Scientist and Society: Problems at Interface

Mikhail Katsnelson
What is science and what is technology?

The aim of technology: to use
The aim of science: to understand

Can wrong idea be practically useful? – yes!

Why had the plague not broken out at the blacksmith’s shop in Munday’s Lane? Because, as I’ve shown you, forges and smithies belong naturally to Mars, and, for his honour’s sake, Mars ’ud keep ’em clean from the creatures of the Moon... “Eureka, good people!” I cried, and cast down a dead mill-rat which I’d found. “Here’s your true enemy, revealed at last by the stars.” “If you would stay the plague, take and kill your rats.” None the less, the plague ceased and took off from the morning of the day that Mars enlightened me by the Lower Mill.’

(R. Kipling, A Doctor of Medicine)
Space travels

Konstantin Tsiolkovsky
"Russian Cosmism"
Nikolai Fedorov
The aim: physical immortality and resurrection of the dead
Need a lot of space!
Motivation for space travels...

Practical use of satellites
Navigation, weather forecast, communications, astronomy... Not talking on military applications
Can correct idea be practically useless?

Well... for sure (how can we use Higgs bosons or gravitational waves discovered very recently)? But...

Einstein’s general theory of relativity (one of the most abstract physical concepts)

Gravitation is the curvature of space-time.

Time is slowing down by gravity.

Should be taken into account in GPS!
Example: classical electrodynamics

From a long view of the history of mankind - seen from, say, ten thousand years from now - there can be little doubt that the most significant event of the 19th century will be judged as Maxwell's discovery of the laws of electrodynamics. The American Civil War will pale into provincial insignificance in comparison with this important scientific event of the same decade (R. P. Feynman)

Faraday and Maxwell together have probably justified all expenses for fundamental science for thousands years in advance
Science and technology II

If we do not know whether the problem is solvable or not, it is science; if we are sure that we can do it but do not know whether it is worth to do or not – it is technology.

Science opens ways for dramatically new solutions.

Based on classical physics

Triode (electronic vacuum tube)

Transistor is based on quantum physics – totally new concept of nature
Science is necessary for survival of humankind

Agriculture ("green revolution")
Medicine (new antibiotics: arms race with bacteria)

We cannot just stop: too many will die

Our society is crucially dependent on communications, transport, computers... well... weapons...

Very important to know how science works
The aim of science: Understanding

Duality of understanding and knowledge

Newton laws... Rotation...
Air resistance... I know this stuff but the result will be... well...

He does not know (!) Newton Mechanics – but it works! He feels (=understands) what to do.

I think I can safely say that nobody understands quantum mechanics

(R. P. Feynman)
A normal way of doing theoretical physics

Combining elements: a (known) method A, apply to calculate a property B (was calculated earlier but in another way), consider a system C (was calculated earlier for other systems)...

You can be taught to do it

Dramatically new ideas (e.g., gravity as a curvature of space-time): very rare, very important and we do not know how it happens

It may be useful to know how people did it before (most of physicists are quite ignorant in history of physics) but you are not guaranteed...
Working with a space of ideas

Mathematics is the *art* of giving the same name to different things (H. Poincare)

Like in a good book or a good movie: a lot of intrinsic relations, cultural references...

Analogy: a quantum computer vs classical

Working with $N$ elements or with the whole “Hilbert space” ($2^N$ combinations)

Graphene: coupling together solid state physics, soft matter, relativistic quantum mechanics and even gravity
Correct theories from wrong assumptions

Electromagnetic fields as deformations in ether; gears and wheels

We do not believe now in mechanical models for electromagnetic field but Maxwell equations are correct

Also: Dirac equation (relativistic wave equation is not necessarily the first-order equation as Dirac postulated)

Landau theory of superfluidity of helium (he did not take into account Bose statistics of helium atoms which is crucially important)
Curiosity-driven research

Physics is like sex: sure, it may give some practical results, but that's not why we do it

R. P. Feynman

Motivations are very different...

Model of science
Resume

1. We do not know what is the origin of new ideas.
2. Sometimes the best results originate from wrong background.
3. We can plan less important works but breakthroughs are always unexpected.
4. Our work is crucially important for humankind but it is impossible to tell what we are doing since we do not know ourselves.
   AND
5. We need money (science is expensive)!
What to do?

1. Trust us, we are smart guys and we know what to do – medieval guilds principle. It will not work in modern society.

2. Convince people that we are useful.
   Well... We are useful but in a complicated way.

Strong temptations: lie and intimidate.
Polite version: tell on success only, overestimate practical importance, promise something too early..
Responsibility of scientists

Practical questions: risk of natural disaster?

Scientists as oracle

May be real...
Too big responsibility?!
Misuse of science

Everything a scientist did was destined to become a weapon (K. Vonnegut, Cat’s Cradle)

Was/is arms race useful for science? Well...
Science as mass occupation

Starts with A-bomb making

Completely changes relations between scientists and society
From History of Soviet Science

After the revolution 1917: Bolsheviks and Science

Humanities – just destroyed ("Marxism-Leninism" in its most primitive forms as obligatory "method")

Science in 1920th: a lot of people sent abroad
A huge amount of very talented people appeared

A very serious contribution to the new physics
From History of Soviet Science II

Landau
(Nobel laureate, pupil of Bohr)

Kapitsa
(Nobel laureate, pupil of Rutherford)

Fock

Frenkel

Gamow

Arrested 1937, released 1938
My background: Theoretical physics in Sverdlovsk

S. P. Shubin (1908-1938)
S. V. Vonsovsky (1910-1998)

Arrested 1929, Professor, head of the department 1933, arrested 1937, died 1938. Published 18 papers

“Polar model” (“Mott insulators”), liquid metals, photoeffect, s-d exchange (Vonsovsky-Zener) model...
Studying and Working in Ural

Ural State Univ.

Inst. Metal Physics

Advanced Physics and Mathematics Schools
Olympiads

Mathematics, Physics, Chemistry vs History, Philosophy, Literature...

No choice: only physics/mathematics/chemistry

Well... Good for science?!
Peculiarities

No grants, no proposals. “You always did whatever you like”

A very broad education

“Physics is an oral science”. Role of journals and seminars

“Scientific schools”. The War of the Roses

No need to be convincing for public (but a huge need to be convincing for authorities)
What happens with Russian physics?

Disaster? or Great success?

Like chemical evolution in stars: a very peculiar medium which does not exist anymore

Reunification with the world science and enrichment of the world science