Physical dimension of Sciences

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Abstract

I propose a classification of scientific fields by the place that their typical objects occupy in three-dimensional space of physical dimensions: length, mass and time - on a logarithmic scale. Classification includes some areas of physics, chemistry, biology and geology, as well as history. Natural interdisciplinary connections are established , as well as the gaps - the region of space in which there are no objects of modern science.

1 Why physical dimensions?

The exponential growth of information in the recent 20 years is connected with the development of Internet. The complexity of finding information in science frequently becomes comparable with the direct researches. The abstract look at this information ocean in spirit of well known DIKW pyramid (data, information, knowledge, wisdom - see [3],[4],[5]) is now not sufficient.

Systematization of the Science is required to obtain fundamentally new knowledge about nature which can not be obtained within narrow areas. Explosive growth in the number of scientific publications and citations necessitates a well-defined binding of disciplines to the real world. I attempt to show how such a systematization may look from the view point of physics. Most of the scientific disciplines has its typical object of study, which has a certain size, weight and time of existence, so that we can identify a discipline with some area in three-dimensional space, with the coordinates of the form "centimeters", "grams" and "seconds".

Such discipline we call metrizable. For example, atomic physics - metrizable. It deals with the atoms typical of which - the hydrogen atom has a size of about one Angstrom and weight of about 10^{-24} grams. Processes investigated in atomic physics, for example, the electron transition with the emission of a photon have a characteristic duration about $10^{-12} - 10^{-11}$ second. We can associate with atomic

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physics cuboid (parallelepiped with edges parallel to the coordinate axes) sized $10^{-8}-10^{-7}, 10^{-24}-10^{-21}, 10^{-12}-10^{-11}$. That is, metrizable scientific discipline can be visualized as the area in three-dimensional spacewhere on the coordinate axes plotted accordingly, centimeters, grams and seconds that characterize the typical subject matter of this discipline. However, this approach is inconvenient in two ways. First, areas are very much different from each other and the picture will not be visible. Secondly, variation of objects within a field will be very large. For example, an oxygen atom will be more than ten times as hydrogen, and if we consider the excited state, then one hydrogen atom in the different states may vary by several times. Therefore it is necessary to represent the region on a logarithmic scale rather than an absolute scale. For example, atomic physics then will be associated with the cuboid $-8:-7, -24:-21, -12:-11$.

Logarithmic scale solves mentioned difficulties. Even if we make a mistake ten times in assessing absolute size of the object of research, in the logarithmic dimensional lattice it will lead to an error of only one unit, which will hardly effect on the overall visual picture or the conclusions that are made based on it.

2 Dimensional classification of natural science and history

I started from the classification shown on the map of Russian science (MRS) [1], meaning not its content, to which there are many complaints, and the universal nature of classification itself.

Note also that the MRS is not complete classification of even basic scientific areas. For example,MRS does not contain such clearly metrizable disciplines as quantum physics and anthropology. Physical measuring can not immediately reach all presented in MRS areas, so using some other, more complete system would not affect significantly to our conclusions. The binding of scientific disciplines to the dimensional lattice looks like this:

- **Physics**: Physics of elementary particles :-20:-12, -25:-23, -20:3, nuclear physics -13:-12,-24:-21,-22:-21, acoustics 3:4,0:-2,-2:-4, atomic physics -8:-7,-24:-21,-12:-11, molecular and chemical physics & physical chemistry -7,-23:-21,-12:-7, optics -4:-3,0,-8:-7, astronomy and astrophysics 9:20,23:40,5:18, physics of liquid, gas and plasma 0:4,-3:9,-2:2, physics of condensed state -4:2,-4:3,-7:2.

- **Chemistry**: electrochemistry -2:0,-3:0,-1:2, analytical chemistry -3:-1,-3:0,-1:2, crystallography -7:-1,-23:-3,-3:10, inorganic chemistry -8:-6,-24:-20,-9:-7, organic chemistry -7:-5,-22:-20,-8:-6, polymers -5:0,-20:-1,-6:3.

- **Biology**: mycology -3:1,-4:2,2:4, microbiology -6:-4,-21:-12,-3:3, botany -1:3,-2:7,4:9, ornithology 0:2,0:4,4:5, biochemistry and molecular biology -7:-6,-21:-

20,-8:-7, ecology 6:9,12:16,7:10, cytology -4,-12,2:9, virology -7:-6,-20,1:3, zoology 1:3,2:7,7:9, entomology -2:1,-6:1,7.

- **Various geology**: oceanography 7:9,13:14,13:14, paleontology 0:3,0:4,13:16, geology 0:9,24:25,16:17, meteorology and atmospheric sciences 9,13,6:7, mineralogy -1:1,-2:3,13:16,

- **History**: history 6:9,10:14,7.5:11.

This classification - approximate, but not arbitrary. It can be clarified by analyzing the content of scientific papers on these subjects (in the exact natural sciences, for example, [2]) and specifying to which specific object the considered method are applied. For example, the history deals with groups of people about a hundred thousand to a billion, so the logarithm of mass varies from 10 to 14; historical events tend to affect the distance of about ten to ten thousand kilometers (logarithmic scale variation from 6 to 9), and the time from one year untill about a thousand years (7.5:11). Events smaller scale (like a disease Of Vladimir Lenin) are of interest to history only due to obvious consequences that they imply in tagged scales (eg, the power struggle in the USSR), and therefore are not, in fact, the subject of history - here historians turn to other disciplines, such as ecology, psychology, or microbiology.

Figure 1 shows these areas in a single coordinate system. It can be seen that the physics of elementary particles and astronomy-astrophysics represent two extreme disciplines indicating the limits of known Nature, and other disciplines are located between them. The total area occupied by metrizable disciplines, is no more than a few per cent of the total volume.

It is interesting to trace the area of ??intersection of different disciplines. Interdisciplinary index (Ii) of a point l, m, t in the dimensional space is the number of disciplines, which areas contain a given point. Figure 2 shows the sequence of the region with $Ii = 2, 3, 4, 5, 6$. Disciplines are identified by the first two - four letters of the name. For example, the class $Ii \geq 5$ contains the following combinations of disciplines: *an co cr el po, co el li mico po, an co cr el mico, an co el mico po, an co cr el mico po, co cr el mico po, an co cr mico po, an cr el mico po*, the class $Ii = 6$ (maximal at the given index) contains only one combination: *an co cr el mico po.*

3 Conclusions

Figure 1 shows how insignificant volume of the entire space is occupied by the metrizable part of modern science. If we figured, in addition to science, also the directions of the human activity (technologies, etc.), the covered area would not change much, because applications in dimensional grid are grouped around (and even inside) tagged fundamental domains. This indicates a superficial penetration of the modern civilization into the world around us.

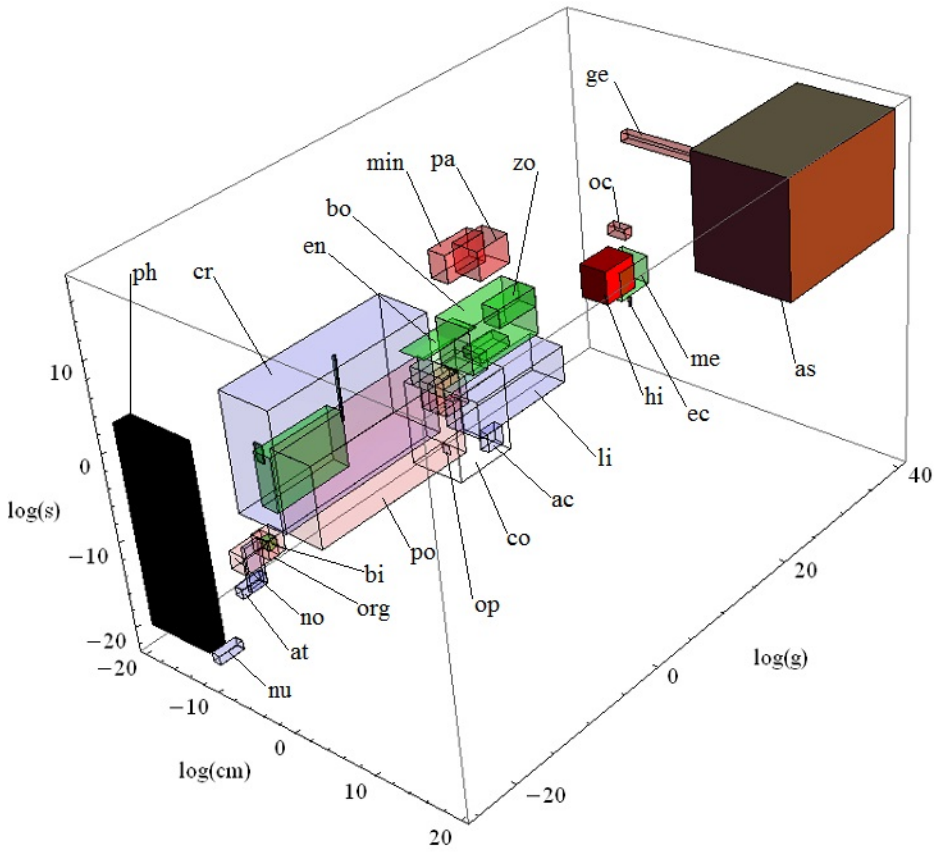

Figure 1: Dimension classification of disciplines

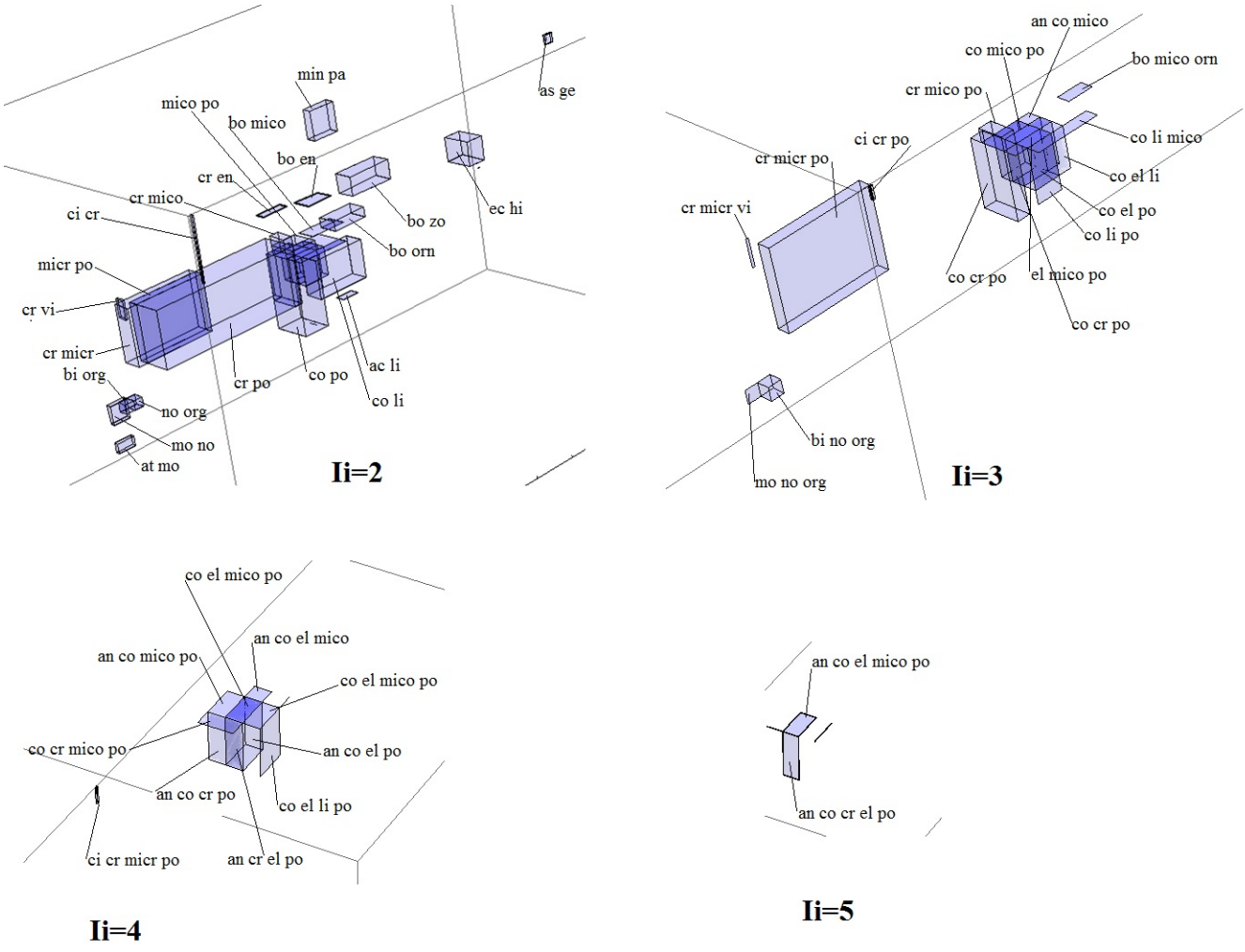

Figure 2: Inter-discipline index ranking

If $Ii > 1$ for some disciplines, it says that the methods of one discipline could potentially be applied to the study of objects belonging to the other discipline. For example, the presence of the intersection between the history and the ecology suggests the possibility of reliable explanations of historical events through environmental causes. Resettlement of people from the Sahara north was associated with desertification of large areas of previously fertile land. But if the possible causes of historical events related, for example to microbiology, one can hardly expect an equally reliable explanations. Were the tumultuous events in the Soviet Union in the 20s consequence of Lenin's illness and whether the infection alone caused his death?Here nothing definite can be said: the history and microbiology have no points of intersection in dimensional grid; the considerable space separates them, and methods of one of these disciplines do not apply to the other directly.

Interesting areas has a high index of interdisciplinarity $Ii > 1$, because here fundamentally different methods can be applied to the same objects. For example, in the area of maximum $Ii = 6$ got along with electrochemistry, crystallography, analytical chemistry, condensed matter physics and polymer also mycology.

Finally, the very distinction of disciplines to metrizable and non-metrizable is nontrivial. This division does not correspond to the conventional division into natural and humanitarian discipline, because, for example biophysics is not easy metrizable, the basic natural science - mathematics is not metrizable at all, whereas humanitarian history, on the contrary, is well-metrizable.

References

[1] Map of the Russian Science (Rus): http://mapofscience.ru/

[2] Archive of electronic preprints (mathematics, physics, computer science, biology) http://xxx.lanl.gov

[3] Rowley, Jennifer (2007). "The wisdom hierarchy: representations of the DIKW hierarchy". Journal of Information Science 33 (2): 163180.

[4] Zins, Chaim (22 January 2007). "Conceptual Approaches for Defining Data, Information, and Knowledge", Journal of the American Society for Information Science and Technology (Wiley Periodicals, Inc.) 58 (4): 479493

[5] Zeleny, Milan (2005). Human Systems Management: Integrating Knowledge, Management and Systems. World Scientific. pp. 1516