 2.73° K CBR, which is of order 10^{-5} !)

3) By observing objects beyond z = 1 (2 or 3× 10^9) years, we ought to see some asymmetry. Otherwise, we are in a special position (pre-Copernicus).

4) The "Black Hole" (BH) problem. The BH concept is being used in two opposite ways:
(a) As the powerhouse in the center of galaxies.
(b) as primeval origin in the Big Bang for **all** matter

The justification is purely mathematical (a + or - in the solutions is claimed to allow either creation or a BH). This is similar to the old Ontological Proof!

5) The observed CBR smoothness is 10^{-5}, which is incompatible with the formation of spirals. E.g., SB galaxies? How can such complicated systems emerge from an explosion?

6) Even the Hubble shift is not necessarily a velocity shift. Could photons not "evaporate" if even BHs can ? A new Hypothesis by Vigier. Too many alternatives are not investigated.

7) C.V.L. Charlier (1908), *Wie eine unendliche Welt aufgebaut sein kann,* Arkiv for Matematik, Astronomi och Fysik, 4, 1-15, and later works:

Charlier assumed progressively increased distances between larger aggregates. It is remarkable how much the density of matter decreases with larger averaging volumes (not with increasing distance!):

Averaging Volume	Average Density
Atomic nucleus	2.7×10^{14} g/cm^3
Earth	5.5×10^{0}
Solar System	2×10^{-12}
Center of Galaxy	10^{-22} (or a few orders larger)
Galaxy average	10^{-23}
Cluster average	10^{-29}
Radius 1Gpc	$< 10^{-30}$ without hypothetical "dark" matter

The Universe is very nearly empty!

de Vaucouleurs found 1970 that, with increasing size of an object, the average material density decreases about with the square of the averaging size. This is far from homogeneity, and de V met disbelief. He lost credibility by reporting findings that were incompatible with the “accepted”.

The strongest support for the HBB comes from

1) Indications of systematic development with age - unless the many more blue remote galaxies are due to hidden selection effects. Hoyle thought that evolution is positive and this became the reason for his *Modified Steady State Theory* which allows it.

2) The high degree of thermalization of the 2.73^{o} K CBR is hard to explain otherwise; but Hoyle et al. have hypotheses.

Conclusion: *A firm belief in a persuasive concept displaces the use of different options in the research establishment.* The Peer Review can't easily allow new ideas to be examined. This should be overcome with the help of discretionary funds to allow some dissimilar research to be funded without the panels.

The Quantum World

An excessive Realism is unwise. Nature is not necessarily what we expect on the basis of our everyday life.

We cannot even assume that objects have properties as such - without, or before, they are being tested. **A particle assumes a specific value of a physical parameter in the process of interaction,** but not before. The often stated idea that the critical point is **human observation** is a gross misunderstanding.

The EPR experiments have been a revelation that was not expected by Einstein himself.

However, the non-separability must also alert us that our “principle of locality” is too restrictive for the quantum world. Two particles which come from a common event, remain a system regardless of their separation. Particles such as photons or electrons are “diffuse” and **cannot be localized between interactions.** Of course, we know of nothing in our daily world that behaves like that and this has led to many misunderstandings.

Comments on an approach to particle physics:

Heisenberg expressed the idea that we may have reached a level where it makes no sense to speak of fixed building blocks as part of the particles. At the time, we seem to be locked into the Quark concept with ever more refinements (our epicycles) required (color, charm, bottom, up and down, xenicity), while other avenues are being relatively neglected.

H seems to have envisioned a new mathematical theory that represents the particles as **abstract systems**, without an internal structure specified. They would be treated as energy packets with a spectrum of excitation levels that correspond with solutions of an Eigenvalue problem. Energy could be added or removed by radiation or by particles. A key can be the fact that energy appears as stationary (particles moving at $v < c$) or as radiation ($v = c$).

Problems to be overcome are: The scheme must be compatible with quantum theory and with relativity. Nevertheless, this could allow a wider-ranging mathematical development than the group theory based quarks. Heisenberg seems to have expected the possibility of a fundamental paradigm change.

Conclusions:

We need to be suspicious in our analysis. The world has an enormously greater variety than what we can imagine. Certainty is not helpful; on the other hand, insecurity is a crippling weakness. To find your way between these two requires a trained character with fortitude, strong and secure enough to persist with questioning. And we must remember the severe limitations of the **individual** mind.

Our mind produces a one dimensional experience (a *succession* of vague "images"). The world is four dimensional. While we concentrate on one thing, an infinity of events takes place - everywhere!

A second problem is the link of our old brain with the cerebrum. This makes our judgment vulnerable to emotions. This colors the relative weight we give to the various factors, in an **uncontrolled** way.

A third limitation is that we can only compare very few items in the mind at any one time. We must return to each factor over and over again. Only the one that is momentarily present, has a high weight.

An excellent observation has been made by HBN, who say in their book (p 242):

The inability to include what is so far unknown within the range of the possible is responsible repeatedly for wrong turnings being taken in cosmology, as well of course as in all other walks of life.

They continue: . . . . *the "happen somehow" syndrome blocks off the way to progress, leaving the community with no way forward except through senescence and replacement.*

I hope, this is too pessimistic. But, it shows why we need to use more thought in science.

Fictions are a necessary focus for interest and effort; they are indispensable to allow new, unknown features in our mind; but most fictions have been confusing detractions that, by holding on to them, caused delay in finding better methods. And a few will always be, or turn into, deliberate frauds.