

# Dictionary of Sports by Dr. S.K.Srivastava and Ms. Tanvangi Singh and the Graphical Law

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## Abstract

We study Dictionary of Sports by Dr. S.K.Srivastava and Ms. Tanvangi Singh. 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. a magnetisation curve for the Bethe-Peierls approximation of the Ising model with four nearest neighbours in the presence of external magnetic field,  $H$ , with  $\beta H = 0.01$ .  $\beta$  is  $\frac{1}{k_B T}$  where,  $T$  is temperature and  $k_B$  is the tiny Boltzmann constant.

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## I. INTRODUCTION

All of us are brought up amidst sports. We take a Dictionary of Sports, namely, Dictionary of Sports by Dr. S.K.Srivastava and Ms. Tanvangi Singh, [1]. We study magnetic field pattern behind the entries of this dictionary, [1], in this article. We count the entries 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, [3], into dictionaries of five disciplines of knowledge and found the existence of a curve of magnetisation under each discipline. This was followed by finding of the graphical law in references from [4] to [76].

We describe how the graphical law is hidden within Dictionary of Sports by Dr. S.K.Srivastava and Ms. Tanvangi Singh, [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 analysis of the entries of Dictionary of Sports by Dr. S.K.Srivastava and Ms. Tanvangi Singh [1]. The section IV 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,[78], 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, [79],  $2\epsilon\gamma\bar{\sigma} + 2H$ , where  $\gamma$  is the number of nearest neighbours of a spin. According to Boltzmann principle,  $\frac{N_-}{N_+}$  equals  $exp(-\frac{\Delta E}{k_B T})$ , [80]. In the Bragg-Williams approximation,[81],  $\bar{\sigma} = L$ , 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,  $c = \frac{H}{\gamma\epsilon}$ ,  $T_c = \gamma\epsilon/k_B$ , [82].  $\frac{T}{T_c}$  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 [79]. 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, [78],[79],[80],[81],[82], due to Bethe-Peierls, [83], 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.

reduced temperature, $\frac{T}{T_c}$				$\frac{M}{M_{max}}$ ,
BW(c=0)	BW(c=0.005)	BW(c=0.01)	BP(4, $\beta H = 0$ )	reduced magnetisation
0	0	0	0	1
0.435	0.437	0.439	0.563	0.978
0.439	0.441	0.443	0.568	0.977
0.491	0.493	0.495	0.624	0.961
0.501	0.504	0.507	0.630	0.957
0.514	0.517	0.519	0.648	0.952
0.559	0.562	0.565	0.654	0.931
0.566	0.569	0.573	0.7	0.927
0.584	0.587	0.590	0.7	0.917
0.601	0.604	0.607	0.722	0.907
0.607	0.610	0.613	0.729	0.903
0.653	0.658	0.661	0.770	0.869
0.659	0.663	0.666	0.773	0.865
0.669	0.674	0.678	0.784	0.856
0.679	0.684	0.688	0.792	0.847
0.701	0.705	0.709	0.807	0.828
0.723	0.728	0.732	0.828	0.805
0.732	0.736	0.743	0.832	0.796
0.753	0.758	0.766	0.845	0.772
0.779	0.784	0.788	0.864	0.740
0.838	0.844	0.853	0.911	0.651
0.850	0.858	0.864	0.911	0.628
0.870	0.877	0.885	0.923	0.592
0.883	0.891	0.899	0.928	0.564
0.899	0.908	0.918		0.527
0.905	0.914	0.926	0.941	0.513
0.944	0.956	0.968	0.965	0.400
		0.985		0.350
		0.998		0.310
0.969	0.985		0.965	0.300
	0.998			0.250
0.987			1	0.200
0.997			1	0.100
1			1	0

TABLE I. Datas for Reduced temperature[ for the Bragg-Williams approximation, in the absence (BW(c=0)) and in the presence (BW(c=0.005), BW(c=0.01)) of magnetic field,  $c = 0$ ,  $c = \frac{H}{\gamma\epsilon} = 0.005$ ,  $c = \frac{H}{\gamma\epsilon} = 0.01$  respectively and in the Bethe-Peierls approximation, BP(4, $\beta H=0$ ), in the absence of magnetic field, for four nearest neighbours] vs reduced magnetisation. Reduced temperature data set( say, data set BW(c=0)) is drawn along the x-axis and the corresponding Reduced magnetisation data set is drawn along the y-axis. In gnuplot the command is plot ".dat" using 1:2 with line; 1 standing for x-axis and 2 standing for y-axis datas.[For example, for drawing BW(c=0), ".dat" file, say denoted as "0.dat", contains BW(c=0) data set in first column and reduced magnetisation data set in second column. Moreover, after (0.944,0.400), next pair of points will be (0.969,0.300), then (0.987,0.200), .and so on in the "0.dat" file.]

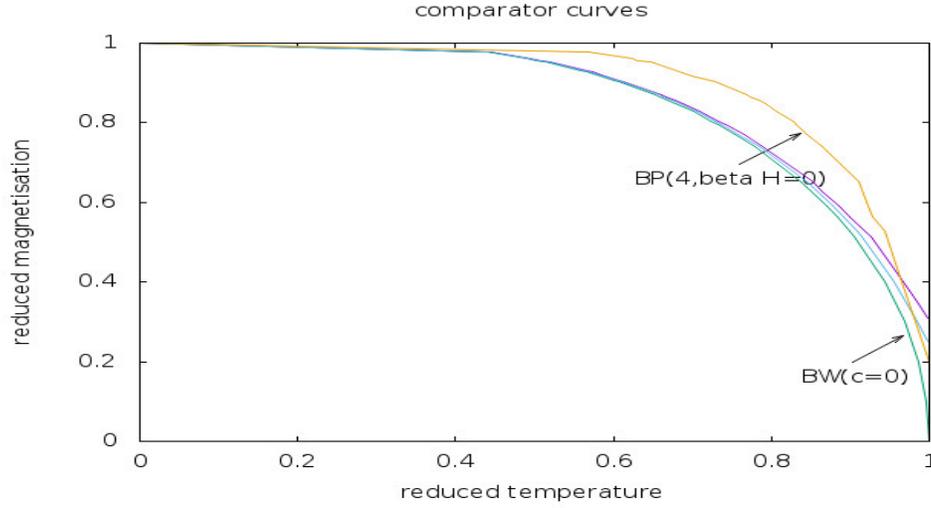


FIG. 1. Reduced magnetisation vs reduced temperature curves, for the Bragg-Williams approximation, in the absence (BW( $c=0$ )) and in the presence (BW( $c=0.005$ ), BW( $c=0.01$ )) of magnetic field,  $c = 0$ ,  $c = \frac{H}{\gamma\epsilon} = 0.005$ ,  $c = \frac{H}{\gamma\epsilon} = 0.01$ , outwards; and in the Bethe-Peierls approximation, BP(4, $\beta H=0$ ), in the absence of magnetic field, for four nearest neighbours (outer in the top).

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

In the Bethe-Peierls approximation scheme , [83], reduced magnetisation varies with reduced temperature, for  $\gamma$  neighbours, in presence of external magnetic field, as

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

Derivation of this formula Ala [83] 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,

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

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.

reduced temperature, $\frac{T}{T_c}$					$\frac{M}{M_{max}}$
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
				0.964	0.513
			1.00		0.500
				1.00	0.400
					0.300
					0.200
					0.100
					0

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

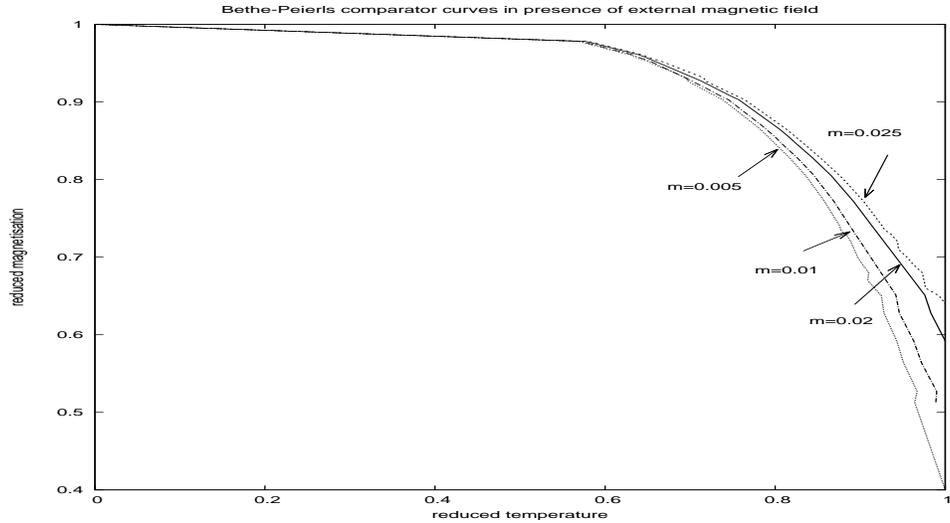


FIG. 2. Reduced magnetisation vs reduced temperature curves for Bethe-Peierls approximation in presence of little external magnetic fields, for four nearest neighbours, with  $\beta H = 2m$ .

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
208	418	414	265	83	322	175	305	102	73	125	196	166	84	154	338	26	242	633	280	54	30	108	2	24	13

TABLE III. The entries of Dictionary of Sports by Dr. S.K.Srivastava and Ms. Tanvangi Singh along the English letters

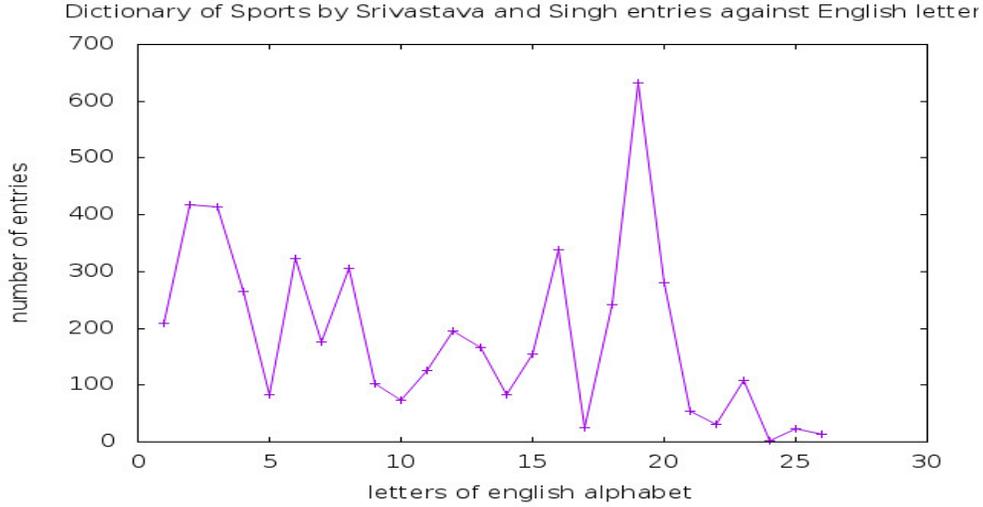


FIG. 3. The vertical axis is the number of entries of Dictionary of Sports by Dr. S.K.Srivastava and Ms. Tanvangi Singh, [1], and the horizontal axis is the respective letters. Letters are represented by the sequence number in the English alphabet.

### III. ANALYSIS OF THE ENTRIES OF DICTIONARY OF SPORTS

We count one by one the entries of Dictionary of Sports by Dr. S.K.Srivastava and Ms. Tanvangi Singh, [1], starting with different letters. The result is the table, III. Highest number of entries, six hundred thirty three, starts with the letter S followed by entries numbering four hundred eighteen beginning with B, four hundred fourteen beginning with C etc. To visualise we plot the number of entries against respective letters in the dictionary sequence, [1], in the 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, denoted by  $k$ .  $k$  is a positive integer starting from one. The lowest value of  $f$  is two. Hence we attach a limiting  $f$  equal to one. The corresponding rank,  $k$ , denoted as  $k_{lim}$  is twenty seven 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

k	lnk	lnk/ $lnk_{lim}$	f	lnf	lnf/ $lnf_{max}$	lnf/ $lnf_{nmax}$	lnf/ $lnf_{2nmax}$	lnf/ $lnf_{3nmax}$	lnf/ $lnf_{4nmax}$	lnf/ $lnf_{5nmax}$
1	0	0	633	6.450	1	Blank	Blank	Blank	Blank	Blank
2	0.69	0.209	418	6.035	0.936	1	Blank	Blank	Blank	Blank
3	1.10	0.333	414	6.026	0.934	0.999	1	Blank	Blank	Blank
4	1.39	0.421	338	5.823	0.903	0.965	0.966	1	Blank	Blank
5	1.61	0.488	322	5.775	0.895	0.957	0.958	0.992	1	Blank
6	1.79	0.542	305	5.720	0.887	0.948	0.949	0.982	0.990	1
7	1.95	0.591	280	5.635	0.874	0.934	0.935	0.968	0.976	0.985
8	2.08	0.630	265	5.580	0.865	0.925	0.926	0.958	0.966	0.976
9	2.20	0.667	242	5.489	0.851	0.910	0.911	0.943	0.950	0.960
10	2.30	0.697	208	5.338	0.828	0.885	0.886	0.917	0.924	0.933
11	2.40	0.727	196	5.278	0.818	0.875	0.876	0.906	0.914	0.923
12	2.48	0.752	175	5.165	0.801	0.856	0.857	0.887	0.894	0.903
13	2.56	0.776	166	5.112	0.793	0.847	0.848	0.878	0.885	0.894
14	2.64	0.800	154	5.037	0.781	0.835	0.836	0.865	0.872	0.881
15	2.71	0.821	125	4.828	0.749	0.8	0.801	0.829	0.836	0.844
16	2.77	0.839	108	4.682	0.726	0.776	0.777	0.804	0.811	0.819
17	2.83	0.858	102	4.625	0.717	0.766	0.768	0.794	0.801	0.809
18	2.89	0.876	84	4.431	0.687	0.734	0.735	0.761	0.767	0.775
19	2.94	0.891	83	4.419	0.685	0.732	0.733	0.759	0.765	0.773
20	3.00	0.909	73	4.290	0.665	0.711	0.712	0.737	0.743	0.75
21	3.04	0.921	54	3.989	0.618	0.661	0.662	0.685	0.691	0.697
22	3.09	0.936	30	3.401	0.527	0.564	0.564	0.584	0.589	0.595
23	3.14	0.952	26	3.258	0.505	0.540	0.541	0.560	0.564	0.570
24	3.18	0.964	24	3.178	0.493	0.527	0.527	0.546	0.550	0.556
25	3.22	0.976	13	2.565	0.398	0.425	0.426	0.440	0.444	0.448
26	3.26	0.988	2	0.693	0.107	0.115	0.115	0.119	0.12	0.121
27	3.30	1	1	0	0	0	0	0	0	0

TABLE IV. Dictionary of Sports entries: ranking,natural logarithm, normalisations

plot  $\frac{lnf}{lnf_{max}}$  against  $\frac{lnk}{lnk_{lim}}$  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  $lnfs$  with next-to-maximum  $lnf_{nextmax}$ , and starting from  $k = 2$  in the figure fig.5. This program then we repeat up to  $k = 6$ , resulting in figures up to fig.9.

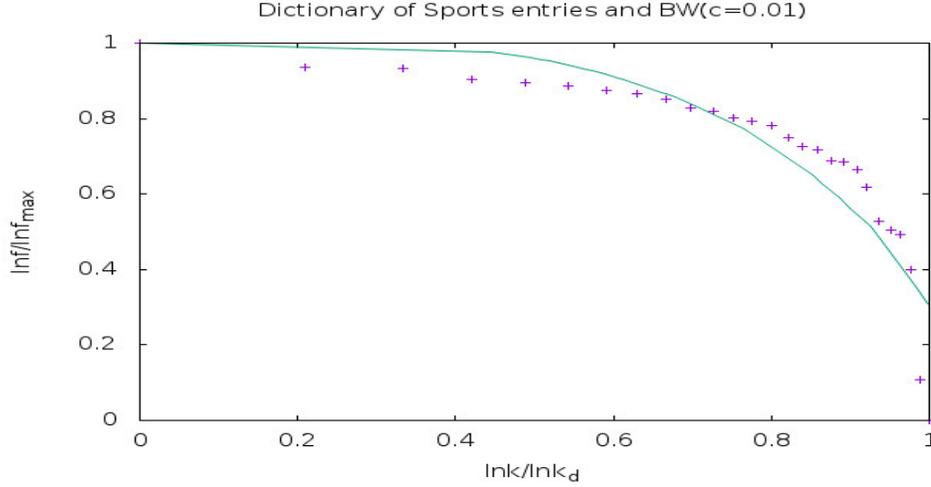


FIG. 4. The vertical axis is  $\frac{\ln f}{\ln f_{max}}$  and the horizontal axis is  $\frac{\ln k}{\ln k_{lim}}$ . The + points represent the entries of Dictionary of Sports by Dr. S.K.Srivastava and Ms. Tanvangi Singh with the fit curve, BW( $c=0.01$ ), being the Bragg-Williams approximation curve in the presence of external magnetic field,  $c = \frac{H}{\gamma\epsilon} = 0.01$ .

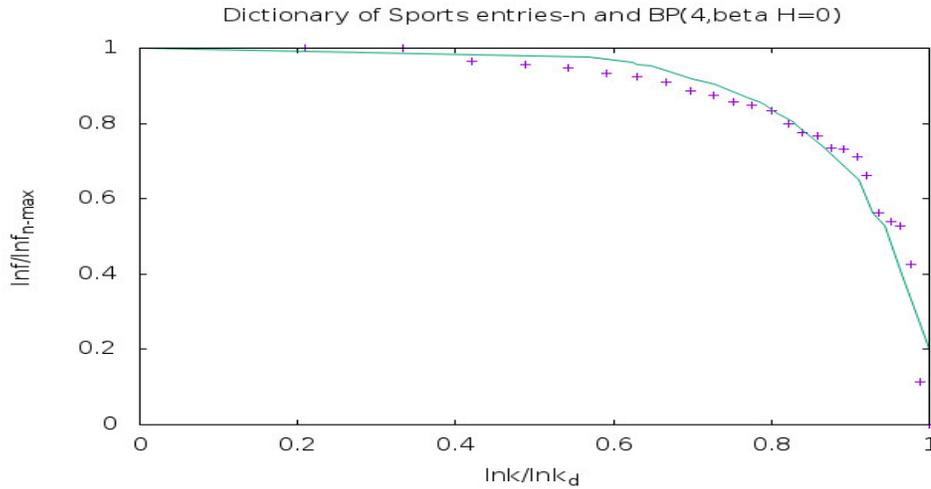


FIG. 5. The vertical axis is  $\frac{\ln f}{\ln f_{n-max}}$  and the horizontal axis is  $\frac{\ln k}{\ln k_{lim}}$ . The + points represent the entries of Dictionary of Sports by Dr. S.K.Srivastava and Ms. Tanvangi Singh with the fit curve being the Bethe-Peierls curve, BP( $4, \beta H = 0$ ), in the presence of four nearest neighbours and in the absence of external magnetic field,  $m = 0$  or,  $\beta H = 0$ .

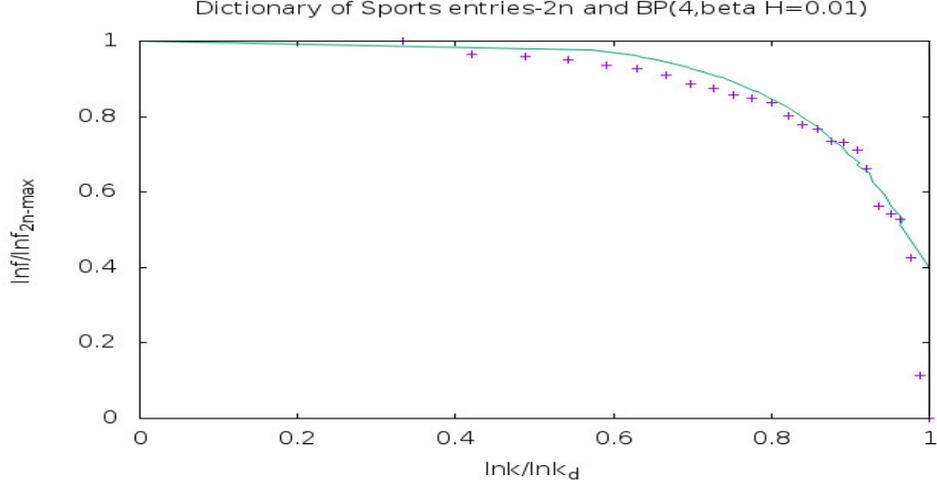


FIG. 6. The vertical axis is  $\frac{\ln f}{\ln f_{2n-max}}$  and the horizontal axis is  $\frac{\ln k}{\ln k_{lim}}$ . The + points represent the entries of Dictionary of Sports by Dr. S.K.Srivastava and Ms. Tanvangi Singh with the fit curve being the Bethe-Peierls curve,  $BP(4, \beta H = 0.01)$ , in the presence of four nearest neighbours and little external magnetic field,  $m = 0.005$  or,  $\beta H = 0.01$ .

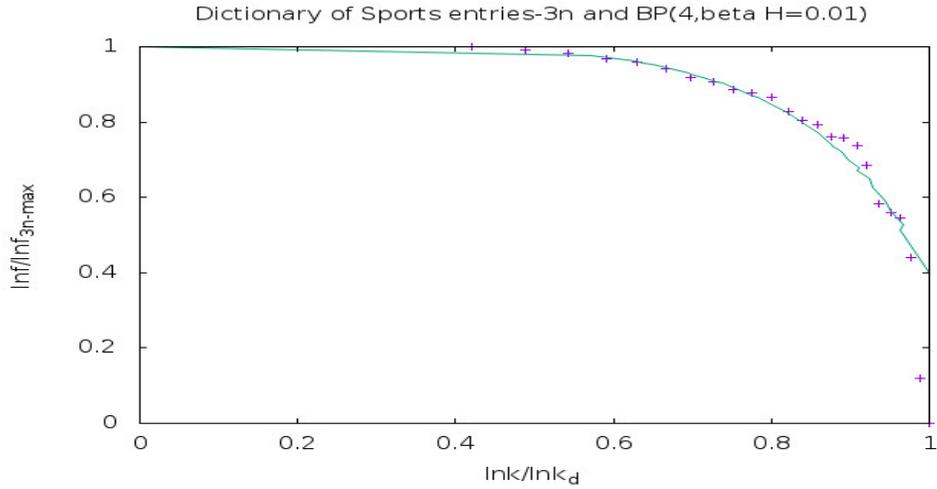


FIG. 7. The vertical axis is  $\frac{\ln f}{\ln f_{3n-max}}$  and the horizontal axis is  $\frac{\ln k}{\ln k_{lim}}$ . The + points represent the entries of Dictionary of Sports by Dr. S.K.Srivastava and Ms. Tanvangi Singh with the fit curve being the Bethe-Peierls curve,  $BP(4, \beta H = 0.01)$ , in the presence of four nearest neighbours and little external magnetic field,  $m = 0.005$  or,  $\beta H = 0.01$ .

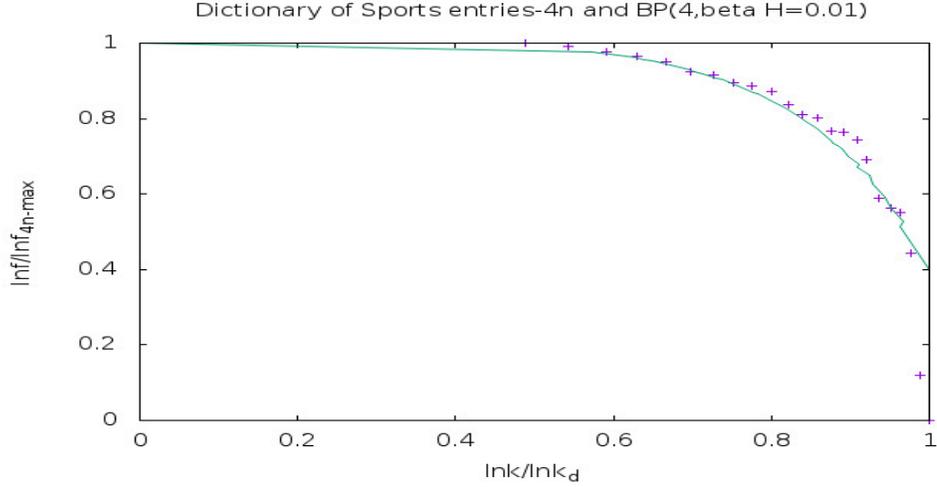


FIG. 8. The vertical axis is  $\frac{\ln f}{\ln f_{4n-max}}$  and the horizontal axis is  $\frac{\ln k}{\ln k_{lim}}$ . The + points represent the entries of Dictionary of Sports by Dr. S.K.Srivastava and Ms. Tanvangi Singh with the fit curve being the Bethe-Peierls curve,  $BP(4, \beta H = 0.01)$ , in the presence of four nearest neighbours and little external magnetic field,  $m = 0.005$  or,  $\beta H = 0.01$ .

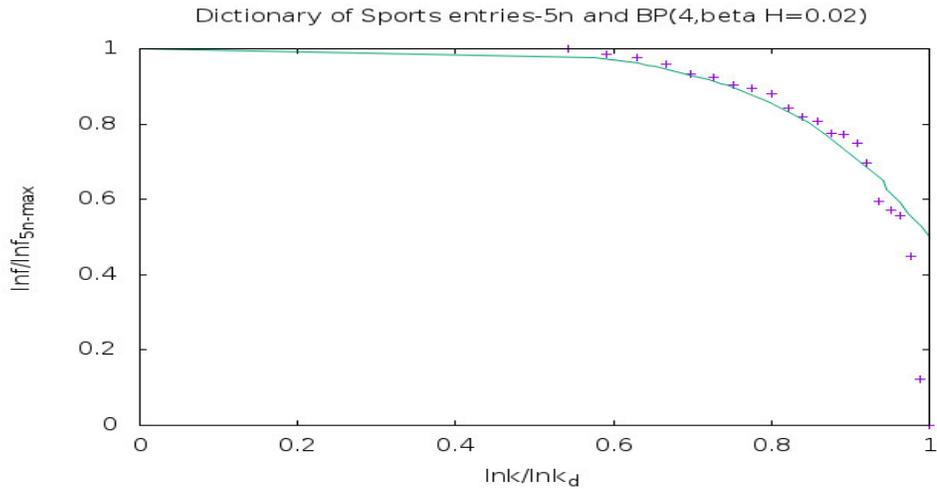


FIG. 9. The vertical axis is  $\frac{\ln f}{\ln f_{5n-max}}$  and the horizontal axis is  $\frac{\ln k}{\ln k_{lim}}$ . The + points represent the entries of Dictionary of Sports by Dr. S.K.Srivastava and Ms. Tanvangi Singh with the fit curve being the Bethe-Peierls curve,  $BP(4, \beta H = 0.02)$ , in the 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.9), we observe that there is a curve of magnetisation, of the Ising model, behind the entries of Dictionary of Sports by Dr. S.K.Srivastava and Ms. Tanvangi Singh, [1], This is the magnetisation curve,  $BP(4, \beta H = 0.01)$ , in the presence of four nearest neighbours and little external magnetic field,  $m = 0.005$  or,  $\beta H = 0.01$ . Moreover, the associated correspondence is,

$$\frac{\ln f}{\ln f_{3n-max}} \longleftrightarrow \frac{M}{M_{max}}, \quad \ln k \longleftrightarrow T.$$

$k$  corresponds to temperature in an exponential scale, [84].

## IV. ACKNOWLEDGMENT

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

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