

# Penguin Dictionary of Physics, the fourth edition, by John Cullerne and the Graphical Law

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## Abstract

We study the Penguin Dictionary of Physics, the fourth edition, by John Cullerne. We draw the natural logarithm of the number of entries, normalised, starting with a letter vs the natural logarithm of the rank of the letter, normalised. We conclude that the Dictionary can be characterised by BP(4,  $\beta H = 0.01$ ), i.e. the Bethe-Peierls curve in the presence of four nearest neighbours and little external magnetic field,  $\beta H = 0.01$ .  $\beta$  is  $\frac{1}{k_B T}$  where, T is temperature and  $k_B$  is the tiny Boltzmann constant.

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## I. INTRODUCTION

'A really useful reference book for anyone who wants to follow developments in our understanding of the universe' Stephen Hawking, about the Penguin Dictionary of Physics by John Cullerne, [1].

Magnetic field is omnipresent in the universe. We study magnetic field pattern behind the entries of this dictionary, [1], in this article. We count all the entries one by one to probe for the magnetic field pattern. We have started considering magnetic field pattern in [2], in the languages we converse with. We have studied there, a set of natural languages, [2] and have found existence of a magnetisation curve under each language. We have termed this phenomenon as the Graphical Law.

Then, we moved on to investigate into, [3], dictionaries of five disciplines of knowledge and found existence of a curve magnetisation under each discipline. This was followed by finding of the graphical law behind the bengali language,[4] and the basque language[5]. This was pursued by finding of the graphical law behind the Romanian language, [6], five more disciplines of knowledge, [7], Onsager core of Abor-Miri, Mising languages,[8], Onsager Core of Romanised Bengali language,[9], the graphical law behind the Little Oxford English Dictionary, [10], the Oxford Dictionary of Social Work and Social Care, [11], the Visayan-English Dictionary, [12], Garo to English School Dictionary, [13], Mursi-English-Amharic Dictionary, [14] and Names of Minor Planets, [15], A Dictionary of Tibetan and English, [16], Khasi English Dictionary, [17], Turkmen-English Dictionary, [18], Websters Universal Spanish-English Dictionary, [19], A Dictionary of Modern Italian, [20], Langenscheidt's German-English Dictionary, [21], Essential Dutch dictionary by G. Quist and D. Strik, [22], Swahili-English dictionary by C. W. Rechenbach, [23], Larousse Dictionnaire De Poche for the French, [24], the Onsager's solution behind the Arabic, [25], the graphical law behind Langenscheidt Taschenwörterbuch Deutsch-Englisch / Englisch-Deutsch, Völlige Neubearbeitung, [26], the graphical law behind the NTC's Hebrew and English Dictionary by Arie Comey and Naomi Tsur, [27], the graphical law behind the Oxford Dictionary Of Media and Communication, [28], the graphical law behind the Oxford Dictionary Of Mathematics, Penguin Dictionary Of Mathematics, [29], the Onsager's solution behind the Arabic Second part, [30], the graphical law behind the Penguin Dictionary Of Sociology, [31], behind the Concise Oxford Dictionary Of Politics, [32], a Dictionary Of Critical Theory by Ian Buchanan, [33],

the Penguin Dictionary Of Economics, [34], the Concise Gojri-English Dictionary by Dr. Rafeeq Anjum, [35], A Dictionary of the Kachin Language by Rev.O.Hanson, [36], A Dictionary Of World History by Edmund Wright, [37], Ekagi-Dutch-English-Indonesian Dictionary by J. Steltenpool, [38], A Dictionary of Plant Sciences by Michael Allaby, [39], respectively. The graphical law was pursued more in Along the side of the Onsager's solution, the Ekagi language ,[40], Along the side of the Onsager's solution, the Ekagi language-Part Three, [41], Oxford Dictionary of Biology by Robert S. Hine and the Graphical law, [42], A Dictionary of the Mikir Language by G. D. Walker and the Graphical law, [43], A Dictionary of Zoology by Michael Allaby and the Graphical Law, [44], Dictionary of all Scriptures and Myths by G. A. Gaskell and the Graphical Law, [45], Dictionary of Culinary Terms by Philippe Pilibossian and the Graphical law, [46], A Greek and English Lexicon by H.G.Liddle et al simplified by Didier Fontaine and the Graphical law, [47], Learner's Mongol-English Dictionary and the Graphical law, [48], Complete Bulgarian-English Dictionary and the Graphical law, [49], A Dictionary of Sindhi Literature by Dr. Motilal Jotwani and the Graphical Law, [50], respectively.

We describe how a graphical law is hidden within the Penguin Dictionary of Physics, the fourth edition, by John Cullerne, [1], in this article. The planning of the paper is as follows. We give an introduction to the standard curves of magnetisation of Ising model in the section II. In the section III, we describe the analysis of the Penguin Dictionary of Physics, the fourth edition, by John Cullerne, [1]. The section IV is comparison with A Dictionary of Zoology by Michael Allaby, [51]. The section V is Acknowledgment. The last section is Bibliography.

## II. MAGNETISATION

### A. Bragg-Williams approximation

Let us consider a coin. Let us toss it many times. Probability of getting head or, tale is half i.e. we will get head and tale equal number of times. If we attach value one to head, minus one to tale, the average value we obtain, after many tossing is zero. Instead let us consider a one-sided loaded coin, say on the head side. The probability of getting head is more than one half, getting tale is less than one-half. Average value, in this case, after many

tossing we obtain is non-zero, the precise number depends on the loading. The loaded coin is like ferromagnet, the unloaded coin is like para magnet, at zero external magnetic field. Average value we obtain is like magnetisation, loading is like coupling among the spins of the ferromagnetic units. Outcome of single coin toss is random, but average value we get after long sequence of tossing is fixed. This is long-range order. But if we take a small sequence of tossing, say, three consecutive tossing, the average value we obtain is not fixed, can be anything. There is no short-range order.

Let us consider a row of spins, one can imagine them as spears which can be vertically up or, down. Assume there is a long-range order with probability to get a spin up is two third. That would mean when we consider a long sequence of spins, two third of those are with spin up. Moreover, assign with each up spin a value one and a down spin a value minus one. Then total spin we obtain is one third. This value is referred to as the value of long-range order parameter. Now consider a short-range order existing which is identical with the long-range order. That would mean if we pick up any three consecutive spins, two will be up, one down. Bragg-Williams approximation means short-range order is identical with long-range order, applied to a lattice of spins, in general. Row of spins is a lattice of one dimension.

Now let us imagine an arbitrary lattice, with each up spin assigned a value one and a down spin a value minus one, with an unspecified long-range order parameter defined as above by  $L = \frac{1}{N}\sum_i \sigma_i$ , where  $\sigma_i$  is i-th spin, N being total number of spins. L can vary from minus one to one.  $N = N_+ + N_-$ , where  $N_+$  is the number of up spins,  $N_-$  is the number of down spins.  $L = \frac{1}{N}(N_+ - N_-)$ . As a result,  $N_+ = \frac{N}{2}(1 + L)$  and  $N_- = \frac{N}{2}(1 - L)$ . Magnetisation or, net magnetic moment,  $M$  is  $\mu\sum_i \sigma_i$  or,  $\mu(N_+ - N_-)$  or,  $\mu NL$ ,  $M_{max} = \mu N$ .  $\frac{M}{M_{max}} = L$ .  $\frac{M}{M_{max}}$  is referred to as reduced magnetisation. Moreover, the Ising Hamiltonian,[52], for the lattice of spins, setting  $\mu$  to one, is  $-\epsilon\sum_{n.n}\sigma_i\sigma_j - H\sum_i\sigma_i$ , where n.n refers to nearest neighbour pairs. The difference  $\Delta E$  of energy if we flip an up spin to down spin is, [53],  $2\epsilon\gamma\bar{\sigma} + 2H$ , where  $\gamma$  is the number of nearest neighbours of a spin. According to Boltzmann principle,  $\frac{N_-}{N_+}$  equals  $exp(-\frac{\Delta E}{k_B T})$ , [54]. In the Bragg-Williams approximation,[55],  $\bar{\sigma} = L$ , considered in the thermal average sense. Consequently,

$$\ln \frac{1+L}{1-L} = 2 \frac{\gamma\epsilon L + H}{k_B T} = 2 \frac{L + \frac{H}{\gamma\epsilon}}{\frac{T}{\gamma\epsilon/k_B}} = 2 \frac{L + c}{\frac{T}{T_c}} \quad (1)$$

where,  $c = \frac{H}{\gamma\epsilon}$ ,  $T_c = \gamma\epsilon/k_B$ , [56].  $\frac{T}{T_c}$  is referred to as reduced temperature.

Plot of  $L$  vs  $\frac{T}{T_c}$  or, reduced magnetisation vs. reduced temperature is used as reference curve. In the presence of magnetic field,  $c \neq 0$ , the curve bulges outward. Bragg-Williams is a Mean Field approximation. This approximation holds when number of neighbours interacting with a site is very large, reducing the importance of local fluctuation or, local order, making the long-range order or, average degree of freedom as the only degree of freedom of the lattice. To have a feeling how this approximation leads to matching between experimental and Ising model prediction one can refer to FIG.12.12 of [53]. W. L. Bragg was a professor of Hans Bethe. Rudolf Peierls was a friend of Hans Bethe. At the suggestion of W. L. Bragg, Rudolf Peierls following Hans Bethe improved the approximation scheme, applying quasi-chemical method.

### **B. Bethe-peierls approximation in presence of four nearest neighbours, in absence of external magnetic field**

In the approximation scheme which is improvement over the Bragg-Williams, [52],[53],[54],[55],[56], due to Bethe-Peierls, [57], reduced magnetisation varies with reduced temperature, for  $\gamma$  neighbours, in absence of external magnetic field, as

$$\frac{\ln \frac{\gamma}{\gamma-2}}{\ln \frac{factor-1}{factor^{\frac{\gamma-1}{\gamma}} - factor^{\frac{1}{\gamma}}}} = \frac{T}{T_c}; factor = \frac{\frac{M}{M_{max}} + 1}{1 - \frac{M}{M_{max}}}. \quad (2)$$

$\ln \frac{\gamma}{\gamma-2}$  for four nearest neighbours i.e. for  $\gamma = 4$  is 0.693. For a snapshot of different kind of magnetisation curves for magnetic materials the reader is urged to give a google search "reduced magnetisation vs reduced temperature curve". In the following, we describe data s generated from the equation(1) and the equation(2) in the table, I, and curves of magnetisation plotted on the basis of those data s. BW stands for reduced temperature in Bragg-Williams approximation, calculated from the equation(1). BP(4) represents reduced temperature in the Bethe-Peierls approximation, for four nearest neighbours, computed from the equation(2). The data set is used to plot fig.1. Empty spaces in the table, I, mean corresponding point pairs were not used for plotting a line.

BW	BW( $c=0.01$ )	BP( $4, \beta H = 0$ )	reduced magnetisation
0	0	0	1
0.435	0.439	0.563	0.978
0.439	0.443	0.568	0.977
0.491	0.495	0.624	0.961
0.501	0.507	0.630	0.957
0.514	0.519	0.648	0.952
0.559	0.566	0.654	0.931
0.566	0.573	0.7	0.927
0.584	0.590	0.7	0.917
0.601	0.607	0.722	0.907
0.607	0.613	0.729	0.903
0.653	0.661	0.770	0.869
0.659	0.668	0.773	0.865
0.669	0.676	0.784	0.856
0.679	0.688	0.792	0.847
0.701	0.710	0.807	0.828
0.723	0.731	0.828	0.805
0.732	0.743	0.832	0.796
0.756	0.766	0.845	0.772
0.779	0.788	0.864	0.740
0.838	0.853	0.911	0.651
0.850	0.861	0.911	0.628
0.870	0.885	0.923	0.592
0.883	0.895	0.928	0.564
0.899	0.918		0.527
0.904	0.926	0.941	0.513
0.946	0.968	0.965	0.400
0.967	0.998	0.965	0.300
0.987		1	0.200
0.997		1	0.100
1	1	1	0

TABLE I. Reduced magnetisation vs reduced temperature data s for Bragg-Williams approximation, in absence of and in presence of magnetic field,  $c = \frac{H}{\gamma\epsilon} = 0.01$ , and Bethe-Peierls approximation in absence of magnetic field, for four nearest neighbours.

### C. Bethe-peierls approximation in presence of four nearest neighbours, in presence of external magnetic field

In the Bethe-Peierls approximation scheme , [57], reduced magnetisation varies with reduced temperature, for  $\gamma$  neighbours, in presence of external magnetic field, as

$$\frac{\ln \frac{\gamma}{\gamma-2}}{\ln \frac{factor-1}{e^{\frac{2\beta H}{\gamma}} factor^{\frac{\gamma-1}{\gamma}} - e^{-\frac{2\beta H}{\gamma}} factor^{\frac{1}{\gamma}}}} = \frac{T}{T_c}; factor = \frac{\frac{M}{M_{max}} + 1}{1 - \frac{M}{M_{max}}}. \quad (3)$$

Derivation of this formula Ala [57] is given in the appendix of [7].

$\ln \frac{\gamma}{\gamma-2}$  for four nearest neighbours i.e. for  $\gamma = 4$  is 0.693. For four neighbours,

$$\frac{0.693}{\ln \frac{factor-1}{e^{\frac{2\beta H}{\gamma}} factor^{\frac{\gamma-1}{\gamma}} - e^{-\frac{2\beta H}{\gamma}} factor^{\frac{1}{\gamma}}}} = \frac{T}{T_c}; factor = \frac{\frac{M}{M_{max}} + 1}{1 - \frac{M}{M_{max}}}. \quad (4)$$

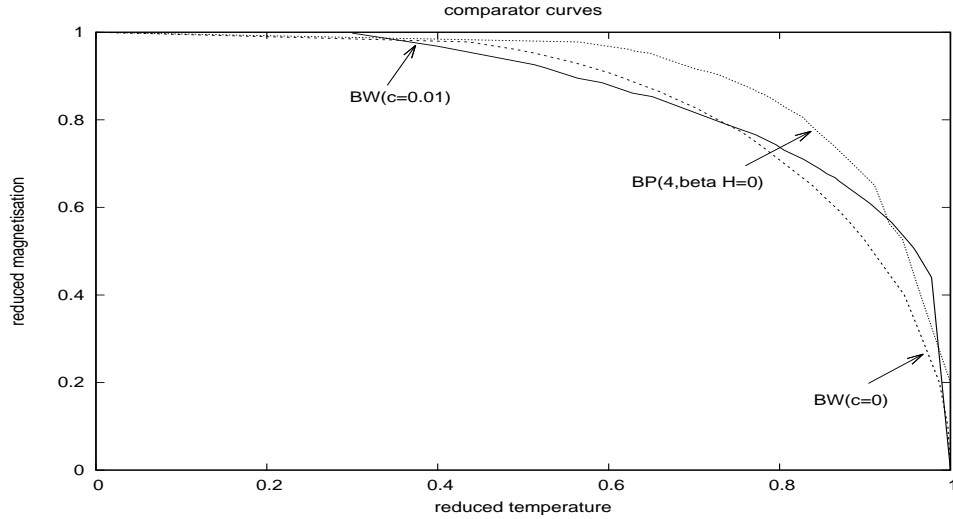


FIG. 1. Reduced magnetisation vs reduced temperature curves for Bragg-Williams approximation, in absence(dark) of and presence(inner in the top) of magnetic field,  $c = \frac{H}{\gamma\epsilon} = 0.01$ , and Bethe-Peierls approximation in absence of magnetic field, for four nearest neighbours (outer in the top).

In the following, we describe data s in the table, II, generated from the equation(4) and curves of magnetisation plotted on the basis of those data s. BP(m=0.03) stands for reduced temperature in Bethe-Peierls approximation, for four nearest neighbours, in presence of a variable external magnetic field, H, such that  $\beta H = 0.06$ . calculated from the equation(4). BP(m=0.025) stands for reduced temperature in Bethe-Peierls approximation, for four nearest neighbours, in presence of a variable external magnetic field, H, such that  $\beta H = 0.05$ . calculated from the equation(4). BP(m=0.02) stands for reduced temperature in Bethe-Peierls approximation, for four nearest neighbours, in presence of a variable external magnetic field, H, such that  $\beta H = 0.04$ . calculated from the equation(4). BP(m=0.01) stands for reduced temperature in Bethe-Peierls approximation, for four nearest neighbours, in presence of a variable external magnetic field, H, such that  $\beta H = 0.02$ . calculated from the equation(4). BP(m=0.005) stands for reduced temperature in Bethe-Peierls approximation, for four nearest neighbours, in presence of a variable external magnetic field, H, such that  $\beta H = 0.01$ . calculated from the equation(4). The data set is used to plot fig.2. Empty spaces in the table, II, mean corresponding point pairs were not used for plotting a line.

BP(m=0.03)	BP(m=0.025)	BP(m=0.02)	BP(m=0.01)	BP(m=0.005)	reduced magnetisation
0	0	0	0	0	1
0.583	0.580	0.577	0.572	0.569	0.978
0.587	0.584	0.581	0.575	0.572	0.977
0.647	0.643	0.639	0.632	0.628	0.961
0.657	0.653	0.649	0.641	0.637	0.957
0.671	0.667		0.654	0.650	0.952
	0.716			0.696	0.931
0.723	0.718	0.713	0.702	0.697	0.927
0.743	0.737	0.731	0.720	0.714	0.917
0.762	0.756	0.749	0.737	0.731	0.907
0.770	0.764	0.757	0.745	0.738	0.903
0.816	0.808	0.800	0.785	0.778	0.869
0.821	0.813	0.805	0.789	0.782	0.865
0.832	0.823	0.815	0.799	0.791	0.856
0.841	0.833	0.824	0.807	0.799	0.847
0.863	0.853	0.844	0.826	0.817	0.828
0.887	0.876	0.866	0.846	0.836	0.805
0.895	0.884	0.873	0.852	0.842	0.796
0.916	0.904	0.892	0.869	0.858	0.772
0.940	0.926	0.914	0.888	0.876	0.740
	0.929			0.877	0.735
	0.936			0.883	0.730
	0.944			0.889	0.720
	0.945				0.710
	0.955			0.897	0.700
	0.963			0.903	0.690
	0.973			0.910	0.680
				0.909	0.670
	0.993			0.925	0.650
		0.976	0.942		0.651
	1.00				0.640
		0.983	0.946	0.928	0.628
		1.00	0.963	0.943	0.592
			0.972	0.951	0.564
			0.990	0.967	0.527
			1.00	0.964	0.513
				1.00	0.500
					0.400
					0.300
					0.200
					0.100
					0

TABLE II. Bethe-Peierls approx. in presence of little external magnetic fields

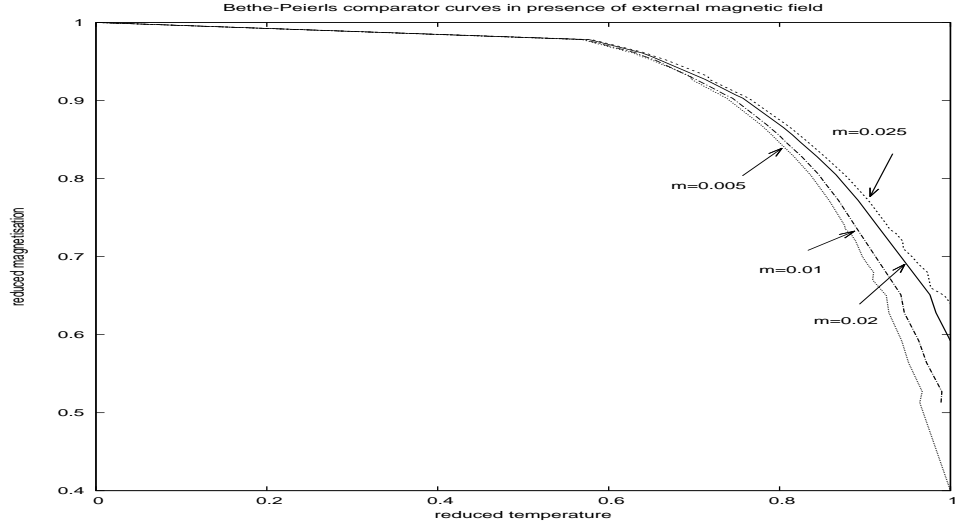


FIG. 2. Reduced magnetisation vs reduced temperature curves for Bethe-Peierls approximation in presence of little external magnetic fields, for four nearest neighbours, with  $\beta H = 2m$ .



A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
288	184	440	243	275	191	160	155	210	29	44	195	307	124	93	345	49	267	457	205	45	113	82	10	13	12

TABLE III. Entries of the Penguin Dictionary of Physics

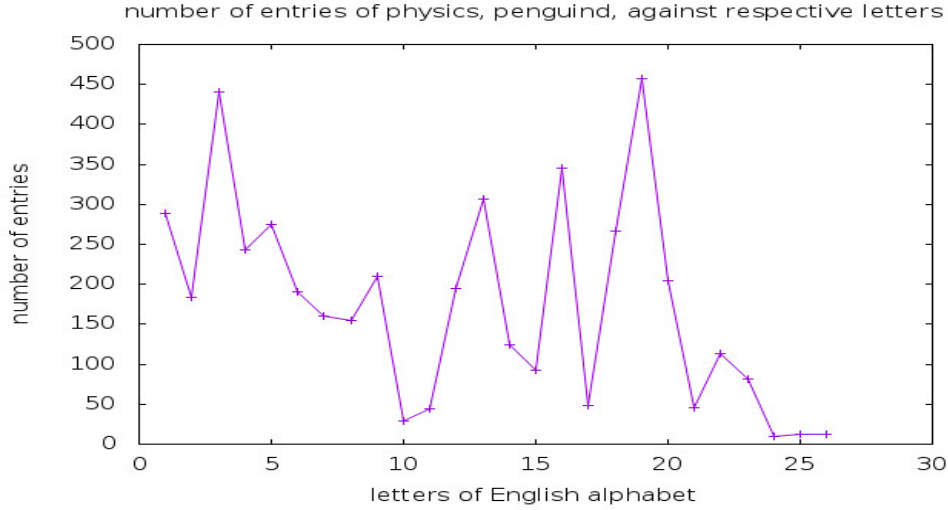


FIG. 3. The vertical axis is number of entries in the Penguin Dictionary of Physics,[1]. The horizontal axis is the letters of the English alphabet. Letters are represented by the sequence number in the alphabet.

### III. ANALYSIS OF THE PENGUIN DICTIONARY OF PHYSICS

In the Penguin Dictionary of Physics, fourth edition, by John Cullerne from Oxford University Press, [1], we have counted all the entries, one by one from the beginning to the end, starting with different letters. The result is the table, III. Highest number of entries, four hundred fifty seven, starts with the letter S followed by entries numbering four hundred forty beginning with C, three hundred forty five with the letter P etc. To visualise we plot the number of entries against respective letters in the dictionary sequence,[1] in the adjoining figure, fig.3. For the purpose of exploring graphical law, we assort the letters according to the number of entries, in the descending order, denoted by  $f$  and the respective rank, [58], denoted by  $k$ .  $k$  is a positive integer starting from one. Moreover, we attach a limiting rank,  $k_{lim}$ , and a limiting number of entries. The limiting rank is maximum rank plus one, here it is twenty seven and the limiting number of entries is one. As a result both  $\frac{\ln f}{\ln f_{max}}$  and  $\frac{\ln k}{\ln k_{lim}}$  varies from zero to one. Then we tabulate in the adjoining table,IV, and plot

k	lnk	lnk/lnk <sub>lim</sub>	f	lnf	lnf/lnf <sub>max</sub>	lnf/lnf <sub>next-max</sub>	lnf/lnf <sub>nnmax</sub>	lnf/lnf <sub>nnnmax</sub>
1	0	0	457	6.125	1	Blank	Blank	Blank
2	0.69	0.209	440	6.087	0.994	1	Blank	Blank
3	1.10	0.333	345	5.844	0.954	0.960	1	Blank
4	1.39	0.421	307	5.727	0.935	0.941	0.980	1
5	1.61	0.488	288	5.663	0.925	0.930	0.969	0.989
6	1.79	0.542	275	5.617	0.917	0.923	0.961	0.981
7	1.95	0.591	267	5.587	0.912	0.918	0.956	0.976
8	2.08	0.630	243	5.493	0.897	0.902	0.940	0.959
9	2.20	0.667	210	5.347	0.873	0.878	0.915	0.934
10	2.30	0.697	205	5.323	0.869	0.874	0.911	0.929
11	2.40	0.727	195	5.273	0.861	0.866	0.902	0.921
12	2.48	0.752	191	5.252	0.857	0.863	0.899	0.917
13	2.56	0.776	184	5.215	0.851	0.857	0.892	0.911
14	2.64	0.800	160	5.075	0.829	0.834	0.868	0.886
15	2.71	0.821	155	5.043	0.823	0.828	0.863	0.881
16	2.77	0.839	124	4.820	0.787	0.792	0.825	0.842
17	2.83	0.858	113	4.727	0.772	0.777	0.809	0.825
18	2.89	0.876	93	4.533	0.740	0.745	0.776	0.792
19	2.94	0.891	82	4.407	0.720	0.724	0.754	0.770
20	3.00	0.909	49	3.892	0.635	0.639	0.666	0.680
21	3.04	0.921	45	3.807	0.622	0.625	0.651	0.665
22	3.09	0.936	44	3.784	0.618	0.622	0.648	0.661
23	3.14	0.952	29	3.367	0.550	0.553	0.576	0.588
24	3.18	0.964	13	2.565	0.419	0.421	0.439	0.448
25	3.22	0.976	12	2.485	0.406	0.408	0.425	0.434
26	3.26	0.988	10	2.303	0.376	0.378	0.394	0.402
27	3.30	1	1	0	0	0	0	0

TABLE IV. The Penguin Dictionary of Physics entries: ranking, natural logarithm, normalisations

$\frac{\ln f}{\ln f_{max}}$  against  $\frac{\ln k}{\ln k_{lim}}$  in the figure fig.4. We then ignore the letter with the highest of entries, tabulate in the adjoining table,IV,and redo the plot, normalising the  $\ln fs$  with next-to-maximum  $\ln f_{next-max}$ , and starting from  $k = 2$  in the figure fig.5. Normalising the  $\ln fs$  with next-to-next-to-maximum  $\ln f_{nextnext-max}$ , we tabulate in the adjoining table,IV, and starting from  $k = 3$  we draw in the figure fig.6. Normalising the  $\ln fs$  with next-to-next-to-next-to-maximum  $\ln f_{nextnextnext-max}$  we record in the adjoining table,IV, and plot starting from  $k = 4$  in the figure fig.7. Similarly we obtain the figures up to the figure fig.9.

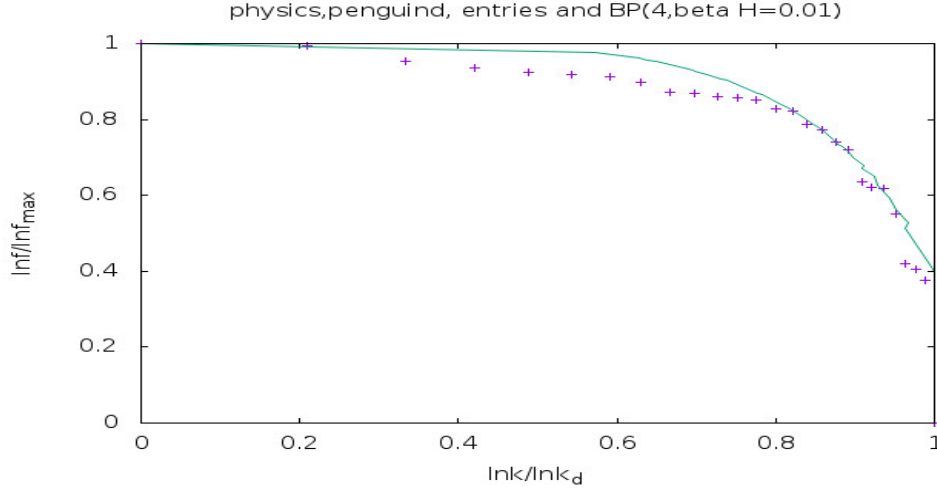


FIG. 4. The vertical axis is  $\frac{\ln f}{\ln f_{max}}$  and the horizontal axis is  $\frac{\ln k}{\ln k_{lim}}$ . The + points represent the entries of the Penguin Dictionary of Physics with the fit curve being the Bethe-Peierls curve in presence of four nearest neighbours and little external magnetic field,  $m = 0.005$  or,  $\beta H = 0.01$ .

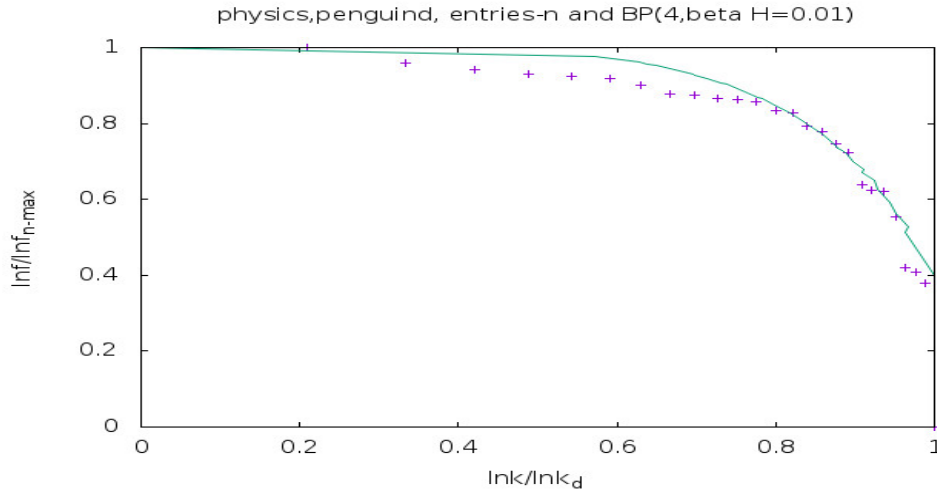


FIG. 5. The vertical axis is  $\frac{\ln f}{\ln f_{next-max}}$  and the horizontal axis is  $\frac{\ln k}{\ln k_{lim}}$ . The + points represent the entries of the Penguin Dictionary of Physics with the fit curve being the Bethe-Peierls curve in presence of four nearest neighbours and little external magnetic field,  $m = 0.005$  or,  $\beta H = 0.01$ .

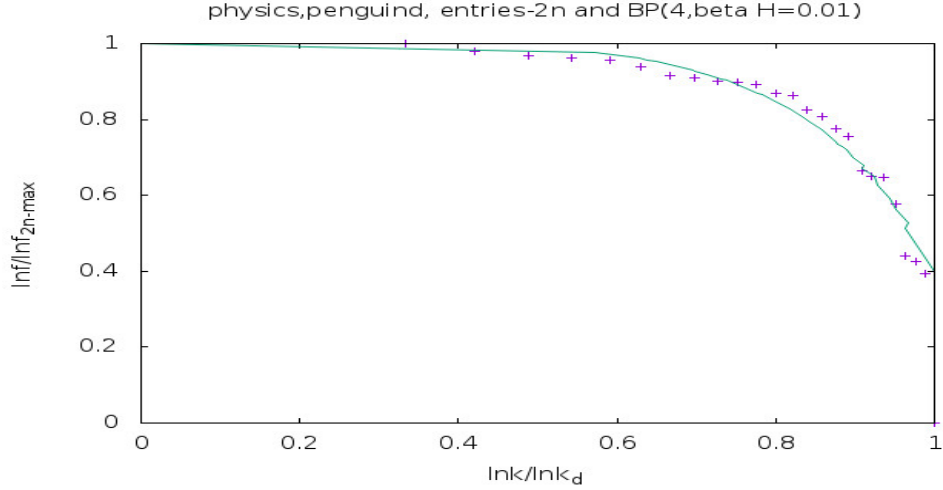


FIG. 6. The vertical axis is  $\frac{\ln f}{\ln f_{nextnext-max}}$  and the horizontal axis is  $\frac{\ln k}{\ln k_{lim}}$ . The + points represent the entries of the Penguin Dictionary of Physics with the fit curve being the Bethe-Peierls curve in presence of four nearest neighbours and little external magnetic field,  $m = 0.005$  or,  $\beta H = 0.01$ .

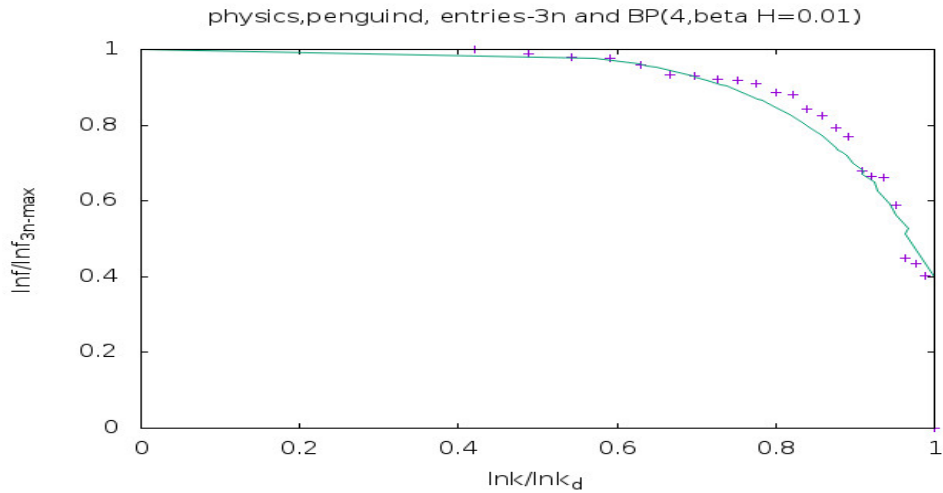


FIG. 7. The vertical axis is  $\frac{\ln f}{\ln f_{nextnextnext-max}}$  and the horizontal axis is  $\frac{\ln k}{\ln k_{lim}}$ . The + points represent the entries of the Penguin Dictionary of Physics with the fit curve being the Bethe-Peierls curve in presence of four nearest neighbours and little external magnetic field,  $m = 0.005$  or,  $\beta H = 0.01$ .

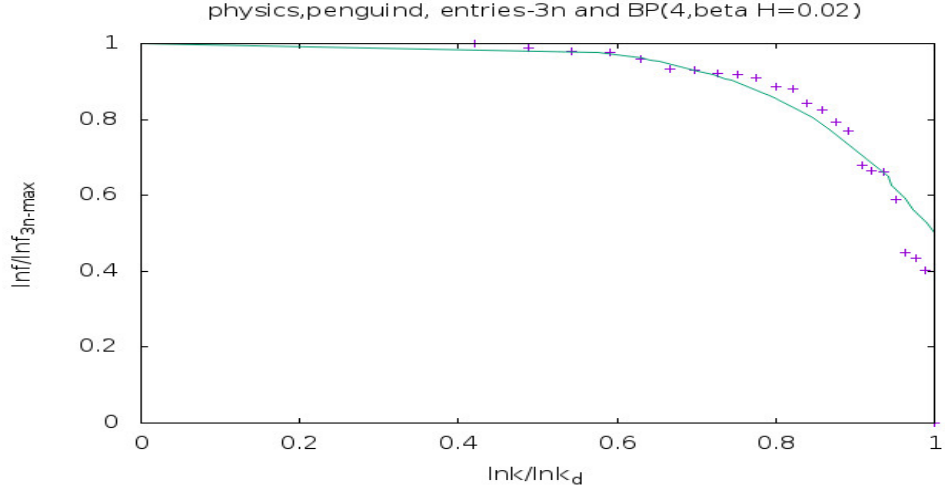


FIG. 8. The vertical axis is  $\frac{\ln f}{\ln f_{\text{nextnextnext-max}}}$  and the horizontal axis is  $\frac{\ln k}{\ln k_{\text{lim}}}$ . The + points represent the entries of the Penguin Dictionary of Physics with the fit curve being the Bethe-Peierls curve in presence of four nearest neighbours and little external magnetic field,  $m = 0.01$  or,  $\beta H = 0.02$ .

## A. conclusion

From the figures (fig.4-fig.8), we observe that there is a curve of magnetisation, behind the entries of the Penguin Dictionary of Physics,[1]. This is the magnetisation curve in the Bethe-Peierls approximation in the presence of four nearest neighbours and little external magnetic field  $\beta H = 0.01$ .

Moreover, the associated correspondence is,

$$\frac{\ln f}{\ln f_{2n-max}} \longleftrightarrow \frac{M}{M_{max}},$$
$$\ln k \longleftrightarrow T.$$

k corresponds to temperature in an exponential scale, [59]. As temperature decreases, i.e.  $\ln k$  decreases, f increases. The letters which are recording higher entries .., .., P, C, S which get enriched more and more, fall at lower and lower temperatures. This is a manifestation of cooling effect, as was first observed in [60], in another way.

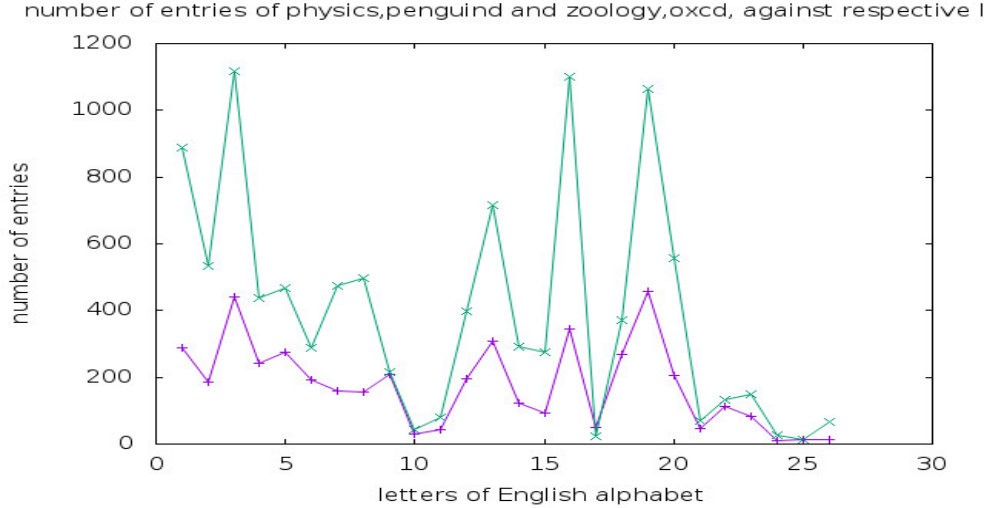


FIG. 9. The vertical axis is number of entries in the Penguin Dictionary of Physics,[1], in red, and the number of head entries of A Dictionary of Zoology by Michael Allaby,[51], in green. The horizontal axis is the letters of the English alphabet. Letters are represented by the sequence number in the alphabet.

#### IV. COMPARISON WITH A DICTIONARY OF ZOOLOGY BY MICHAEL ALLABY

We have studied, in [44], before, A Dictionary of Zoology by Michael Allaby from the Oxford University Press, [51]. The Dictionary was characterised  $BP(4, \beta H = 0.01)$  and  $\frac{\ln f}{\ln f_{max}}$  was also fit by  $BP(4, \beta H = 0.01)$  as in this case. To notice the similarity more between the two dictionaries, [1] and [51], we plot in the figure fig.9, both the set of entries. To make the similarity transparent, we multiply all the entries of the Penguin Dictionary of Physics by 2.5 and compare with the head entries of A Dictionary of Zoology by Michael Allaby in the figure fig.10. We see from the figures(fig.9, fig.10), barring one place entries of both the dictionaries go hand in hand.

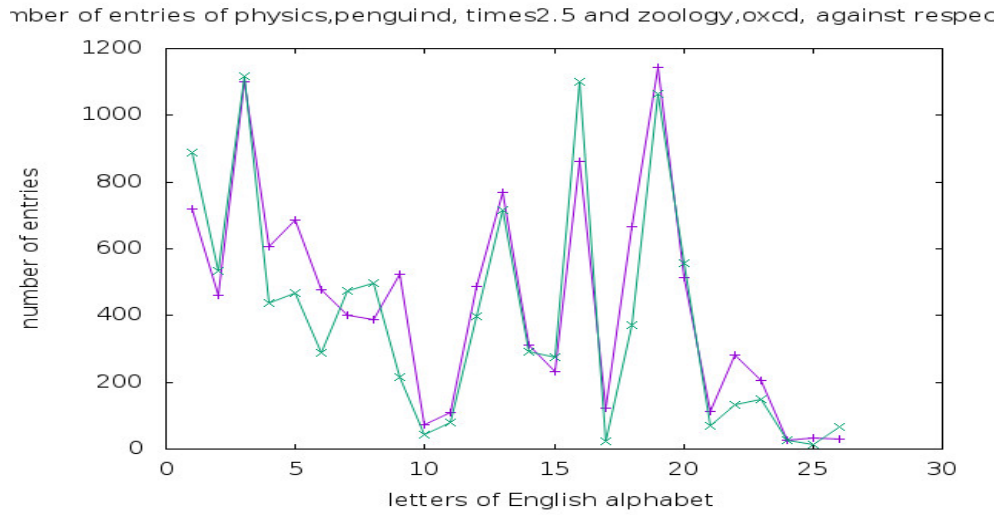


FIG. 10. The vertical axis is number of entries in the Penguin Dictionary of Physics,[1], times 2.5, in red, and the number of head entries of A Dictionary of Zoology by Michael Allaby,[51], in green. The horizontal axis is the letters of the English alphabet. Letters are represented by the sequence number in the alphabet.



## V. ACKNOWLEDGMENT

We have used gnuplot for plotting the figures in this paper.

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