A Dictionary of the Kachin Language by Rev. O. Hanson and the Graphical Law

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Abstract

We study A Dictionary of the Kachin Language by Rev. O. Hanson, 1954 printing. We draw the natural logarithm of the number of the Kachin words, normalised, starting with a letter vs the natural logarithm of the rank of the letter, normalised(unnormalised). We find that the Kachin words underlie a magnetisation curve of a Spin-Glass in the presence of little external magnetic field. Moreover, the naturalness number of the Kachin language as seen through this dictionary is nine by sixteen.

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I. INTRODUCTION

In this article, we study the Dictionary of the Kachin Language by Rev. O. Hanson, 1954 printing, [1], looking for the graphical law. We study magnetic field pattern behind the words of this dictionary, [1], in this work. 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 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], behind a Dictionary Of Critical Theory by Ian Buchanan, [33], behind the Penguin Dictionary Of Economics, [34], behind the Concise Gojri-English Dictionary by Dr. Rafeeq Anjum, [35], respectively.

In our first paper, [2], we have studied the Kachin English Dicionary,[1]. There we took resort to average counting i.e. finding an average number of words par page and multiplying by the number of pages corresponding to a letter we obtained the number of words starting with a letter. We deduced that the dictionary,[1], is characterised by BP(4,βH=0). Here, in this paper we leave behind the approximate method. We count thoroughly, one by one each word. Moreover, we augment the analysis. We conclude here, that the dictionary can be characterised by BP(4,βH=0), but better be characterised by a magnetisation curve of a Spin-Glass in the presence of little external magnetic field.

We describe how a graphical law is hidden within the words of the Kachin Dictionary, [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 words of the words of the Kachin Dictionary, [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 $L = \frac{1}{N}\Sigma_i\sigma_i$, 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 $\mu\Sigma_i\sigma_i$ 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,[36], for the lattice of spins, setting μ to one, is $-\epsilon\Sigma_{n.n}\sigma_i\sigma_j - H\Sigma_i\sigma_i$, where n.n refers to nearest neighbour pairs. The difference $\triangle E$ of energy if we flip an up spin to down spin is, [37], $2\epsilon\gamma\bar{\sigma} + 2H$, where γ is the number of nearest neighbours of a spin. According to Boltzmann principle, $\frac{N_-}{N_+}$ equals $exp(-\frac{\triangle E}{k_BT})$, [38]. In the Bragg-Williams approximation,[39], $\bar{\sigma} = L$, considered in the thermal average sense. Consequently,

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

where, $c = \frac{H}{\gamma\epsilon}$, $T_c = \gamma\epsilon/k_B$, [40]. $\frac{T}{T_c}$ is referred to as reduced temperature.

Plot of L vs $\frac{T}{T_c}$ or, reduced magentisation 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 [37]. 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, [36],[37],[38],[39],[40], due to Bethe-Peierls, [41], 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 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,βH = 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,βH=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.]

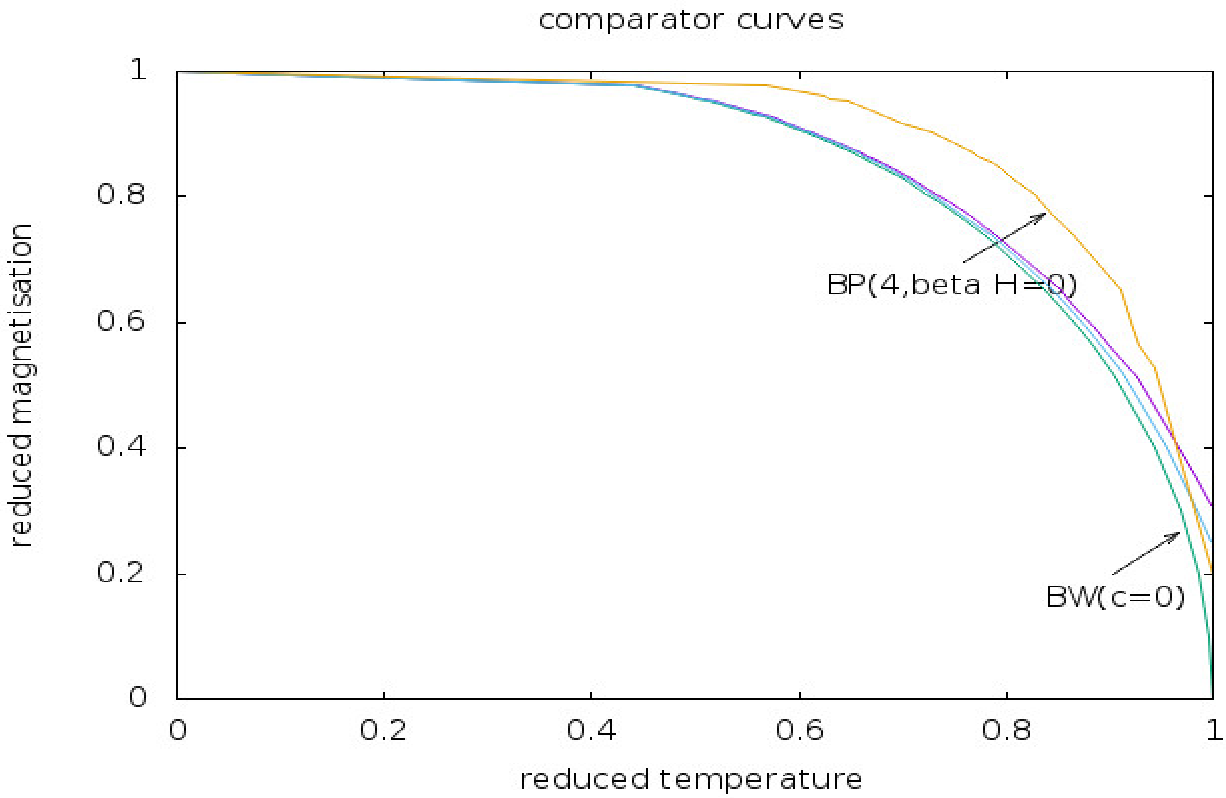

FIG. 1. Reduced magnetisation vs reduced temperature curves, for the Bragg-Williams approximation, in the absence (BW(c=0)) and in the presence (BW(c=0.005), BW(c=0.01)) of magnetic field, $c = 0$, $c = \frac{H}{\gamma\epsilon} = 0.005$, $c = \frac{H}{\gamma\epsilon} = 0.01$, outwards; and in the Bethe-Peierls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

C. Spin-Glass

In the case coupling between(among) the spins, not necessarily n.n, for the Ising model is(are) random, we get Spin-Glass. When a lattice of spins randomly coupled and in an external magnetic field, goes over to the Spin-Glass phase, magnetisation increases steeply like $\frac{1}{T-T_c}$ i.e. like the branch of rectangular hyperbola, up to the the phase transition temperature, followed by very little increase,[42–44], in magnetisation, as the ambient temperature continues to drop.

Theoretical study of Spin Glass started with the paper by Edwards, Anderson,[45]. They were trying to explain two experimental results concerning continuous disordered freezing(phase transition) and sharp cusp in static magnetic susceptibility. This was followed by a paper by Sherrington, Kickpatrick, [46], who dealt with Ising model with interactions being present among all neighbours. The interaction is random, follows Gaussian distribution and does not distinguish one pair of neighbours from another pair of neighbours, irrespective of the distance between two neighbours. In presence of external magnetic field, they predicted in their next paper, [47], below spin-glass transition temperature a spin-glass phase with non-zero magnetisation. Almeida etal, [48], Gray and Moore, [49],finally Parisi, [50], [51] improved and gave final touch, [52], to their line of work. Parisi and collaborators, [53]-[57], wrote a series of papers in postscript, all revolving around a consistent assumption of constant magnetisation in the spin-glass phase in presence of little constant external magnetic field.

In another sequence of theoretical work, by Fisher etal,[58–60], concluded that for Ising model with nearest neighbour or, short range interaction of random type spin-glass phase does not exist in presence of external magnetic field.

For recent series of experiments on spin-glass, the references, [61, 62], are the places to look into.

For an in depth account, accessible to a commoner, the series of articles by late P. W. Anderson in Physics Today, [63]-[69], is probably the best place to look into. For a book to enter into the subject of spin-glass, one may start at [70].

Here, in our work to follow, spin-glass refers to spin-glass phase of a system with infinite range random interactions.

letter	A	Ă	E	Ē	$\grave{E}$	I	O	U	Ai	Au	Aw	Oi	B	Chy	D	G	H	J
number	552	0	1	2	1	6	1	227	5	5	12	4	310	248	517	720	4	379
letter	K	HK	L	M	N	P	HP	Pf	R	S	Sh	T	Ts	Ht	V	W	Y	Z
number	659	595	619	842	840	266	360	5	175	448	546	153	124	215	1	239	184	82

TABLE II. Kachin words: the first row represents letters of the Kachin alphabet in the serial order, the second row is the respective number of words.

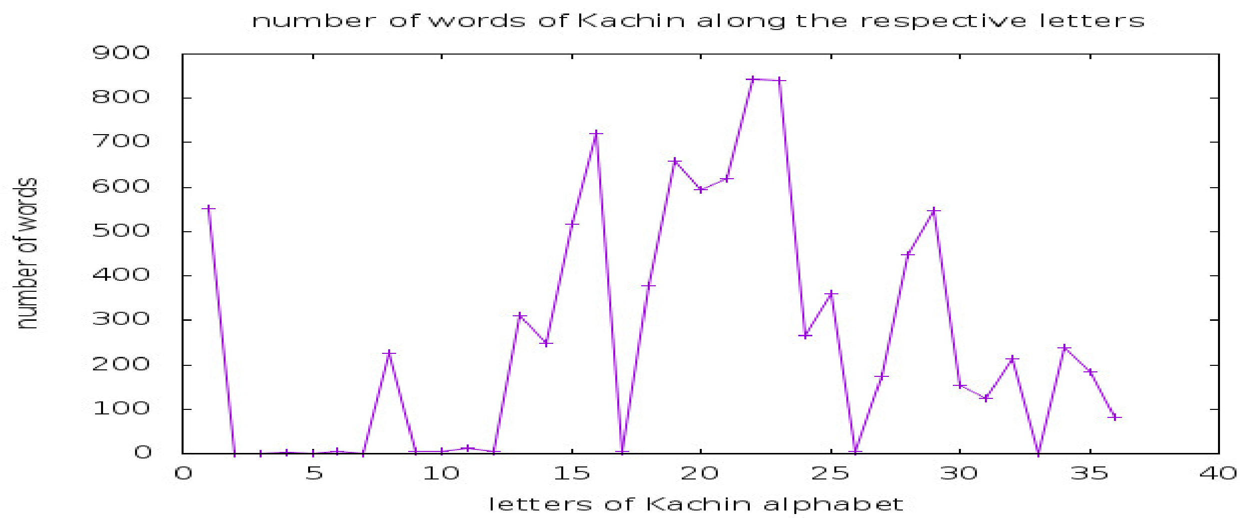

FIG. 2. The vertical axis is the number of words of the Kachin Dictionary [1], and the horizontal axis is the respective letters. Letters are represented by the sequence number in the alphabet or, dictionary sequence,[1].

III. ANALYSIS OF THE WORDS OF THE KACHIN DICTIONARY

We count all the words of the Kachin Dictionary [1], one by one from the beginning to the end, starting with different letters. Two or, many words having the same spelling has been counted as one. The result is the table, II. Highest number of words, eight hundred forty two, starts with the letter M followed by words numbering eight hundred forty beginning with N, seven hundred twenty initiating with the letter G etc. To visualise we plot the number of words against respective letters in the dictionary sequence, [1], in the figure fig.2. It was proposed in [23], that it may be reasonable to define naturalness of a language by the ratio of number of major peaks to the number of minor peaks. One may take major peaks as those with height up to the half of the height of the highest peak. The naturalness number of the French, [24], tuned out to be 11/5. The naturalness number of the German, [26], tuned out to be 7/9. The naturalness number of the Hebrew, [27], tuned out to be 1/3. The naturalness number of the Gojri language, [35], turned out to be one. In this case,[1], the highest peak has the frequency 842. Half of it is 421. Number of peaks greater than 421 is 4.5. Number of peaks less than 421 is 8. Hence the naturalness number is 9/16.

For the purpose of exploring graphical law, we assort the letters according to the number of words, in the descending order, denoted by f and the respective rank, [71], denoted by k. k is a positive integer starting from one. The lowest value of f is one. The corresponding rank, k, denoted as k_{lim} is twenty nine. As a result both $\frac{lnf}{lnf_{max}}$ and $\frac{lnk}{lnk_{lim}}$ varies from zero to one. Then we tabulate in the adjoining table, III and plot $\frac{lnf}{lnf_{max}}$ against $\frac{lnk}{lnk_{lim}}$ in the figure fig.3. We then ignore the letter with the highest of words, tabulate in the adjoining table, III and redo the plot, normalising the lnfs with next-to-maximum $lnf_{nextmax}$, and starting from $k = 2$ in the figure fig.4. This program then we repeat up to $k = 4$, resulting in figures up to fig.6.

k	lnk	lnk/lnk_{lim}	f	lnf	lnf/lnf_{max}	lnf/lnf_{n-max}	lnf/lnf_{2n-max}	lnf/lnf_{3n-max}
1	0	0	842	6.736	1	Blank	Blank	Blank
2	0.69	0.205	840	6.733	0.9996	1	Blank	Blank
3	1.10	0.326	720	6.579	0.977	0.977	1	Blank
4	1.39	0.412	659	6.491	0.964	0.964	0.987	1
5	1.61	0.478	619	6.428	0.954	0.955	0.977	0.990
6	1.79	0.531	595	6.389	0.948	0.949	0.971	0.984
7	1.95	0.579	552	6.314	0.937	0.938	0.960	0.973
8	2.08	0.617	546	6.303	0.936	0.936	0.958	0.971
9	2.20	0.653	517	6.248	0.928	0.928	0.950	0.963
10	2.30	0.682	448	6.105	0.906	0.907	0.928	0.941
11	2.40	0.712	379	5.938	0.882	0.882	0.903	0.915
12	2.48	0.736	360	5.886	0.874	0.874	0.895	0.907
13	2.56	0.760	310	5.737	0.852	0.852	0.872	0.884
14	2.64	0.783	266	5.583	0.829	0.829	0.849	0.860
15	2.71	0.804	248	5.513	0.818	0.819	0.838	0.849
16	2.77	0.822	239	5.476	0.813	0.813	0.832	0.844
17	2.83	0.840	227	5.425	0.805	0.806	0.825	0.836
18	2.89	0.858	215	5.371	0.797	0.798	0.816	0.827
19	2.94	0.872	184	5.215	0.774	0.775	0.793	0.803
20	3.00	0.890	175	5.165	0.767	0.767	0.785	0.796
21	3.04	0.902	153	5.030	0.747	0.747	0.765	0.775
22	3.09	0.917	124	4.820	0.716	0.716	0.733	0.743
23	3.14	0.932	82	4.407	0.654	0.655	0.670	0.679
24	3.18	0.944	12	2.485	0.369	0.369	0.378	0.383
25	3.22	0.955	6	1.792	0.266	0.266	0.272	0.276
26	3.26	0.967	5	1.609	0.239	0.239	0.245	0.248
27	3.30	0.979	4	1.386	0.206	0.206	0.211	0.214
28	3.33	0.988	2	0.693	0.103	0.103	0.105	0.107
29	3.37	1	1	0	0	0	0	0

TABLE III. Words of the Kachin Dictionary: ranking, natural logarithm, normalisations

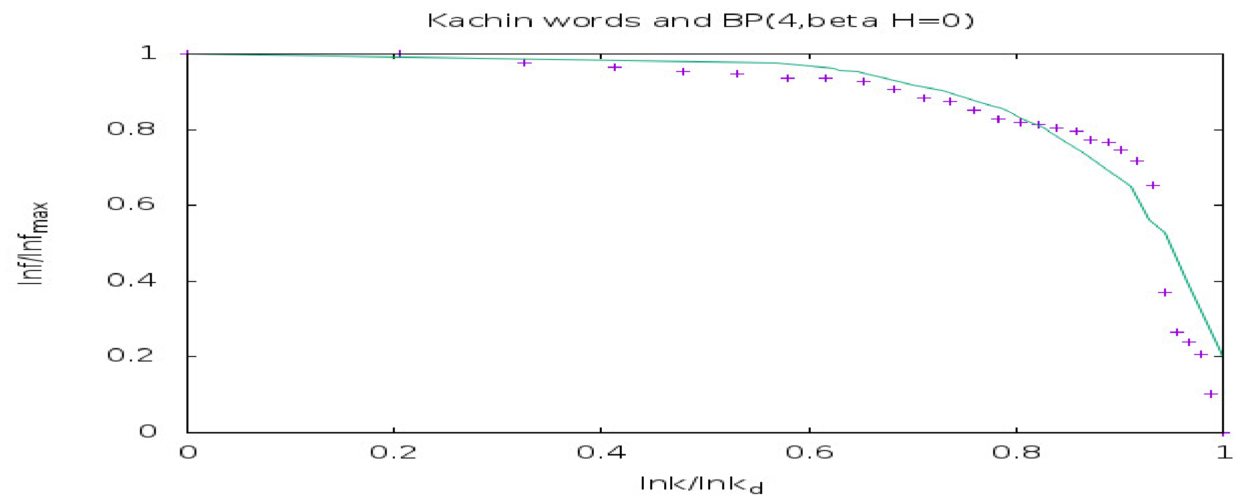

FIG. 3. The vertical axis is $\frac{lnf}{lnf_{max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the words of the Kachin Dictionary with the fit curve being the Bethe-Peierls curve, BP(4, $\beta H = 0$), with four nearest neighbours, in the absence of external magnetic field.

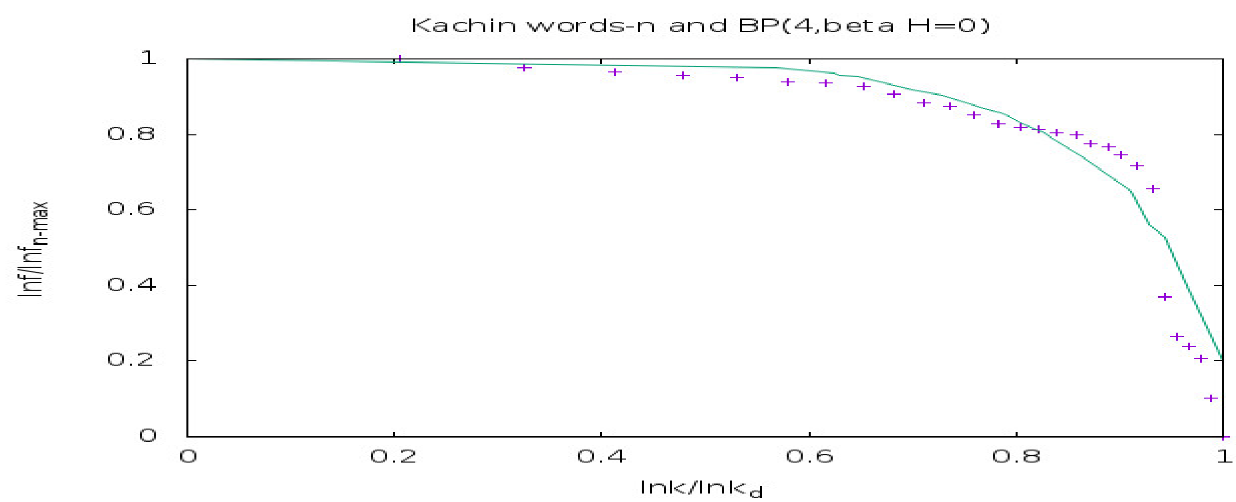

FIG. 4. The vertical axis is $\frac{lnf}{lnf_{next-max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the words of the Kachin Dictionary with the fit curve being the Bethe-Peierls curve, BP(4, $\beta H = 0$), with four nearest neighbours, in the absence of external magnetic field.

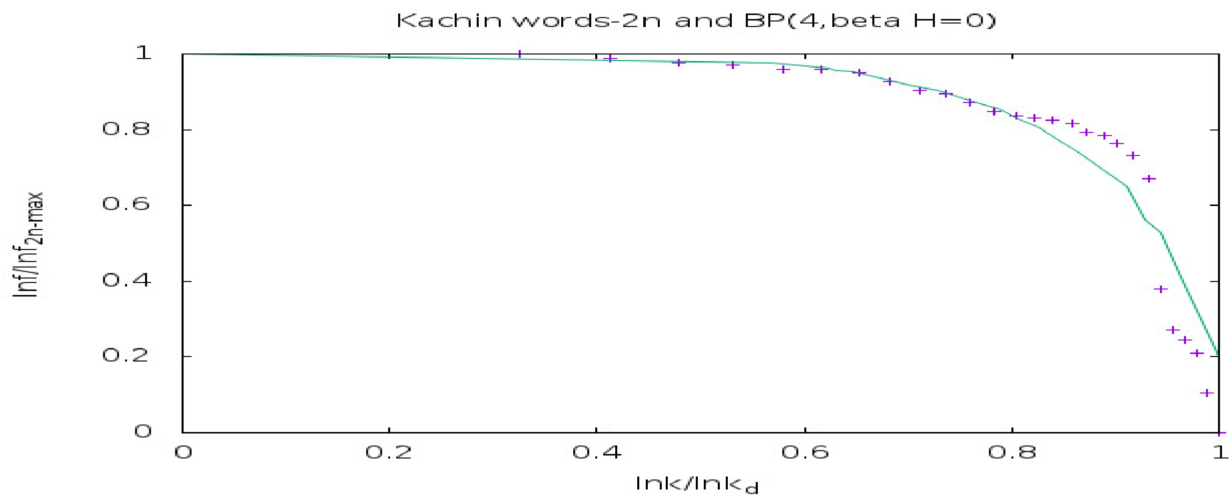

FIG. 5. The vertical axis is $\frac{lnf}{lnf_{nextnext-max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the words of the Kachin Dictionary with the fit curve being the Bethe-Peierls curve, BP(4, $\beta H = 0$), with four nearest neighbours, in the absence of external magnetic field.

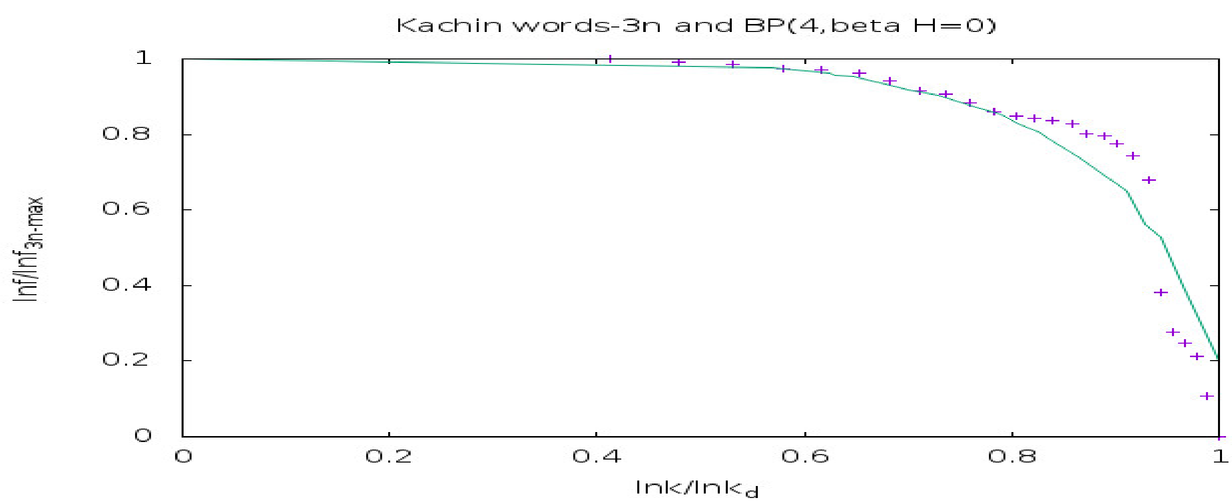

FIG. 6. The vertical axis is $\frac{lnf}{lnf_{nextnextnext-max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the words of the Kachin Dictionary with the fit curve being the Bethe-Peierls curve, BP(4, $\beta H = 0$), with four nearest neighbours, in the absence of external magnetic field.

A. conclusion

From the figures (fig.3-fig.6), we observe that there is a curve of magnetisation, behind the words of the the Kachin Dictionary,[1]. This is the magnetisation curve in the Bethe-Peierls approximation with four nearest neighbours and in the absence of external magnetic field, BP(4, $\beta H = 0$). Moreover, the associated correspondence is,

$$\frac{lnf}{lnf_{max}} \longleftrightarrow \frac{M}{M_{max}}, \quad lnk \longleftrightarrow T.$$

k corresponds to temperature in an exponential scale, [72]. As temperature decreases, i.e. lnk decreases, f increases. The letters which are recording higher words compared to those which have lesser words are at lower temperature. As the Kachin language expands, the letters like ...G, N, M, which get enriched more and more, fall at lower and lower temperatures. This is a manifestation of cooling effect, as was first observed in [73], in another way.

Matching of the plots in the figures fig.(3-6), with comparator curves i.e. the magnetisation curves of Bethe-Peierls approximations, BP(4, $\beta H = 0$), is with dispersion and dispersion does remains almost the same over higher orders of normalisations. BP(4, $\beta H = 0$) remains here as more an average line rather than a trend curve.

To explore for possible existence of spin-glass transition, in presence of little external magnetic field, $\frac{lnf}{lnf_{rn-max}}$ are drawn against lnk in the figures fig.7-fig.10, where r varies from zero to three.

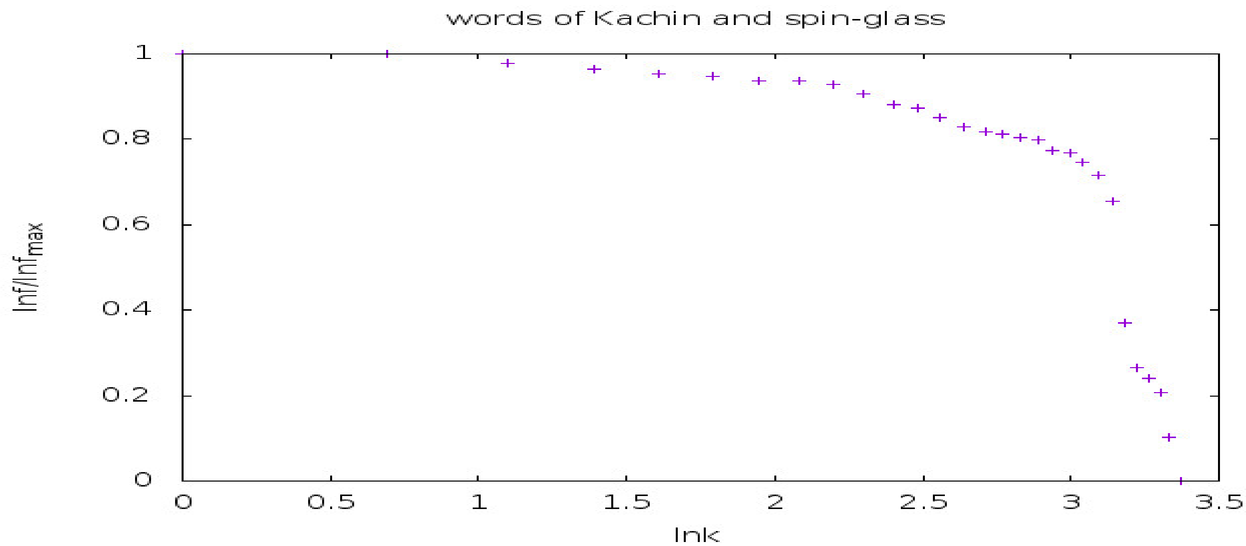

FIG. 7. The vertical axis is $\frac{lnf}{lnf_{max}}$ and the horizontal axis is lnk. The + points represent the words of the Kachin Dictionary.

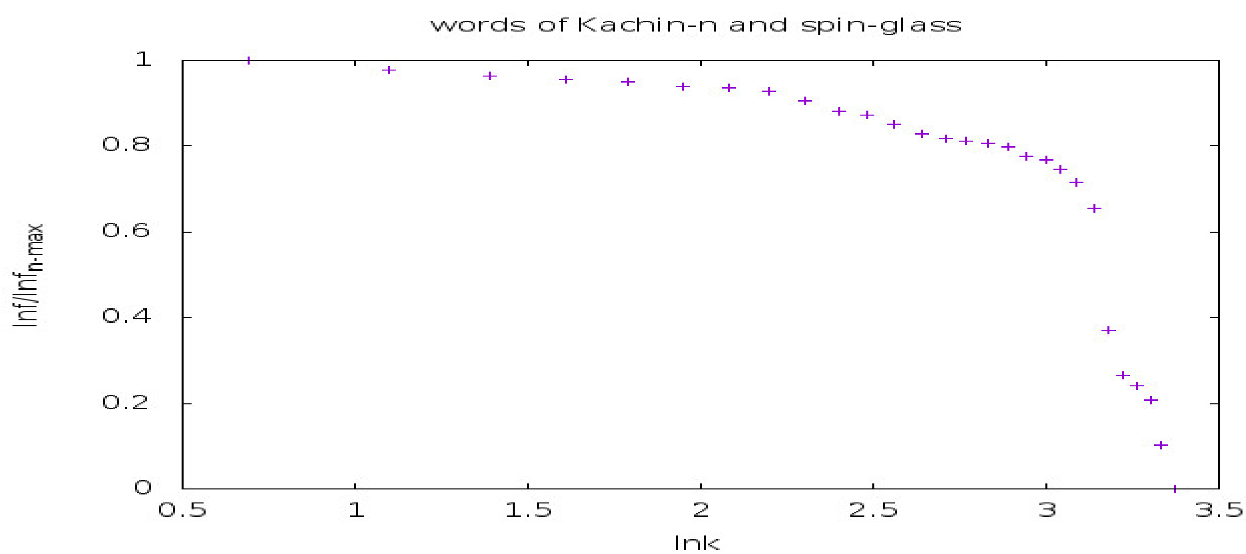

FIG. 8. The vertical axis is $\frac{lnf}{lnf_{next-max}}$ and the horizontal axis is lnk. The + points represent the the words of the Kachin Dictionary.

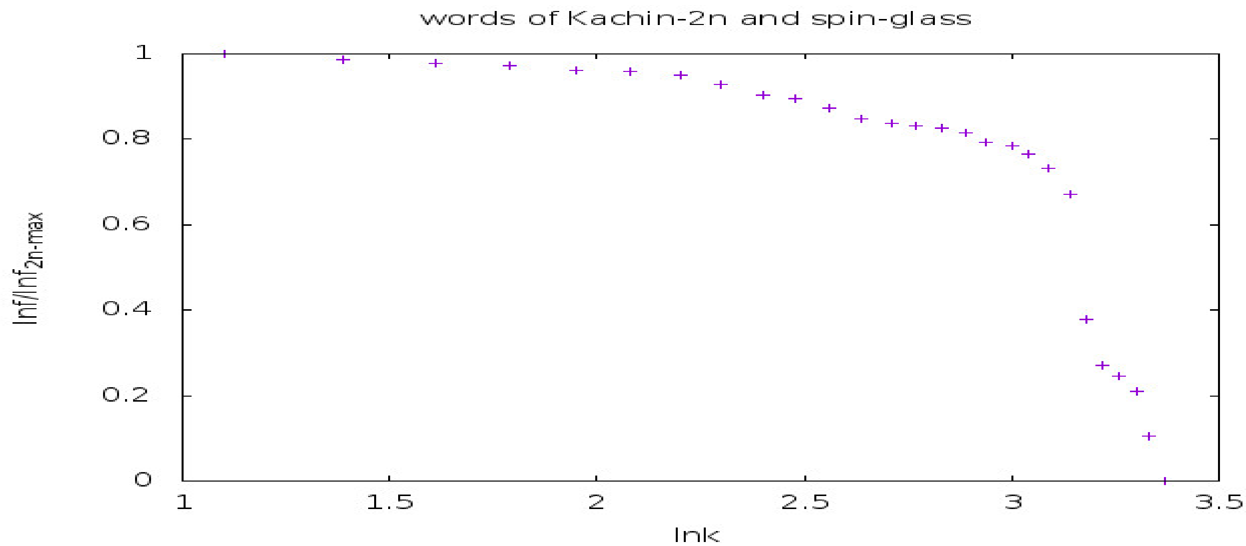

FIG. 9. The vertical axis is $\frac{lnf}{lnf_{nn-max}}$ and the horizontal axis is lnk. The + points represent the the words of the Kachin Dictionary.

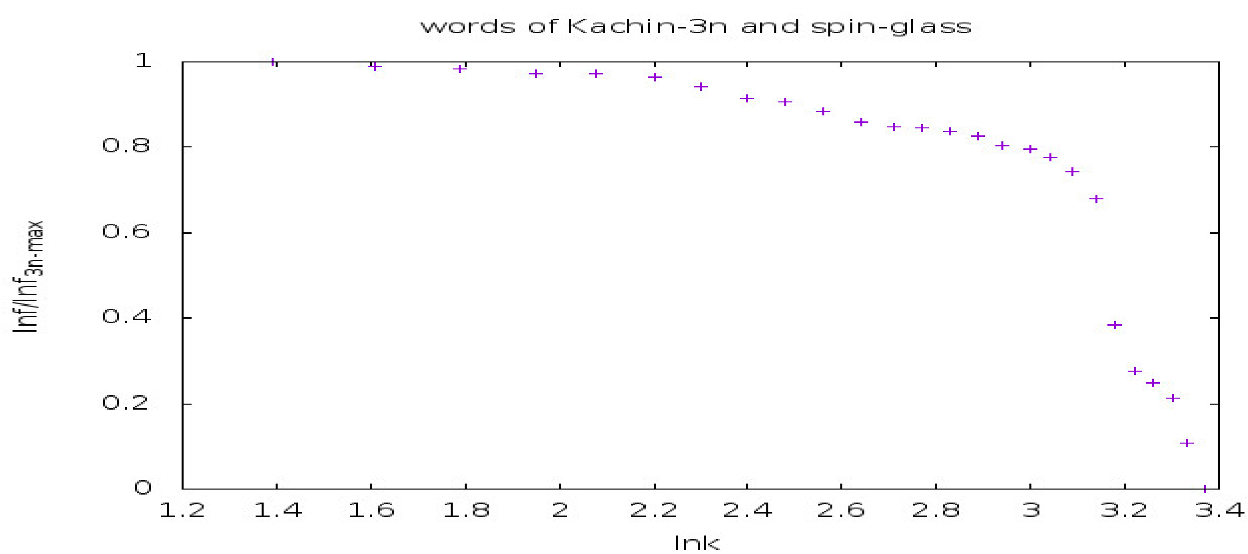

FIG. 10. The vertical axis is $\frac{lnf}{lnf_{nnn-max}}$ and the horizontal axis is lnk. The + points represent the the words of the Kachin Dictionary.

B. conclusion

In the figures Fig.7-Fig.10, below the transition point, the points-line(s) rises nicely like a rectangular hyperbola(the best we have gotten up till now), though the transition is not clear-cut, rather a smoothened transition and above the transition point, pointsline(s) slopes up to some extent, rather than fully horizontal. Hence, the words of the Kachin Dictionary, [1], is preferably be described by a Spin-Glass magnetisation curve, [42], in the presence of little external magnetic field.

IV. ACKNOWLEDGMENT

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