

Rudyard Kipling's Verse and the Graphical Law

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Abstract

We study the Rudyard Kipling's Verse, Definitive edition. We draw the natural logarithm of the number of the titles of the verses, normalised, starting with a letter vs the natural logarithm of the rank of the letter, normalised. We conclude that the Rudyard Kipling's Verse can be characterised by $BW(c=0.01)$, the magnetisation curve of the Ising Model in the Bragg-Williams approximation in the presence of external magnetic field, H . $c = \frac{H}{\gamma\epsilon} = 0.01$ with ϵ being the strength of coupling between two neighbouring spins in the Ising Model, γ representing the number of nearest neighbours of a spin, which is very large.

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letter	A	B	C	D	E	F	G	H	I	J	K	L	M
number	19	46	39	24	15	26	20	16	10	12	9	36	35
letter	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
number	13	17	39	3	28	68	33	4	8	21	0	2	1

TABLE I. Rudyard Kipling’s Verse titles: the odd rows represent letters of the English alphabet, the even rows represent the corresponding number of the titles of the verses in the Rudyard Kipling’s Verse , [1].

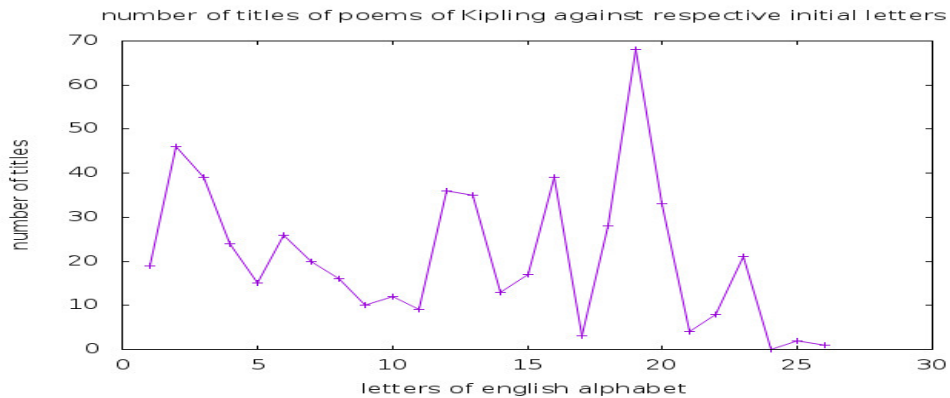


FIG. 1. The vertical axis is the number of the titles of the verses in the Rudyard Kipling’s Verse , [1]. The horizontal axis is the letters of the English alphabet. Letters are represented by the sequence number in the alphabet.

I. INTRODUCTION

Rudyard Kipling was a monumental figure in wide spectrum of literary activities in the English literature spanning poetry, short stories, novels etc. in the pre-independence India, in the British Empire. His collections of verses is Rudyard Kipling’s Verse Definitive edition, [1]. The Rudyard Kipling’s Verse is read widely and has undergone many editions. We come across one, [1] and ask to us how many verses are there inside it. We start counting title after title and enlist the number of the titles of the verses starting with an English letter. The result is the table, I. To visualise we plot the number of the titles of the verses against the letters of the English alphabet, in the adjoining figure, fig.1. Out of curiosity we ask to ourselves, is there a magnetic field pattern behind the Rudyard Kipling’s Verse? The answer is in the affirmative. The rest of the paper goes to elaborate on the affirmation. 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 Zool-

ogy 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], Penguin Dictionary of Physics, the Fourth Edition, by John Cullerne, and the Graphical law, [51], Oxford Dictionary of Chemistry, the seventh edition and the Graphical Law, [52], A Burmese-English Dictionary, Part I-Part V, by J. A. Stewart and C. W. Dunn et al, head entries and the Graphical Law, [53], The Graphical Law behind the head words of Dictionary Kannada and English written by W. Reeve, revised, corrected and enlarged by Daniel Sanderson, [54], Sanchayita and the Graphical Law, [55], Samsad Bangla Abhidan and The Graphical Law, [56], Bangiya Sabdakosh and The Graphical Law, [57], Samsad Bengali-English Dictionary and The Graphical Law, [58], respectively.

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 graphical law analysis of the titles of the verses of the Rudyard Kipling’s Verse, [1]. Sections IV, V are Acknowledgment and Bibliography respectively.

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 paramagnet, 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 σ_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, μNL , $M_{max} = \mu N$. $\frac{M}{M_{max}} = L$. $\frac{M}{M_{max}}$ is referred to as reduced magnetisation. Moreover, the Ising Hamiltonian,[60], for the lattice of spins, setting μ 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 ΔE of energy if we flip an up spin to down spin is, [61], $2\epsilon\gamma\bar{\sigma} + 2H$, where γ is the number of nearest neighbours of a spin. According to Boltzmann principle, $\frac{N_-}{N_+}$ equals $exp(-\frac{\Delta E}{k_B T})$, [62]. In the Bragg-Williams approximation,[63], $\bar{\sigma} = L$, 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, $c = \frac{H}{\gamma\epsilon}$, $T_c = \gamma\epsilon/k_B$, [64]. $\frac{T}{T_c}$ 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 [61]. W. L. Bragg was a professor of Hans Bethe. Rudlof Peierls was a friend of Hans Bethe. At the suggestion of W. L. Bragg, Rudlof 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, [60],[61],[62],[63],[64], due to Bethe-Peierls, [65], reduced magnetisation varies with reduced temperature, for γ 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 datas generated from the equation(1) and the equation(2) in the table, II, and curves of magnetisation plotted on the basis of those datas. 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.2. Empty spaces in the table, II, 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 II. Reduced magnetisation vs reduced temperature datas 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 .

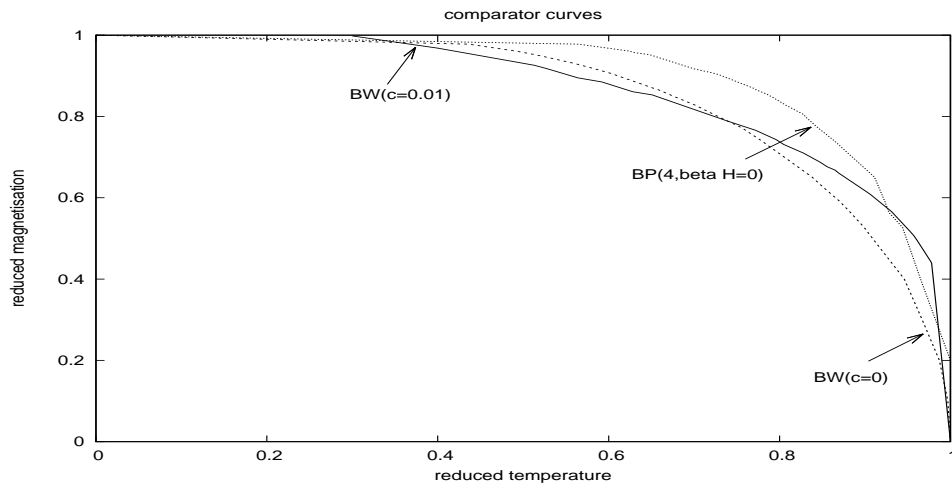


FIG. 2. Reduced magnetisation vs reduced temperature curves for the Bragg-Williams approximation, in the absence(broken line) of, BW(c=0) and the presence(inner in the top) of, BW(c=0.01), the external magnetic field, $c = \frac{H}{\gamma\epsilon} = 0.01$, and the Bethe-Peierls approximation in the absence of external magnetic field, for four nearest neighbours (outer in the top).

III. THE GRAPHICAL LAW ANALYSIS

For the purpose of exploring graphical law, we assort the letters according to the number of titles, in the descending order, denoted by f and the respective rank, [59], denoted by k . k is a positive integer starting from one. Minimum number of titles is one. The limiting rank, k_{lim} , is maximum rank, here it is twenty four and the limiting number of titles, 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, III, and plot $\frac{\ln f}{\ln f_{max}}$ against $\frac{\ln k}{\ln k_{lim}}$ in the figure fig.3.

We then ignore the letter with which the highest number of titles start, tabulate in the adjoining table, III, and redo the plot, normalising the $\ln f$ s with next-to-maximum $\ln f_{n-max}$, and starting from $k = 2$ in the figure fig.4. Normalising the $\ln f$ s with next-to-next-to-maximum $\ln f_{2n-max}$, we tabulate in the adjoining table, III, and starting from $k = 3$ we draw in the figure fig.5 and continuing we get figures up to the figure fig.8

k	lnk	$\ln k / \ln k_{lim}$	f	lnf	$\ln f / \ln f_{max}$	$\ln f / \ln f_{next-max}$	$\ln f / \ln f_{2nmax}$	$\ln f / \ln f_{3nmax}$	$\ln f / \ln f_{4nmax}$	$\ln f / \ln f_{5nmax}$
1	0	0	68	4.220	1	Blank	Blank	Blank	Blank	Blank
2	0.69	0.217	46	3.829	0.907	1	Blank	Blank	Blank	Blank
3	1.10	0.346	39	3.664	0.868	0.957	1	Blank	Blank	Blank
4	1.39	0.437	36	3.584	0.849	0.936	0.978	1	Blank	Blank
5	1.61	0.506	35	3.555	0.842	0.928	0.970	0.992	1	Blank
6	1.79	0.563	33	3.497	0.829	0.913	0.954	0.976	0.984	1
7	1.95	0.613	28	3.332	0.790	0.870	0.909	0.930	0.937	0.953
8	2.08	0.654	26	3.258	0.772	0.851	0.889	0.909	0.916	0.932
9	2.20	0.692	24	3.178	0.753	0.830	0.867	0.887	0.894	0.909
10	2.30	0.723	21	3.045	0.722	0.795	0.831	0.850	0.857	0.871
11	2.40	0.755	20	2.996	0.710	0.782	0.818	0.836	0.843	0.857
12	2.48	0.780	19	2.944	0.698	0.769	0.803	0.821	0.828	0.842
13	2.56	0.805	17	2.833	0.671	0.740	0.773	0.790	0.797	0.810
14	2.64	0.830	16	2.773	0.657	0.724	0.757	0.774	0.780	0.793
15	2.71	0.852	15	2.708	0.642	0.707	0.739	0.756	0.762	0.774
16	2.77	0.871	13	2.565	0.608	0.670	0.700	0.716	0.722	0.733
17	2.83	0.890	12	2.485	0.589	0.649	0.678	0.693	0.699	0.711
18	2.89	0.909	10	2.303	0.546	0.601	0.629	0.643	0.648	0.659
19	2.94	0.925	9	2.197	0.521	0.574	0.600	0.613	0.618	0.628
20	3.00	0.943	8	2.079	0.493	0.543	0.567	0.580	0.585	0.595
21	3.04	0.956	4	1.386	0.328	0.362	0.378	0.387	0.390	0.396
22	3.09	0.972	3	1.099	0.260	0.287	0.300	0.307	0.309	0.314
23	3.14	0.987	2	0.693	0.164	0.181	0.189	0.193	0.195	0.198
24	3.18	1	1	0	0	0	0	0	0	0

TABLE III. Titles of the verses of the Rudyard Kipling's Verse : ranking, natural logarithm, normalisations

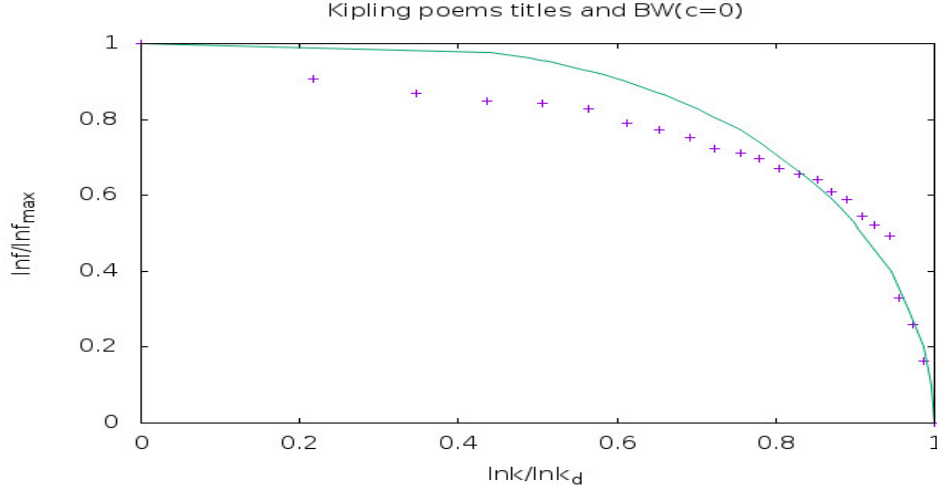


FIG. 3. Vertical axis is $\frac{\ln f}{\ln f_{max}}$ and horizontal axis is $\frac{\ln k}{\ln k_{lim}}$. The + points represent the titles of the verses of Rudyard Kipling's Verse with the fit curve being the Bragg-Williams curve in the absence of external magnetic field, $c = \frac{H}{\gamma\epsilon} = 0$.

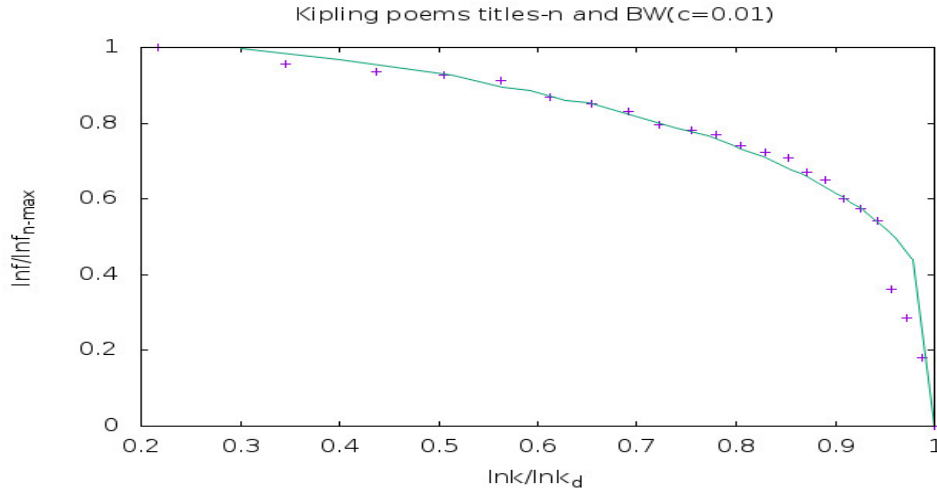


FIG. 4. Vertical axis is $\frac{\ln f}{\ln f_{n-max}}$ and horizontal axis is $\frac{\ln k}{\ln k_{lim}}$. The + points represent the titles of the verses of Rudyard Kipling's Verse with the fit curve being the Bragg-Williams curve in the presence of external magnetic field, $c = \frac{H}{\gamma\epsilon} = 0.01$.

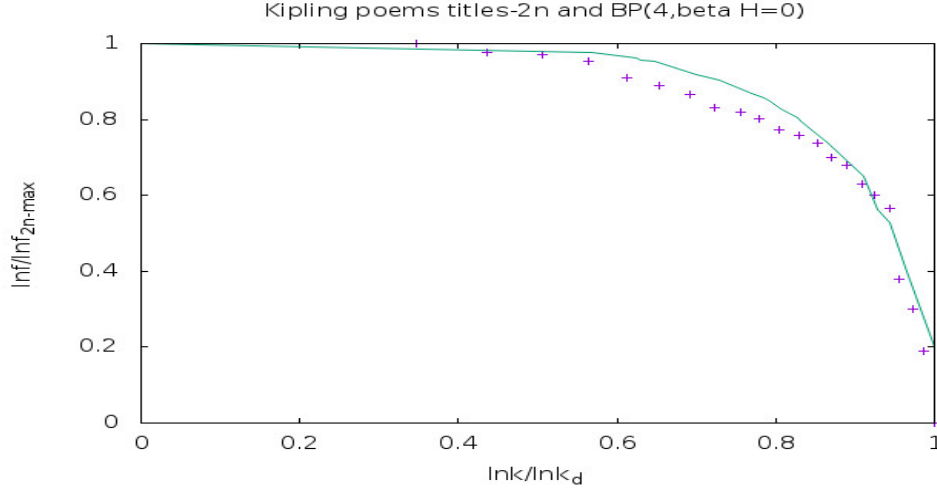


FIG. 5. Vertical axis is $\frac{\ln f}{\ln f_{2n-max}}$ and horizontal axis is $\frac{\ln k}{\ln k_{lim}}$. The + points represent the titles of the verses of Rudyard Kipling's Verse with the fit curve being the Bethe-Peierls curve in the presence of four nearest neighbours and in the absence of external magnetic field.

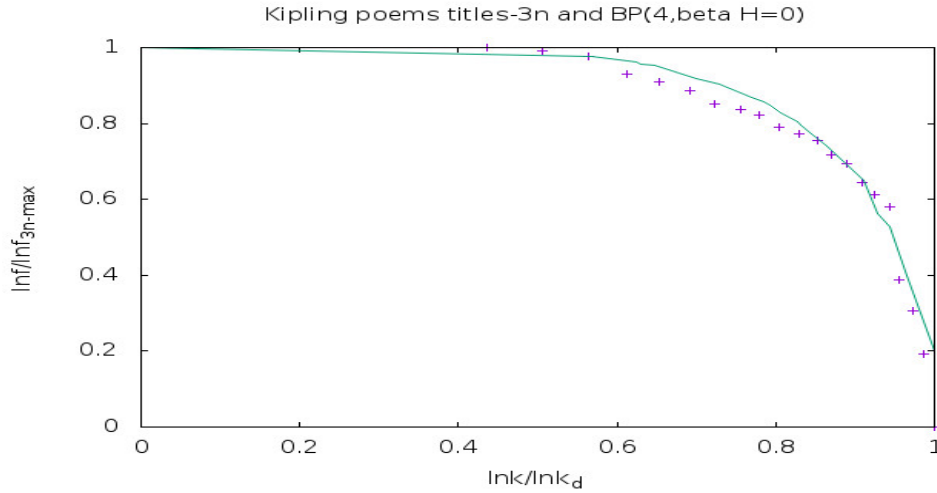


FIG. 6. Vertical axis is $\frac{\ln f}{\ln f_{3n-max}}$ and horizontal axis is $\frac{\ln k}{\ln k_{lim}}$. The + points represent the titles of the verses of Rudyard Kipling's Verse with the fit curve being the Bethe-Peierls curve in the presence of four nearest neighbours and in the absence of external magnetic field.

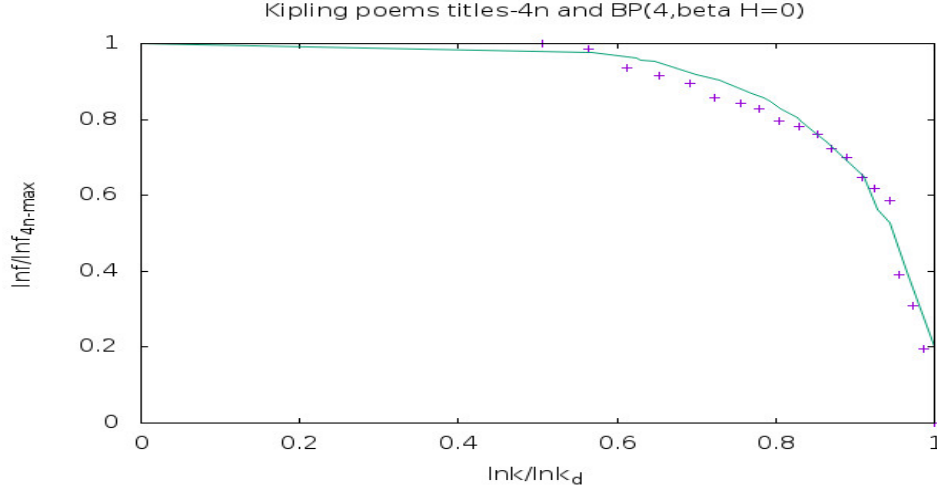


FIG. 7. Vertical axis is $\frac{\ln f}{\ln f_{4n-max}}$ and horizontal axis is $\frac{\ln k}{\ln k_{lim}}$. The + points represent the titles of the verses of Rudyard Kipling's Verse with the fit curve being the Bethe-Peierls curve in the presence of four nearest neighbours and in the absence of external magnetic field.

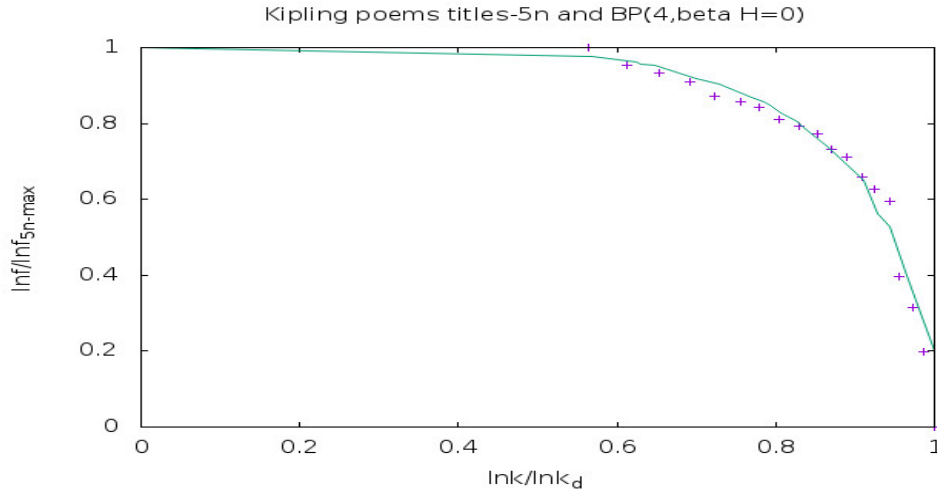


FIG. 8. Vertical axis is $\frac{\ln f}{\ln f_{5n-max}}$ and horizontal axis is $\frac{\ln k}{\ln k_{lim}}$. The + points represent the titles of the verses of Rudyard Kipling's Verse with the fit curve being the Bethe-Peierls curve in the presence of four nearest neighbours and in the absence of external magnetic field.

A. conclusion

From the figures (fig.3-fig.8), we observe that there is a curve of magnetisation, behind the titles of the verses of Rudyard Kipling. This is the magnetisation curve in the Bragg-Williams approximation of the Ising model, in the presence of external magnetic field, $c = \frac{H}{\gamma\epsilon} = 0.01$. Moreover, the associated correspondence is,

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

Nevertheless on successive normalisations, the titles of the verses of Rudyard Kipling's Verse, go over to the magnetisation curve, $BP(4, \beta H = 0)$. Hence, the titles of the verses of Rudyard Kipling's Verse has a Bethe-Peierls core(in the presence of four nearest neighbours and in the absence of external magnetic field).

IV. ACKNOWLEDGMENT

We have used the gnuplot for drawing the figures. We would like to thank the nehu library for allowing us to use the reference, [1].

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