FIELD MOBILITY IN CZECH PHYSICS-RELATED INSTITUTES AND FACULTIES

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Items such as division of labour within R&D laboratories, diversity of scientists in specialty areas, and the role of field mobility in scientific career were already documented /1/ and there have also appeared fact-finding studies on the particular case of physics.

Some of the reports dealt with the proportion of physicists in industrial laboratories /2,3/ and mentioned the collaboration of different specialists at Philips /4/. Professional differentiation of physicists working in various types of research establishments were tabulated in a French survey /5/. There were published figures on the distribution of research personnel by graduation fields in five physics-related institutes of the USSR Academy of Sciences and the percentage of physicists, mathematicians and chemists in the Academy major sections /6,7/. Another study was concerned with how the recognition of active British physicists had been influenced by the individual's own specialty area rather than by the specialties of his colleagues /8/. Age distributions of physicists and biophysicists were also compared for three national physics communities /9,10/. To assess the distance of employment specialty from graduation specialty (including physics) in the USSR research establishments of chemical technology, a step mobility index was applied /11/. The field retention rate of physicists and other scientists was investigated in research establishments of two Soviet cities /12,13/. The organization and information process in a nuclear physics laboratory witnessed for the British case the relative commonality of background education and the high level of common specialized training /14/. An inquirement about high energy physicists in US universities /15/ proved regression of recognition on specialty heterogeneity and other individual or organizational characteristics. The diversity patterns were computed with respect to seven specialties (derived from the results of factor and cluster analyses performed on 25 research areas) by Liberson's index /16/. The conclusions indicated that diversity of departmental personnel facilitated cross-institutional contacts and thus scientific performance, which in turn increased the likelihood of recognition for achievement. Several statistical tools were used to study field mobility of academic staff in Dutch universities, the interrelatedness of scientific disciplines and trends in the number of graduates /17/. Some of these findings have been recently summarized and commented in a more detail elsewhere /18/.

Our aim now is to report on professional mobility in thirteen institutes of the Czechoslovak Academy of Sciences, a faculty of the Charles University, and a faculty of the Technical University, Prague, the research and education programs of which are closely related to physics. Table 1 contains background information on ratios between scientific, creative and total staff, as well as on diversity measures for the two former categories. From the hitherto used indexes of diversity or dispersion, we have chosen Singleton's dispersion coefficient D, a measure suitable for frequency-rank distributions when the subject field of interest is divided into categories. The coefficient D, first used in bibliometrics /19/ and later generalized /20/, ranges in value from 0 for zero dispersion to 1 for coverage uniformly over all categories. Clearly, its complement 1 - D may be called a coefficient of concentration. (Another existing measure, Lieberson's index /16/, reflects the probability that any two persons chosen at random are in different specialties or fields).

Two cases are treated separately: mobility of creative staff (graduates involved in research work) between the field of study (graduation field) and field of current scientific or pedagogical activity, and mobility of CSc/DrSc-degree holders between the field of study and field of scientific major. The values of D in table 1 indicate with the exception of some statistically insignificant low rates that there is a marked shift toward less diversified population in term of disciplinary coverage after both types of transfer. Relative mobility counts for all the 15 institutions are presented in tables 2 and 3 for up to eight graduation fields and a category Oo of nongraduates, seven activity fields and category Oo for nonscience activity (MP = math+phys) and seven science degree fields. Categories Oo were not included for the computation of D, percentages do not always add up to 100 due to rounding.

Table 1: Relationship between the number of scientists, creative staff, and all employees at the institutes or all research and pedagogical staff at the faculties. Values of dispersion coefficient D computed for the distribution of personnel by graduation field, activity field and scientific degree field

institute, faculty	$\frac{\text{creat}}{\text{employ}}$	$\frac{\text{scient}}{\text{employ}}$	$\frac{\text{scient}}{\text{creat}}$	dispersion coefficient			
				creative		scientists	
				grad	acti	grad	scie
Inst.of Physics	42.0 %	18.1 %	43.1 %	.157	.056	.358	.019
Inst.of Solid State Physics	40.1 %	16.3 %	40.7 %	.209	.171	.123	.097
Inst.of Scient.Instruments	29.7 %	8.7 %	29.3 %	.063	.083	.029	.059
Inst.of Nuclear Physics	38.5 %	14.2 %	37.0 %	.107	.087	.051	.023
Inst.of Plasma Physics	37.1 %	15.2 %	41.0 %	.143	.000	.109	.047
Lab. of Radiation Dosimetry	94.7 %	31.6 %	33.3 %	.179	.161	.167	.167
Inst.of Astronomy	41.0 %	16.0 %	39.0 %	.163	.056	.033	.042
Inst.of Geophysics	46.8 %	21.1 %	44.9 %	.151	.151	.081	.000
Inst.of the Phys.Atmosphere	38.6 %	21.1 %	54.5 %	.091	.039	.042	.000
Inst.of Radiotech.Electron.	45.3 %	20.3 %	44.8 %	.095	.130	.058	.109
Inst.of Physical Metallurgy	42.2 %	13.7 %	32.6 %	.157	.012	.089	.089
Inst.of Physical Chemistry	52.5 %	30.2 %	57.5 %	.147	.000	.119	.006
Inst.of Biophysics	53.1 %	21.7 %	40.8 %	.413	.119	.258	.048
Fac. of Mathem.and Physics	100.0 %	55.4 %	55.4 %	.052	.031	.144	.156
Fac. of Nucl.and Phys.Engin.	100.0 %	43.9 %	43.9 %	.226	.216	.195	.236

These manpower figures may be compared with the publication output from some of the institutions, using e.g. bibliographies /21,22/, entries in abstracting periodicals or other information sources. Distinctive features found on field mobility of women personnel will be reported elsewhere. The upcoming paper on interdisciplinary aspects of physics contains further indicators, such as the proportions of physicists among graduation, activity and scientific degree fields, retention rates for major disciplines, and fractions of scientific degrees in theoretical, experimental and applied physics /23/.

With the exception of special studies on field mobility /24/, the other materials are essentially national in scope and enable good comparisons. Almost historical data were presented about employment and professional experience before receiving pure physics PhD in Germany, 1896-1906 /25/. Another work was concerned with the fraction of graduate students who reported their interest in interface areas of physics /26/. Variances were found among mobility rates of scientists by disciplines, indicating a minimum for physicists /27,28/, but these figures may have changed substantially over the years elapsed. Different field retention rates from graduation to employment were analyzed for physics and other fields over the early 60´s /29/. Later on, a detailed evidence was acquired about migration (mobility) trends within physics subfields over a three-year span /30/ and the percentage of physicists who changed subfields was compared with the situation among mathematicians and chemists /31/. The effect of diversity in subject area for the members of Czechoslovak Physical Sci.Sect. was related to several other characteristics /32/. Another national study was concerned with the physics bachelor´s-degree recipients who had chosen a non-physics subject for study in graduate school /33/. In addition to several more annually published US reports /34/ and other studies /35,36/, statistics were assembled on enrollments in introductory physics courses designed for physical science,engineering, biology, health-related and other majors /37/. After a probe into mobility patterns of nuclear physicists in the early 60´s /38/, there appeared a detailed report on mobility within US nuclear physics community /39/, and a study on graduate training in optics which revealed a heavy inflow into this subfield with its positive and negative consequences /40/. The multiplicity of disciplines involved in physicists´ career, field mobility of physics manpower and correlation between subfields of PhD and subfield of activity was again documented a short time ago with emphasis on opportunities in industry/41/. A more general study /42/ suggested that there existed connections between mobility in science and the means by which individual researchers form new concepts. We shall review most of these quantitative approaches on another occasion.

Table 2: Percentage of creative staff by graduation and activity fields

PHYSICS

graduat.field	MP	Ge	Ch	Bi	Te	So	Oo
Ma	2	-	-	-	-	-	-
Ph	50	-	-	-	1	1	-
Ge	-	-	-	-	-	-	-
Ch	-	-	-	-	2	-	-
Bi	-	-	-	-	-	-	-
Te	23	-	1	-	8	-	5
Me	1	-	1	-	-	-	-
So	1	-	-	-	-	-	1
Oo	-	-	-	-	1	-	3

SOLID STATE PHYSICS

graduat.field	MP	Ge	Ch	Bi	Te	So	Oo
Ma	3	-	-	-	-	-	-
Ph	41	-	1	-	1	1	4
Ge	2	-	-	-	-	-	-
Ch	2	-	6	-	1	1	-
Bi	-	-	-	-	-	-	-
Te	15	-	5	-	7	-	3
Me	-	-	1	-	-	-	-
So	-	-	-	-	-	3	-
Oo	-	-	-	-	-	3	-

INSTRUMENTS

graduat.field	MP	Ge	Ch	Bi	Te	So	Oo
Ma	-	-	-	-	-	-	-
Ph	9	-	-	-	2	-	3
Ge	-	-	-	-	-	-	-
Ch	-	-	-	-	-	-	-
Bi	-	-	-	-	-	-	-
Te	5	-	3	-	57	-	10
Me	-	-	-	-	-	-	-
So	-	-	-	-	-	-	3
Oo	2	-	-	-	-	-	5

NUCLEAR PHYSICS

graduat.field	MP	Ge	Ch	Bi	Te	So	Oo
Ma	-	-	-	-	-	-	-
Ph	59	-	-	-	1	-	6
Ge	-	-	-	-	-	-	-
Ch	-	-	1	-	-	-	-
Bi	-	-	-	-	-	-	-
Te	5	-	1	-	24	-	-
Me	-	-	-	-	-	-	-
So	1	-	-	-	-	-	2
Oo	-	-	-	-	-	-	2

PLASMA PHYSICS

graduat.field	MP	Ge	Ch	Bi	Te	So	Oo
Ma	-	-	-	-	-	-	-
Ph	49	-	-	-	-	-	3
Ge	-	-	-	-	-	-	-
Ch	-	-	-	-	-	-	-
Bi	-	-	-	-	-	-	-
Te	41	-	-	-	-	-	3
Me	-	-	-	-	-	-	-
So	-	-	-	-	-	-	3
Oo	-	-	-	-	-	-	3

RADIATION DOSIMETRY

graduat.field	MP	Ge	Ch	Bi	Te	So	Oo
Ma	-	-	-	-	-	-	-
Ph	17	-	-	-	-	-	-
Ge	-	-	-	-	-	-	-
Ch	6	-	6	-	-	-	-
Bi	-	-	-	-	-	-	-
Te	22	-	17	-	6	-	11
Me	-	-	-	-	-	-	-
So	-	-	-	-	-	6	-
Oo	11	-	-	-	-	-	-

ASTRONOMY

graduat.field	MP	Ge	Ch	Bi	Te	So	Oo
Ma	1	-	-	-	1	-	-
Ph	46	-	-	-	-	-	6
Ge	-	-	-	-	-	-	-
Ch	-	-	-	-	-	-	-
Bi	-	-	-	-	-	-	-
Te	12	-	-	-	14	-	1
Me	-	-	-	-	-	-	-
So	3	-	-	-	-	-	7
Oo	-	-	-	-	-	-	7

GEOPHYSICS

graduat.field	MP	Ge	Ch	Bi	Te	So	Oo
Ma	6	-	-	-	-	-	1
Ph	45	-	-	-	2	-	6
Ge	1	3	-	-	-	-	-
Ch	-	-	-	-	-	-	-
Bi	-	-	-	-	-	-	-
Te	3	-	-	-	29	-	-
Me	-	-	-	-	-	-	-
So	-	-	-	-	-	2	-
Oo	-	-	-	-	-	-	-

PHYSICS OF ATMOSPHERE

graduat.field	MP	Ge	Ch	Bi	Te	So	Oo
Ma	-	-	-	-	-	-	-
Ph	77	-	-	-	-	-	-
Ge	-	-	-	-	-	-	-
Ch	-	-	-	-	14	-	-
Bi	-	-	-	-	-	-	-
Te	9	-	-	-	-	-	-
Me	-	-	-	-	-	-	-
So	-	-	-	-	-	-	-
Oo	-	-	-	-	-	-	-

RADIOTECH.ELECTRONICS

graduat.field	MP	Ge	Ch	Bi	Te	So	Oo
Ma	1	-	-	-	-	-	-
Ph	12	-	-	-	5	-	1
Ge	-	-	-	-	-	-	-
Ch	1	-	6	-	-	-	-
Bi	-	-	-	-	-	-	-
Te	5	-	6	-	56	-	5
Me	-	-	-	-	-	-	-
So	-	-	-	-	-	-	-
Oo	-	-	-	-	-	-	3

PHYSICAL METALLURGY

graduat.field	MP	Ge	Ch	Bi	Te	So	Oo
Ma	-	-	-	-	2	-	-
Ph	1	-	-	-	17	-	7
Ge	-	-	1	-	-	-	-
Ch	-	-	-	-	7	-	1
Bi	-	-	-	-	-	-	-
Te	-	-	-	-	52	-	5
Me	-	-	-	-	-	-	-
So	-	-	-	-	1	-	-
Oo	-	-	-	-	-	-	5

PHYSICAL CHEMISTRY

graduat.field	MP	Ge	Ch	Bi	Te	So	Oo
Ma	-	-	-	-	-	-	-
Ph	-	-	6	-	-	-	1
Ge	-	-	-	-	-	-	-
Ch	-	-	52	-	-	-	6
Bi	-	-	-	-	-	-	-
Te	-	-	25	-	-	-	2
Me	-	-	2	-	-	-	-
So	-	-	-	-	-	-	-
Oo	-	-	-	-	-	-	6

BIOPHYSICS

graduat.field	MP	Ge	Ch	Bi	Te	So	Oo
Ma	-	-	-	-	-	-	-
Ph	5	-	1	1	-	-	1
Ch	-	-	12	-	-	-	4
Bi	-	-	-	20	-	-	16
Te	-	-	4	-	-	-	1
Ag	-	-	-	1	-	-	3
Me	-	-	1	24	-	-	-
So	-	-	-	-	-	-	3
Oo	-	-	-	-	-	-	3

MATHEMATICS,PHYSICS

graduat.field	MP	Ge	Ch	Bi	Te	So	Oo
Ma	34	-	-	-	-	-	-
Ph	50	-	-	-	-	-	-
Ch	1	-	1	-	-	-	-
Bi	-	-	-	-	-	-	-
Te	1	-	-	-	-	-	-
Ag	-	-	-	-	-	-	-
Me	-	-	-	-	-	-	-
So	5	-	-	-	-	10	-
Oo	-	-	-	-	-	-	-

NUCL+PHYS.ENGINEERING

graduat.field	MP	Ge	Ch	Bi	Te	So	Oo
Ma	12	-	-	-	1	-	-
Ph	27	-	-	-	4	-	-
Ch	-	-	9	-	-	-	-
Bi	-	-	-	-	-	-	-
Te	12	-	4	-	24	-	-
Ag	-	-	-	-	-	-	-
Me	-	-	-	-	-	-	-
So	-	-	-	-	-	7	-
Oo	-	-	-	-	-	-	-

Table 3: Percentage of scientists by graduation and CSc/DrSc degree fields

PHYSICS

graduat.field	Ma	Ph	As Ge	Ch	Bi	Te	So
Ma	-	-	-	-	-	-	-
Ph	-	68	-	-	-	-	-
Ge	-	-	-	-	-	-	-
Ch	-	-	-	4	-	-	-
Bi	-	-	-	-	-	-	-
Te	-	-	-	-	-	-	-
Me	-	-	-	-	-	-	-
So	-	-	-	-	-	-	-

SOLID STATE PHYSICS

graduat.field	Ma	Ph	As Ge	Ch	Bi	Te	So
Ma	2	-	-	-	-	-	-
Ph	-	63	2	2	-	-	-
Ge	-	-	-	-	-	-	-
Ch	-	-	-	7	-	5	-
Bi	-	-	-	-	-	-	-
Te	-	15	-	-	-	5	-
Me	-	-	-	-	-	-	-
So	-	-	-	-	-	-	-

INSTRUMENTS

graduat.field	Ma	Ph	As Ge	Ch	Bi	Te	So
Ma	-	-	-	-	-	-	-
Ph	-	12	-	-	-	-	-
Ge	-	-	-	-	-	-	-
Ch	-	-	-	-	-	-	-
Bi	-	-	-	-	-	-	-
Te	-	12	-	-	-	77	-
Me	-	-	-	-	-	-	-
So	-	-	-	-	-	-	-

NUCLEAR PHYSICS

graduat.field	Ma	Ph	As Ge	Ch	Bi	Te	So
Ma	-	-	-	-	-	-	-
Ph	-	80	-	-	-	2	-
Ge	-	-	-	-	-	-	-
Ch	-	-	-	-	-	-	-
Bi	-	-	-	-	-	-	-
Te	-	9	-	2	-	5	-
Me	-	-	-	-	-	-	-
So	-	-	-	-	-	-	5

PLASMA PHYSICS

graduat.field	Ma	Ph	As Ge	Ch	Bi	Te	So
Ma	-	-	-	-	-	-	-
Ph	-	56	-	-	-	-	-
Ge	-	-	-	-	-	-	-
Ch	-	-	-	-	-	-	-
Bi	-	-	-	-	-	-	-
Te	-	25	-	-	-	19	-
Me	-	-	-	-	-	-	-
So	-	-	-	-	-	-	-

RADIATION DOSIMETRY

graduat.field	Ma	Ph	As Ge	Ch	Bi	Te	So
Ma	-	-	-	-	-	-	-
Ph	-	17	-	-	-	-	-
Ge	-	-	-	-	-	-	-
Ch	-	-	-	33	-	-	-
Bi	-	-	-	-	-	-	-
Te	-	17	-	17	-	17	-
Me	-	-	-	-	-	-	-
So	-	-	-	-	-	-	-

ASTRONOMY

graduat.field	Ma	Ph	As Ge	Ch	Bi	Te	So
Ma	-	-	-	-	-	-	-
Ph	-	13	73	-	-	-	-
Ge	-	-	-	-	-	-	-
Ch	-	-	-	-	-	-	-
Bi	-	-	-	-	-	-	-
Te	-	3	10	-	-	-	-
Me	-	-	-	-	-	-	-
So	-	-	-	-	-	-	-

GEOPHYSICS

graduat.field	Ma	Ph	As Ge	Ch	Bi	Te	So
Ma	-	-	-	-	-	-	-
Ph	-	-	70	-	-	-	-
Ge	-	-	3	-	-	-	-
Ch	-	-	-	-	-	-	-
Bi	-	-	-	-	-	-	-
Te	-	-	27	-	-	-	-
Me	-	-	-	-	-	-	-
So	-	-	-	-	-	-	-

PHYSICS OF ATMOSPHERE

graduat.field	Ma	Ph	As Ge	Ch	Bi	Te	So
Ma	-	-	-	-	-	-	-
Ph	-	-	83	-	-	-	-
Ge	-	-	17	-	-	-	-
Ch	-	-	-	-	-	-	-
Bi	-	-	-	-	-	-	-
Te	-	-	-	-	-	-	-
Me	-	-	-	-	-	-	-
So	-	-	-	-	-	-	-

RADIOTECH.ELECTRONICS

graduat.field	Ma	Ph	As Ge	Ch	Bi	Te	So
Ma	-	-	-	-	-	-	-
Ph	-	10	-	-	-	3	-
Ge	-	-	-	-	-	-	-
Ch	-	-	-	5	-	-	-
Bi	-	-	-	-	-	-	-
Te	-	13	-	5	-	64	-
Me	-	-	-	-	-	-	-
So	-	-	-	-	-	-	-

PHYSICAL METALLURGY

graduat.field	Ma	Ph	As Ge	Ch	Bi	Te	So
Ma	-	-	-	-	-	-	-
Ph	-	18	-	-	-	11	-
Ge	-	-	-	-	-	-	-
Ch	-	-	-	4	-	-	-
Bi	-	-	-	-	-	-	-
Te	-	4	-	4	-	61	-
Me	-	-	-	-	-	-	-
So	-	-	-	-	-	-	-

PHYSICAL CHEMISTRY

graduat.field	Ma	Ph	As Ge	Ch	Bi	Te	So
Ma	-	-	-	-	-	-	-
Ph	-	-	-	5	-	-	-
Ge	-	-	-	-	-	-	-
Ch	-	-	-	64	-	-	-
Bi	-	-	-	-	-	-	-
Te	-	-	-	25	-	2	-
Me	-	-	-	4	-	-	-
So	-	-	-	-	-	-	-

BIOPHYSICS

graduat.field	Ma	Ph	As Ge	Ch	Bi	Te	So
Ma	-	-	-	-	-	-	-
Ph	-	-	-	-	13	-	-
Ge	-	-	-	-	-	-	-
Ch	-	-	-	3	16	-	-
Bi	-	-	-	3	23	-	-
Te	-	-	-	-	-	-	-
Me	-	-	-	-	36	-	6
So	-	-	-	-	-	-	-

MATHEMATICS,PHYSICS

graduat.field	Ma	Ph	As Ge	Ch	Bi	Te	So
Ma	40	1	-	-	-	-	-
Ph	-	45	6	-	-	-	1
Ge	-	-	-	-	-	-	-
Ch	-	1	-	-	-	-	-
Bi	-	-	-	-	-	-	-
Te	-	1	-	-	-	-	-
Me	-	-	-	-	-	-	-
So	-	3	-	-	-	-	3

NUCL+PHYS.ENGINEERING

graduat.field	Ma	Ph	As Ge	Ch	Bi	Te	So
Ma	8	-	-	-	-	-	-
Ph	-	19	-	-	-	-	-
Ge	-	-	-	-	-	-	-
Ch	-	-	-	17	-	-	-
Bi	-	-	-	-	-	-	-
Te	-	25	-	8	-	22	-
Me	-	-	-	-	-	-	-
So	-	-	-	-	-	-	-

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