During the general functional crisis in science the behavioral norms of scientists in this country persist in a more or less stable condition of survival. They even support the hopes that Russian science will overcome its comatose state. It is quite possible that in this crisis scientists' *disinterestedness* will become a principle of the scientific ethos that passes us collectively through a decisive test. After that it would not be so easy to make ironic remarks on the state of science.

I will say in conclusion the following and would like to not be misunderstood. Considering the Mertonian sociology of knowledge as one approach in social epistemology, I do not detract from the scientific value of these studies, and I do not disparage the kind of science to which they belong. Quite the contrary: it is because these studies assimilate scientific methodology and data along with philosophical interpretation that they have produced a certain cultural awareness which accompanies the entire history of Mertonian sociology of science. It makes R. Merton's contribution to science and philosophy, and further on to the present-day culture, so distinguished.

Irena Marshakova-Shaikevich

The Institute of Philosophy RAN,
Moscow, Russia,
AM University, Poznan-Kalisz, Poland;
ishaikev@mail.ru

Meeting Robert Merton: Discussion of Co-citation Maps of Science and the Evaluation of Scientific Journals

Introduction

From January till April of 1990 I stayed at ISI (Philadelphia, PA). Eugene Garfield, the founder and president of that well-known institution had invited me there, and to this day I recollect with gratitude those months. I was lucky to do my research there, to enjoy Garfield's benevolence, to have talks with interesting people. A few days before leaving for Russia I had a talk with B. Griffith Professor at Drexel University and he asked me: 'Whom do you wish to meet in US?' 'My dream is to meet Robert Merton', I answered.

I had read the works of that renowned scholar; some ten years before he had mentioned co-citation as a tool of research in the history and sociology of science. (The method had been elaborated independently by H. Small and myself). To hear his opinion on co-citation and on evaluation of scientific journals would be very important to me.

'But it is hardly possible, I added, I don't know if he is still in the subject, and besides I am leaving US in three days'.

The same night I had a call from Professor Griffith: 'Bob will wait you on Monday at 12.25 in Russell Sage Foundation (NYC)'. That I was glad and excited, is quite clear. The thing that struck me most was the time of the appointment — 12.25, not 12.30, nor 12.45. In a rush I began collecting materials for discussion wish Merton and contacting my friends' son who would help me with my English.

I was in Russell Sage Foundation at 12.00. In the lounge I asked a lady. 'How will I know Professor Merton?' She answered: 'You are sure to recognize him, he is a GENTLEMAN!'. Indeed, when I saw a tall grey-haired man with kind smile and penetrating eyes, there was no mistake: It was Merton! I stood up and approached him.

Co-citation maps of science

Bibliometrics is one of the approaches to the study of science. It was in the 1960s and is associated with a quantitative analysis of flow of documents. Items of bibliometric analysis are publications grouped according to a multitude of aspects: journals, authors, countries, thematic groupings, organizations, words, etc. The specific feature of bibliometrics is the use of secondary information: all kinds of bibliographic indexes and databases which stimulated the development of such methods and special interest for fundamental aspects of information science.

The corresponding statistics may be of great interest for the analysts of science development, it may help in planning and management of science.

Two important sides of these directions of analysis should be mentioned at once.

Bibliometrics is based on the huge amount of easily accessible secondary information well represented in various databases, particularly in the databases of the ISI. It was exactly those databases that served as a starting point for the development of bibliometrics.

Bibliometrics is primarily a quantitative study of the flow of documents. It is not aimed at finding a particular bit of information, it concentrates on discovering middle- and long-range trends, on strategic monitoring the development of science.

Various bibliometric methods in the study of science fall into two major approaches. The first is based on the analysis of the dynamics of separate features — 'plain bibliometrics'. The second is associated with the study of correlation between objects, their clustering and classification — 'structural bibliometrics'.

The development of both approaches in bibliometric studies was greatly facilitated with the advent of ISI system (today DBs ISI/Thomson Reuters) — a universal (worldwide and polythematic) information base. It was Merton's followers ((D. Crane, J. R. Cole and others) who started using Science Citation Index system for measurement of scientific activity and citation rating of scientists.

The second approach to the quantitative study of information has been gaining popularity since the early 1970s. It is aimed at getting structural (or qualitative) picture of the state of science. The quantitative characteristics of information processes are not considered here as final results of the analysis, they are used as tools to describe the everever changing structure of science in general and of particular fields of knowledge.

One of the few methods elaborated along these lines is cocitational analysis.

From the mathematical point of view Citation network is a set of documents with the relation of citing imposed on it. In other words it is a union of a set of citing papers and a set of cited papers. A citation network is a potential base for various classification of member-papers. Search for practical algorithmic (automatic) classification is a characteristic feature of present-day bibliometric analysis of citation networks. It was M. Kessler who in 1962 formulated the concept of 'bibliographic coupling''bibliographic coupling' as a measure of similarity of two documents based on the number of common references.

The logical opposite of bibliographic coupling is the concept of co-citation proposed in 1973 independently by H. Small in the USA and by the present author in the USSR. The similarity of two documents depends on the number of papers citing both documents. When a new paper appears it is not linked to any other paper until it starts to be cited in scientific literature. I called this connection *prospective* for it is based on citations in future literature. Kessler's term *bibliographic coupling* I called *retrospective* connection. I admitted that H. Small's Small's term *co-citation* proved a happier coinage and I borrowed it into Russian as *kocitacia* or *kocitirovanie*.

When applied to a vast bibliographic material (primarily to the SCI databases) cocitational analysis serves as a means of getting clusters in the citation nets which can be interpreted as elements of a complex hierarchical structure of science with very broad fields of knowledge at the top and many individual research fronts at the bottom.

Among numerous techniques covered by 'structural bibliometrics''structural bibliometrics' the place of honor belongs to co-citation analysis and corresponding mapping of science. I do not intend to discuss here this well known method — its results are shown in maps: fig. 1 — co-citation map of publications (for the 1968–1969 period), fig. 2 — co-citation map of the authors of those publications.

First we discussed those maps of science. The 1968–69 map, which included 442 publications (fig. 1), served as a source for establishing links between authors. The productivity (number of publications) of each author in 1968–69 was taken into consideration, when the sum of mutual prospective links was calculated. On the basis of those normalized links between authors a *n*-measured symmetrical matrix was built. Graphic representation of that

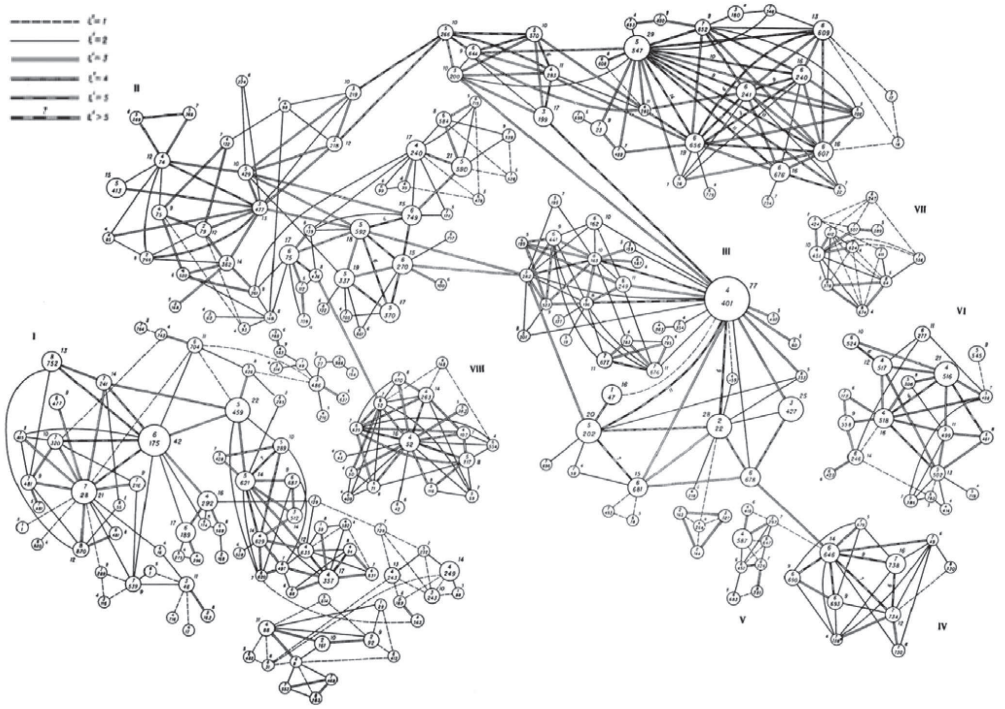

Fig.1. Map 1968-69 Research Fronts in Laser's field

matrix was published as a map of author-to-author links (fig. 2 — the map Professional communication between authors in the Laser's field 1968–69). There is a difference between maps of co-cited publications and maps of co-cited authors, which means that cognitive and social structures of a field of knowledge differ as well.

The difference between the two maps was the central point of our discussion with Professor Merton. It is important to mention the fact that the map of co-cited publications representing the cognitive structure of a scientific field does not coincide with the map of co-cited authors where some social factors are reflected. The method of co-citation analysis (method of structural bibliometric) serves to identify cognitive and social structures of science and the nature of their correlations (congruence, non-congruence), as well as forms of professional communication. This method should be used in scientific knowledge and identification of social institutes of science. Maps of science produced by the method of co-citation reflected one more way of knowledge existence — prospective connections between publications determined by relationships within the scientific community (on the whole). Prof. Merton acknowledged the fact that such maps should be regarded as an objective picture of the cognitive and social structures of science; they could lead to discovery of important individual papers, true leaders in new fields and directions of science.

Robert Merton was always interested in the emergence of new specialties, their further development and their influence on scientific knowledge. I knew that and I drew his attention to the co-citation map of publications for the 1966–1967 period (fig. 3) and stressed that my research of the corpus of laser publications had been carried out in two separate stages 1) for 1966–1967 and 2) for 1968–1969. On the basis of the formal mathematical model

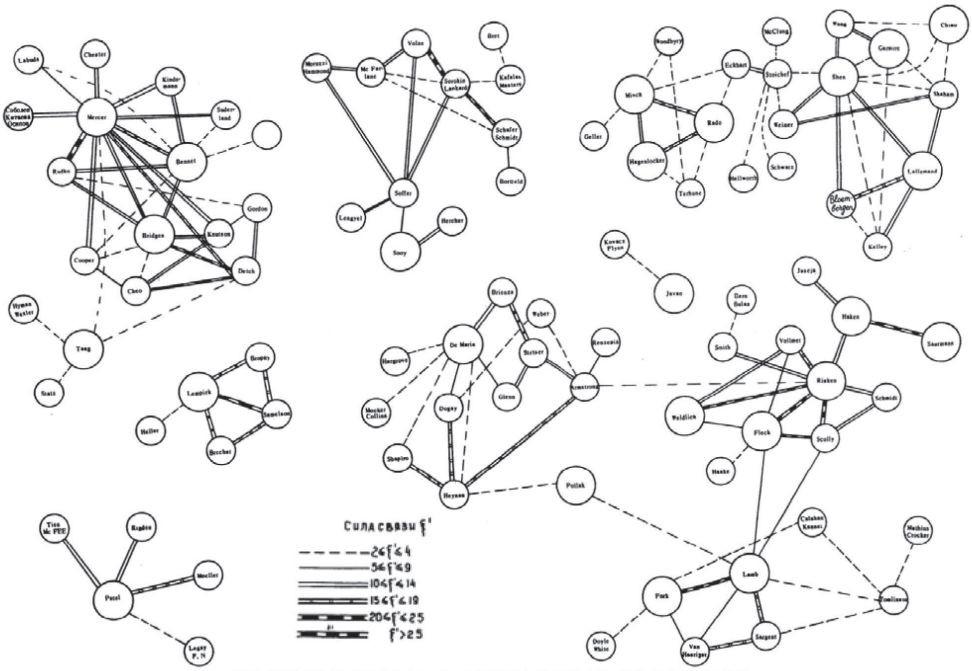

Fig. 2. Co-citation map of authors

and resulting procedure 13 autonomous groups were found for 1966–1967 and 26 groups for 1968–1969: those groups are easily interpreted and labeled e. g. Laser'*s theory of laser; Quantum theory of OKG; Laser in magnetic field; Stimulation of laser radiation; Self-focusing of laser beams; Brillouin scattering; Interaction of oscillations; Zeeman effect in lasers; Giant pulse laser; Research on distribution of laser radiation; Generation of optical harmonics; Solid-state laser; Organic dyer laser; Molecular gas lasers; Liquid lasers; Ion lasers.*

The changes in configuration are due to: a) stabilization of groups, b) division of a group into related groups, c) appearance of new groups. Stable groups are characterized by strong prospective links. Documents with weak prospective links are unstable and can be easily re-grouped. Changes in classification usually show landmarks in the development of the given field of science. Group 'Laser on water vapors', which appears on 1968–69 map, is the result of research, done in 1964–1965. W.E.Lamb's paper of 1964 (number 4 401 on the maps, a classical work in Price's terms) is the core of the 'Theory of gas lasers' group [Lamb W.E.Jr. Theory of laser// Phys.Review, 1964, 134 , N 6A, 1429].

Normalized impact factor of scientific journal

We also discussed possibilities of bibliometric assessment of scientific journals and fields of knowledge. My idea was to introduce a special measure — normalized impact factor (K) to the data bases of Journal Citation Report Science Edition (JCR:SE), which was elaborated by me for evaluation od Russian journals and published in 1988 (in Russian). It is well known that level of citedness differs significantly across various fields of science: it very high e. g. in biology and medicine and very low in mathematics or engineering. Therefore the traditional

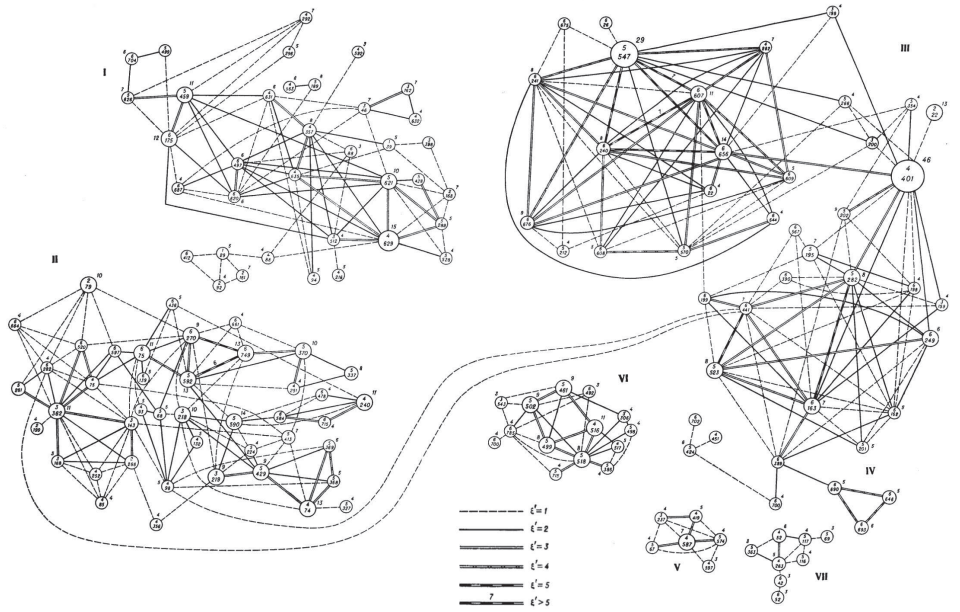

Fig. 3. Map 1966–67 Research Fronts in Laser's field

impact factor (Ip) of a journal, as indicated in JCR DB, would be valid only within a certain large field of science. To facilitate cross-field evaluation particular journals a new measure is introduced. The Ip of a journal is divided by the standard impact factor (Ig) of the field, to which this journal belongs. The technique of calculation of the standard impact factor for a field (Ig) is an inherent part of the method. For each field of science 5 journals with the highest Ip values were selected. If the total number of papers in those journals (for the two preceding years) was less than 500, the list was extended until the threshold of 500 was reached. The ratio of the total number of citations (in ISI source journals) of articles in the list journals to the total number of source items in those journals (Ig) should represent the field as a whole and is called standard impact factor of the field. It should reminded that in calculation of both Ip and Ig include current year citations of the items in two preceding years.

Once standard impact factor of the field is obtained, the numerical assessment of a particular journal becomes evident. The most obvious and simple indicator would be the ratio of the two measures: **K= (Ip / Ig) x 100%** - % — Normalized impact factor of a journal.

If a journal belongs to two or more fields the arithmetic mean of the two or more Igs may be used.

First results of calculation K-index for Russian scientific journals were shown and discussed with R. Merton. Table 1 may serve as an illustration to this point.

Table 1 JCR: Science Edition 2000 RUSSIAN SCIENTIFIC JOURNALS
ranking by Normalized impact (K > 20)

Journal Abbreviation	Title in Russian	Ip	K
PETROLOGY	Петрология	0.786	32.61
LASER PHYS	LASER PHYSICS	0.891	30.83
PLASMA PHYS REP	Физика плазмы	0.650	30.23
GLASS PHYS CHEM	Физика и химия стекла	0.394	28.14
QUANTUM ELECTRON	Квантовая электроника	0.741	26.18
INSTRUM EXP TECH	Приборы и техника эксперимента	0.361	25.78
ACOUST PHYS	Акустический журнал	0.356	23.40
RUSS MATH SURV	Математическое обозрение	0.379	22.56
ASTRON LETT	Письма в Астрономический журнал	0.953	21.66
JETR LETT	Письма в ЖЭТФ	1.411	21.22

Robert Merton seemed interested**.** Our talk carried on for four hours. At parting he gave me seven of his papers and his well-known book “On the shoulders of giants” with the following inscription: