Swahili, a lingua franca, Swahili-English Dictionary by C. W. Rechenbach and the Graphical Law

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Abstract

We study the Swahili-English Dictionary by Charles W. Rechenbach. We draw the natural logarithm of the number of the words, normalised, starting with a letter vs the natural logarithm of the rank of the letter, normalised. We find that the dictionary is classified by BP(4,βH=0.04). β is $\frac{1}{k_B T}$ where, T is temperature and k_B is the Boltzmann constant. BP(4,βH=0.04) is the magnetisation curve for the Bethe-Peierls approximation of the Ising model with four nearest neighbours in the presence of little external magnetic field, H, such that βH is equal to 0.04. Moreover, the words of the dictionary go over to the Onsager solution on successive normalisations.

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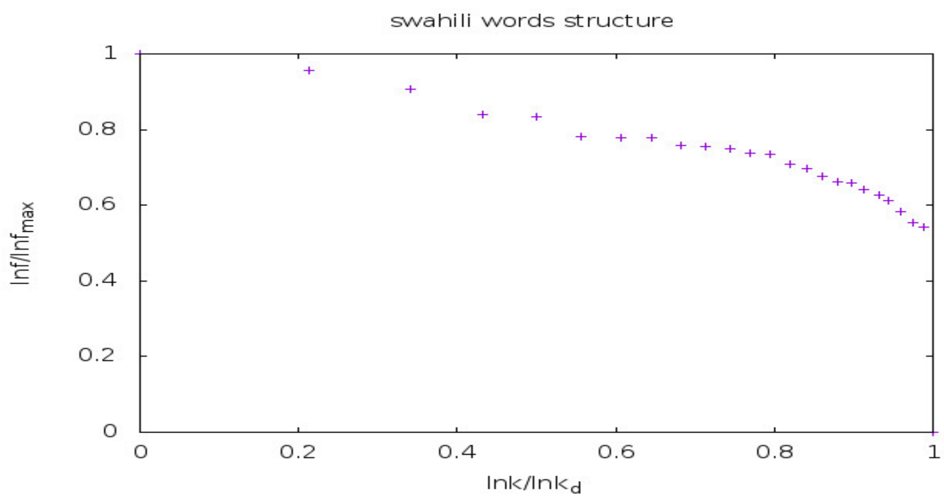

FIG. 1. The vertical axis is $\frac{lnf}{lnf_{max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the words of the Swahili language. There is a marked distinction between group of points before $\frac{lnk}{lnk_{lim}}$ being before 0.55 and after 0.55. Points after $\frac{lnk}{lnk_{lim}}$ being equal to 0.68, come clearly nestling in a class.

I. INTRODUCTION

Swahili is a lingua franca in use in Africa starting from the east and south coast. Zanzibar dialect is the "official" version of it. Lot of words are added onto the vocabualry from Arabic, Portugese, German etc. Probably this feature is apparent in the figure, fig.1. This is a result of our study of the Swahili-English Dictionary, [1].

In this article, we study magnetic field pattern behind this dictionary of the Swahili,[1]. 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], 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 headwords of the dictionary of the Swahili language, [1]. Sections IV and 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 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,[23], 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, [24], $2\epsilon\gamma\bar{\sigma} + 2H$, where γ is the number of nearest neighbours of a spin. According to Boltzmann principle, $\frac{N_-}{N_+}$ equals $exp(-\frac{\triangle E}{k_B T})$, [25]. In the Bragg-Williams approximation,[26], $\bar{\sigma} = L$, considered in the thermal average sense. Consequently,

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

where, $c = \frac{H}{\gamma\epsilon}$, $T_c = \gamma\epsilon/k_B$, [27]. $\frac{T}{T_c}$ 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 [24]. 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, [23],[24],[25],[26],[27], due to Bethe-Peierls, [28], 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.2. 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.]

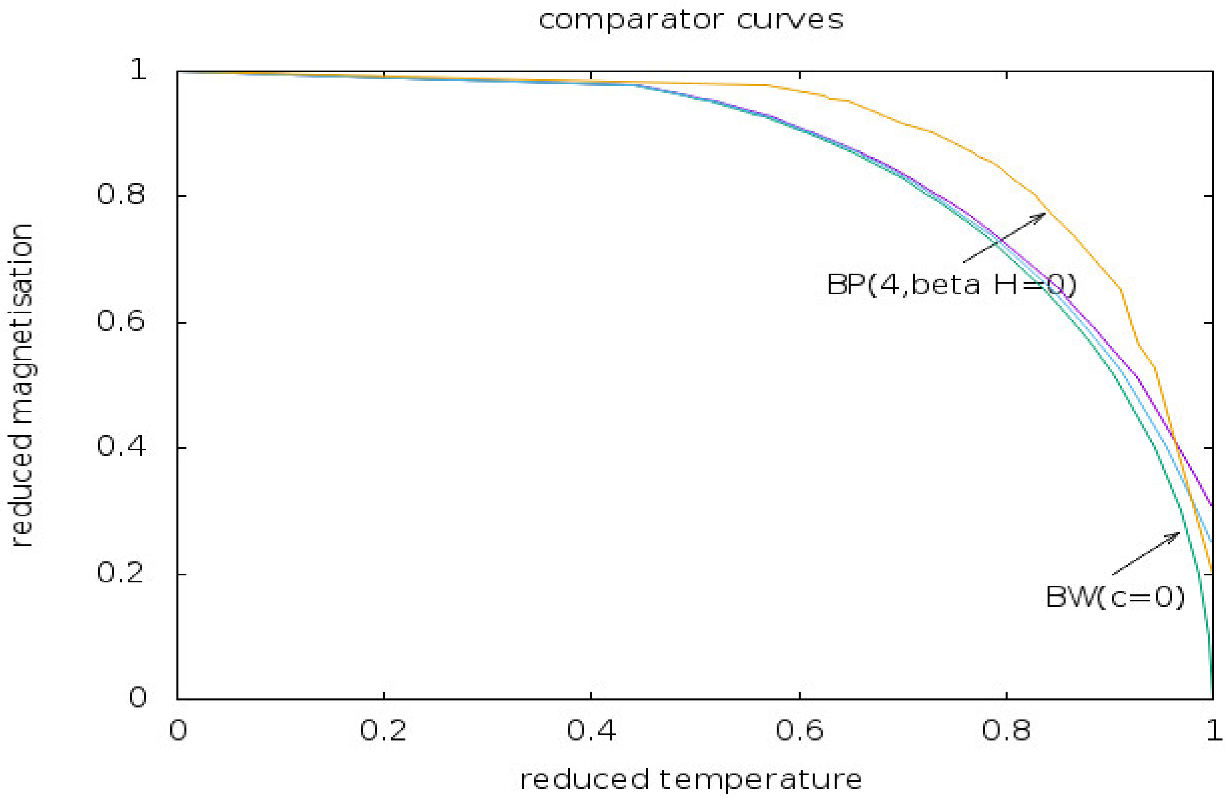

FIG. 2. Reduced magnetisation vs reduced temperature curves, for the Bragg-Williams approximation, in the absence (BW(c=0)) and in the presence (BW(c=0.005), BW(c=0.01)) of magnetic field, $c = 0$, $c = \frac{H}{\gamma\epsilon} = 0.005$, $c = \frac{H}{\gamma\epsilon} = 0.01$, outwards; and in the Bethe-Peierls approximation, BP(4,βH=0), in the absence of magnetic field, for four nearest neighbours (outer in the top).

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

In the Bethe-Peierls approximation scheme , [28], reduced magnetisation varies with reduced temperature, for γ 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 [28] 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,

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

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.3. Similarly, we plot fig.4. Empty spaces in the table, II, mean corresponding point pairs were not used for plotting a line.

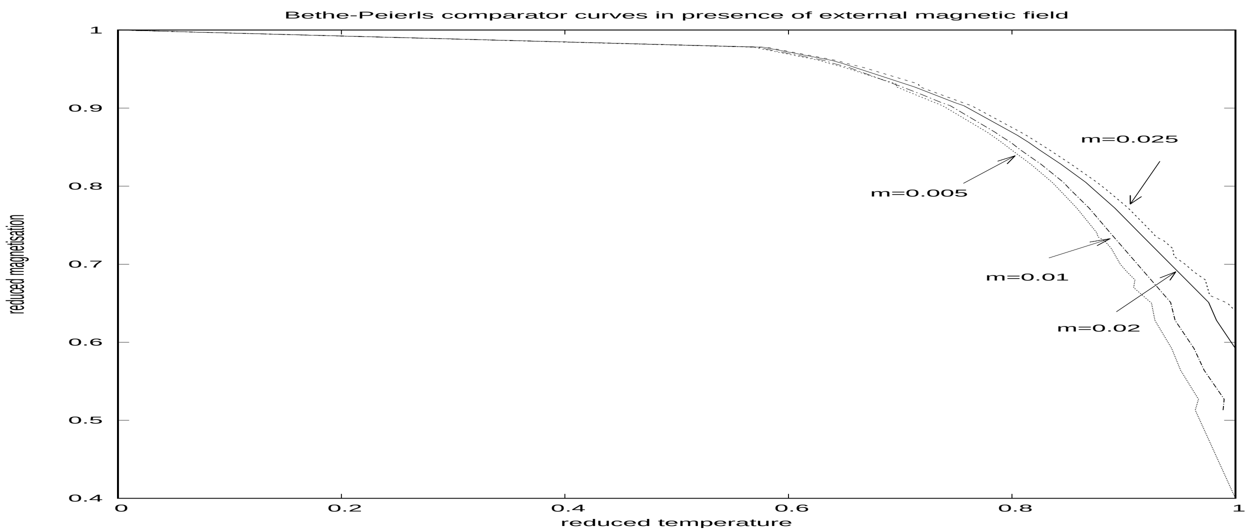

FIG. 3. Reduced magnetisation vs reduced temperature curves for Bethe-Peierls approximation in presence of little external magnetic fields, for four nearest neighbours, with $\beta H = 2m$.

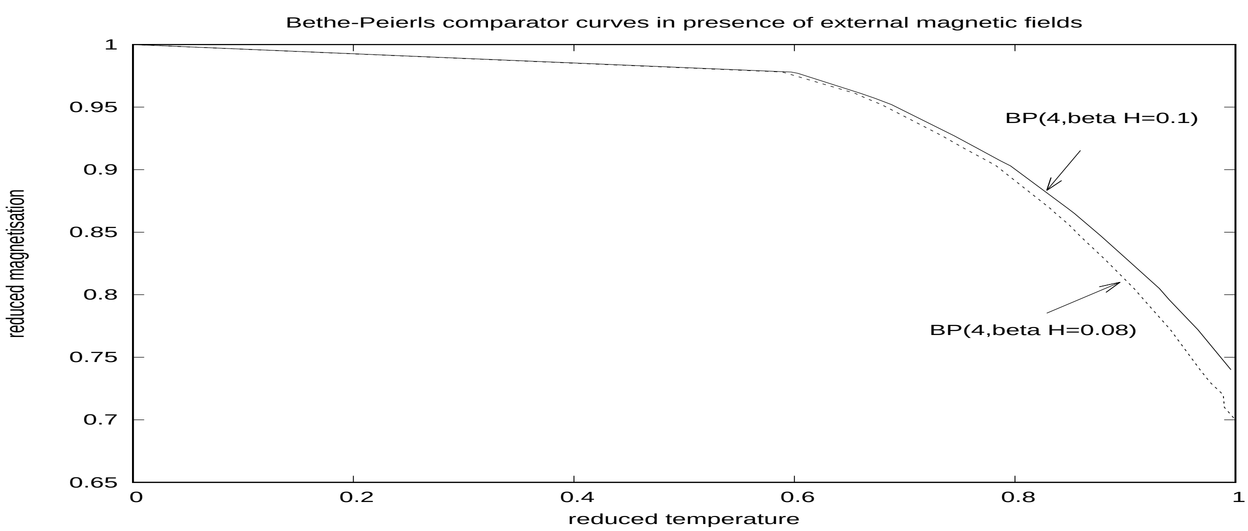

FIG. 4. Reduced magnetisation vs reduced temperature curves for Bethe-Peierls approximation in presence of little external magnetic fields, for four nearest neighbours, with $\beta H = 2m$.

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

D. Onsager solution

At a temperature T, below a certain temperature called phase transition temperature, T_c, for the two dimensional Ising model in absence of external magnetic field i.e. for H equal to zero, the exact, unapproximated, Onsager solution gives reduced magnetisation as a function of reduced temperature as, [29], [30], [31], [28],

$$\frac{M}{M_{max}} = [1 - (sinh\frac{0.8813736}{\frac{T}{T_c}})^{-4}]^{1/8}.$$

Graphically, the Onsager solution appears as in fig.5.

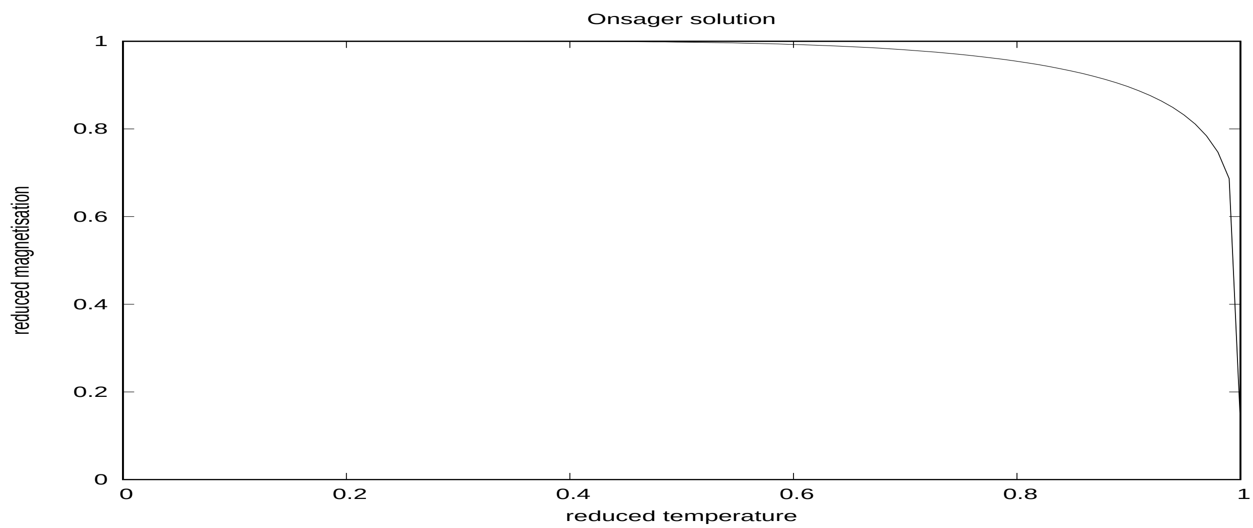

FIG. 5. Reduced magnetisation vs reduced temperature curves for exact solution of two dimensional Ising model, due to Onsager, in absence of external magnetic field

A	B	CH	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
419	517	429	358	106	370	291	403	136	263	2100	224	3008	507	84	503	0	203	845	800	1429	152	171	0	76	194

TABLE III. Swahili words

III. ANALYSIS OF WORDS OF THE SWAHILI-ENGLISH DICTIONARY

The Swahili language alphabet, written in the latin script, is composed of twenty four letters. Twenty three are English letters. There is no "C", no "Q", no "X". "CH" is a new "letter" instead. We take a Swahili-English dictionary,[1]. Then we count all the words, [1], one by one from the beginning to the end, starting with different letters. Strictly speaking, we have counted all the headwords. The result is the table, III.

Highest number of words, three thousand eight, starts with the letter M followed by words numbering two thousand one hundred beginning with K, one thousand four hundred twenty nine with the letter U etc. To visualise we plot the number of words against respective letters in the dictionary sequence, [1], in the figure fig.6. It is noticable of the lessness of the number of major peaks compared to the number of minor peaks, probably a common feature of a lingua franca. 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, in this case up to 1500, from above.

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, denoted by k. Moreover, we attach a limiting rank, k_{lim}, and a limiting number of words. The limiting rank is maximum rank plus one, denoted as k_{lim} or, k_d. Here it is twenty five and the limiting number of words is one. As a result, k is a positive integer starting from one and both $\frac{lnf}{lnf_{max}}$ and $\frac{lnk}{lnk_{lim}}$ varies from zero to one. Then we tabulate in the adjoining table, IV and plot $\frac{lnf}{lnf_{max}}$ against $\frac{lnk}{lnk_{lim}}$ in the figure fig.7. We then ignore the letter with the highest of words, 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.8. This program then we repeat up to $k = 11$, resulting in figures up to fig.17.

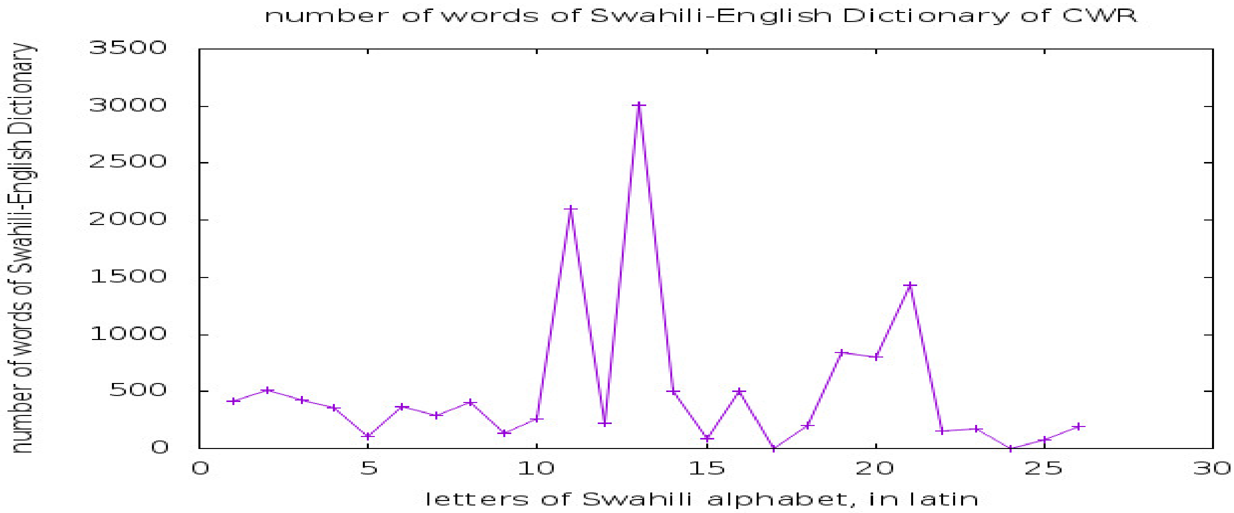

FIG. 6. The vertical axis is number of headwords of the Swahili language, [1], and the horizontal axis is the respective letters. Letters are represented by the sequence number in the English alphabet, position of "C" being taken by "CH".

k	lnk	lnk/lnk_{lim}	f	lnf	lnf/lnf_{max}	lnf/lnf_{n-max}	lnf/lnf_{2nmax}	lnf/lnf_{3nmax}	lnf/lnf_{4nmax}	lnf/lnf_{5nmax}	lnf/lnf_{6nmax}	lnf/lnf_{7nmax}	lnf/lnf_{8nmax}	lnf/lnf_{9nmax}	lnf/lnf_{10nmax}
1	0	0	3008	8.009	1	Blank	Blank	Blank	Blank	Blank	Blank	Blank	Blank	Blank	Blank
2	0.69	0.214	2100	7.650	0.955	1	Blank	Blank	Blank	Blank	Blank	Blank	Blank	Blank	Blank
3	1.10	0.342	1429	7.265	0.907	0.950	1	Blank	Blank	Blank	Blank	Blank	Blank	Blank	Blank
4	1.39	0.432	845	6.739	0.841	0.881	0.928	1	Blank	Blank	Blank	Blank	Blank	Blank	Blank
5	1.61	0.500	800	6.685	0.835	0.874	0.920	0.992	1	Blank	Blank	Blank	Blank	Blank	Blank
6	1.79	0.556	517	6.248	0.780	0.817	0.860	0.927	0.935	1	Blank	Blank	Blank	Blank	Blank
7	1.95	0.606	507	6.229	0.778	0.814	0.857	0.924	0.932	0.997	1	Blank	Blank	Blank	Blank
8	2.08	0.646	503	6.221	0.777	0.813	0.856	0.923	0.931	0.996	0.999	1	Blank	Blank	Blank
9	2.20	0.683	429	6.061	0.757	0.792	0.834	0.899	0.907	0.970	0.973	0.974	1	Blank	Blank
10	2.30	0.714	419	6.038	0.754	0.789	0.831	0.896	0.903	0.966	0.969	0.971	0.996	1	Blank
11	2.40	0.745	403	5.999	0.749	0.784	0.826	0.890	0.897	0.960	0.963	0.964	0.990	0.994	1
12	2.48	0.770	370	5.914	0.738	0.773	0.814	0.878	0.885	0.947	0.949	0.951	0.976	0.979	0.986
13	2.56	0.795	358	5.881	0.734	0.769	0.809	0.873	0.880	0.941	0.944	0.945	0.970	0.974	0.980
14	2.64	0.820	291	5.673	0.708	0.742	0.781	0.842	0.849	0.908	0.911	0.912	0.936	0.940	0.946
15	2.71	0.842	263	5.572	0.696	0.728	0.767	0.827	0.834	0.892	0.895	0.896	0.919	0.923	0.929
16	2.77	0.860	224	5.412	0.676	0.707	0.745	0.803	0.810	0.866	0.869	0.870	0.893	0.896	0.902
17	2.83	0.879	203	5.313	0.663	0.695	0.731	0.788	0.795	0.850	0.853	0.854	0.877	0.880	0.886
18	2.89	0.898	194	5.268	0.658	0.689	0.725	0.782	0.788	0.843	0.846	0.847	0.869	0.872	0.878
19	2.94	0.913	171	5.142	0.642	0.672	0.708	0.763	0.769	0.823	0.825	0.827	0.848	0.852	0.857
20	3.00	0.932	152	5.024	0.627	0.657	0.692	0.746	0.752	0.804	0.807	0.808	0.829	0.832	0.837
21	3.04	0.944	136	4.913	0.613	0.642	0.676	0.729	0.735	0.786	0.789	0.790	0.811	0.814	0.819
22	3.09	0.960	106	4.663	0.582	0.610	0.642	0.692	0.698	0.746	0.749	0.750	0.769	0.772	0.777
23	3.14	0.975	84	4.431	0.553	0.579	0.610	0.658	0.663	0.709	0.711	0.712	0.731	0.734	0.739
24	3.18	0.988	76	4.331	0.541	0.566	0.596	0.643	0.648	0.693	0.695	0.696	0.715	0.717	0.722
25	3.22	1	1	0	0	0	0	0	0	0	0	0	0	0	0

TABLE IV. Swahili language words: ranking,natural logarithm, normalisations

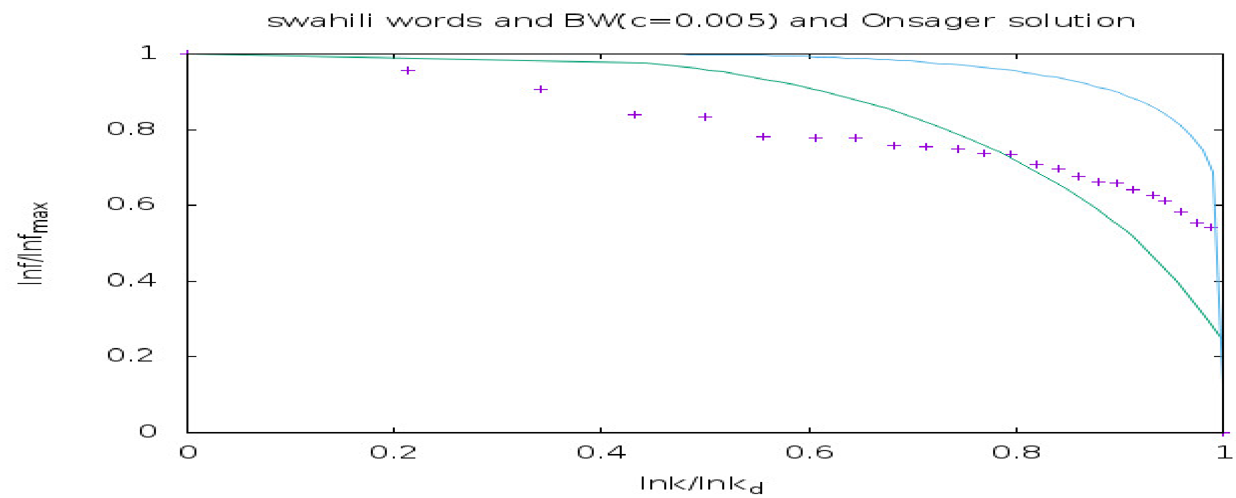

FIG. 7. The vertical axis is $\frac{lnf}{lnf_{max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the words of the Swahili language with the fit curve being the Bragg-Williams curve, BW(c=0.005), in the presence of external magnetic field. The uppermost curve is the Onsager solution.

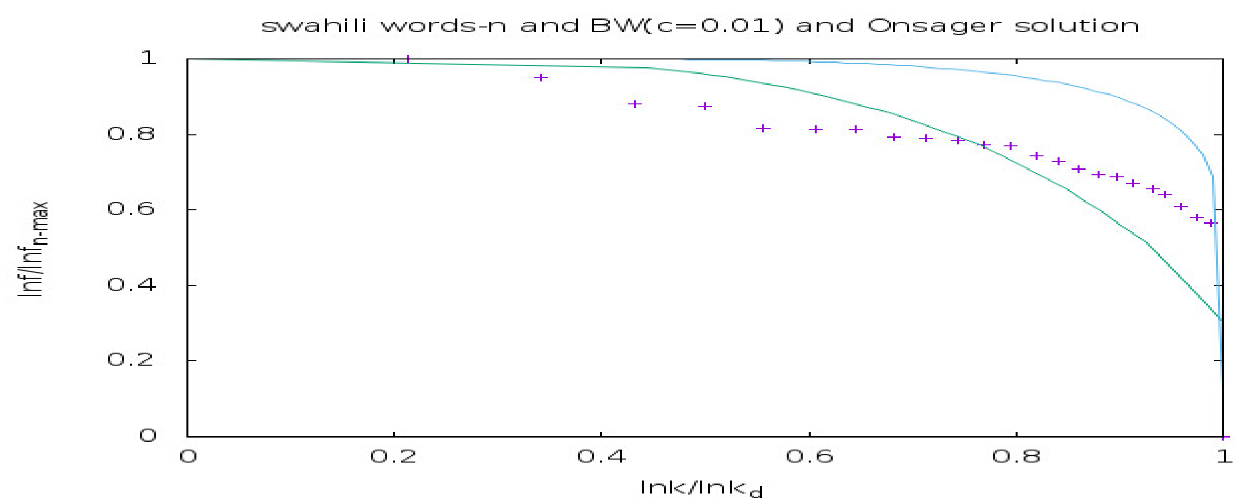

FIG. 8. The vertical axis is $\frac{lnf}{lnf_{next-max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the words of the Swahili language with the fit curve being the Bragg-Williams curve, BW(c=0.01), in the presence of external magnetic field. The uppermost curve is the Onsager solution.

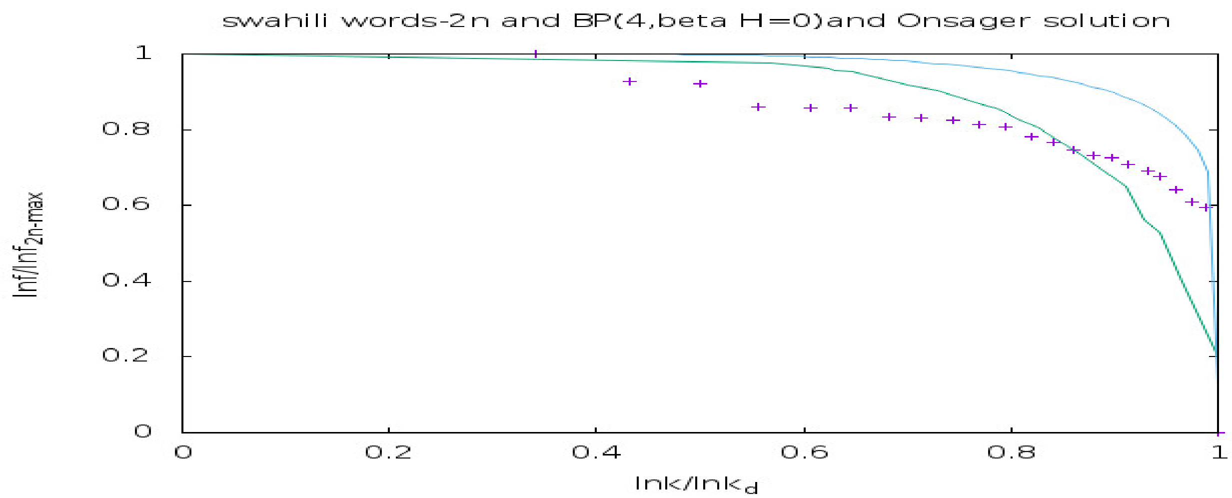

FIG. 9. The vertical axis is $\frac{lnf}{lnf_{nextnext-max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the words of the Swahili language with the fit curve being the Bethe-Peierls curve, BP(4, $\beta H = 0$), with four nearest neighbours, in the absence of external magnetic field. The uppermost curve is the Onsager solution.

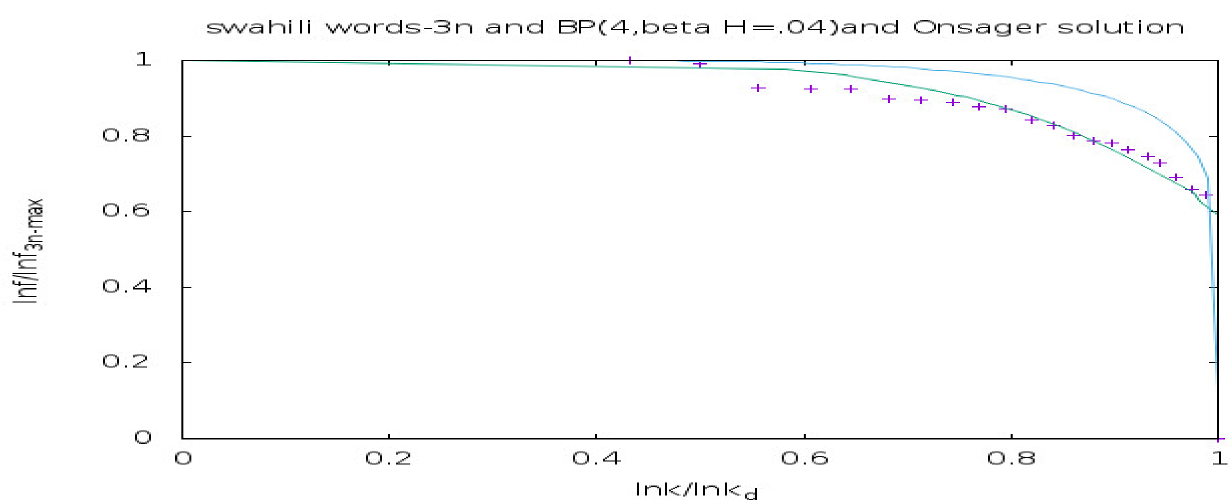

FIG. 10. The vertical axis is $\frac{lnf}{lnf_{nextnextnext-max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the words of the Swahili language with the fit curve being the Bethe-Peierls curve, BP(4, $\beta H = 0.04$), with four nearest neighbours, in the presence of little magnetic field, m=0.02 or, $\beta H = 0.04$. The uppermost curve is the Onsager solution.

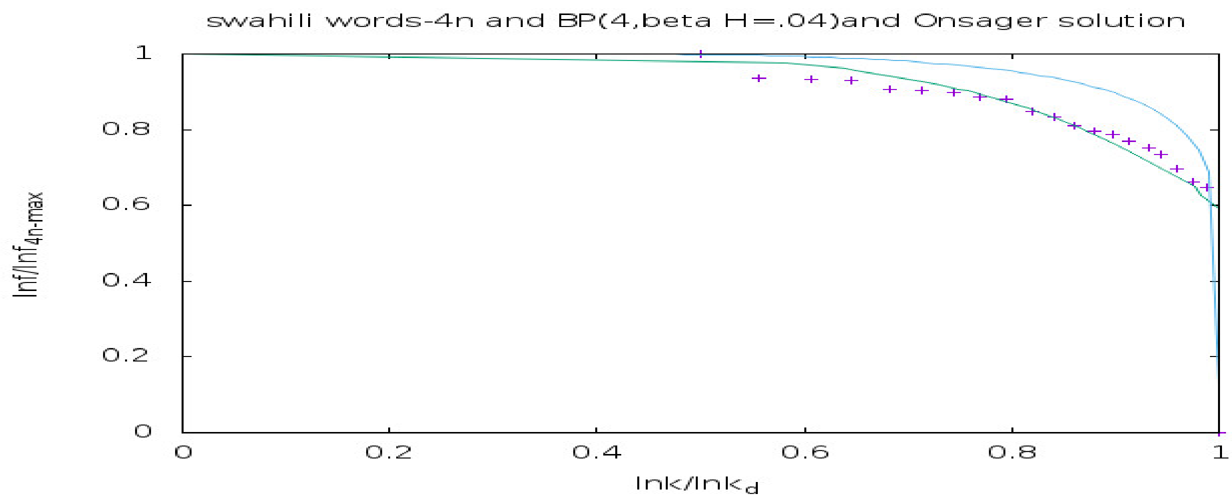

FIG. 11. The vertical axis is $\frac{lnf}{lnf_{nextnextnextnext-max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the words of the Swahili language with the fit curve being the Bethe-Peierls curve, BP(4, $\beta H = 0.04$), with four nearest neighbours, in the presence of little magnetic field, m=0.02 or, $\beta H = 0.04$. The uppermost curve is the Onsager solution.

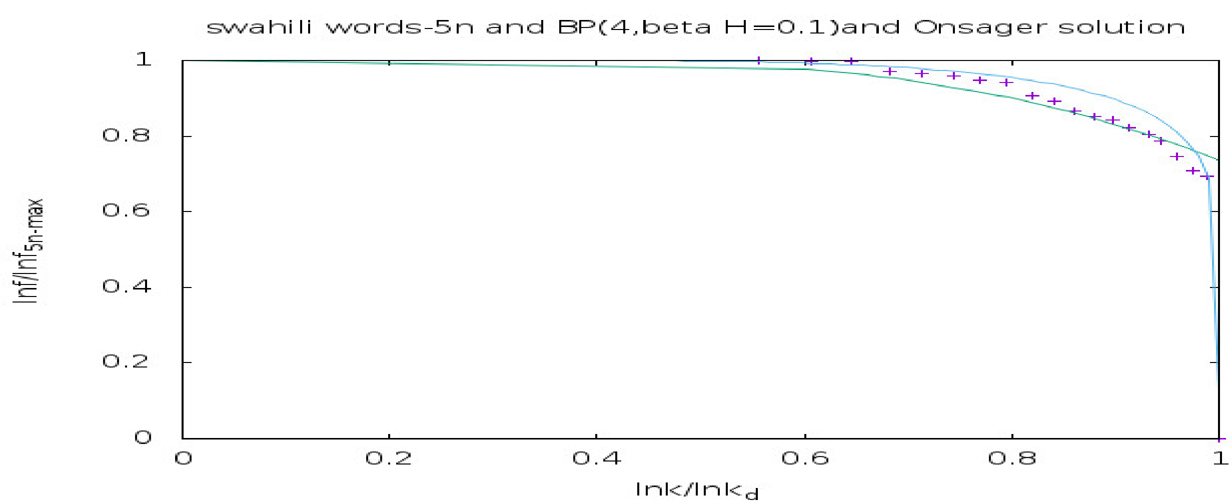

FIG. 12. The vertical axis is $\frac{lnf}{lnf_{nnnnn-max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the words of the Swahili language with the fit curve being the Bethe-Peierls curve, BP(4, $\beta H = 0.1$), with four nearest neighbours, in presence of little magnetic field, m=0.05 or, $\beta H = 0.1$. The uppermost curve is the Onsager solution.

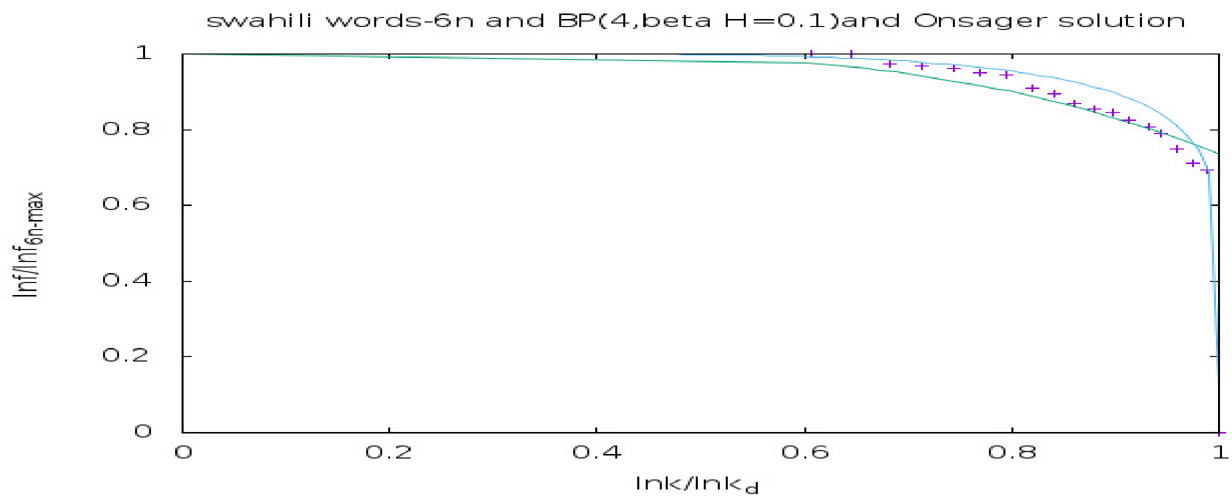

FIG. 13. The vertical axis is $\frac{lnf}{lnf_{6n-max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the words of the Swahili language with the fit curve being the Bethe-Peierls curve, BP(4, $\beta H = 0.1$), with four nearest neighbours, in presence of little magnetic field, m=0.05 or, $\beta H = 0.1$. The uppermost curve is the Onsager solution.

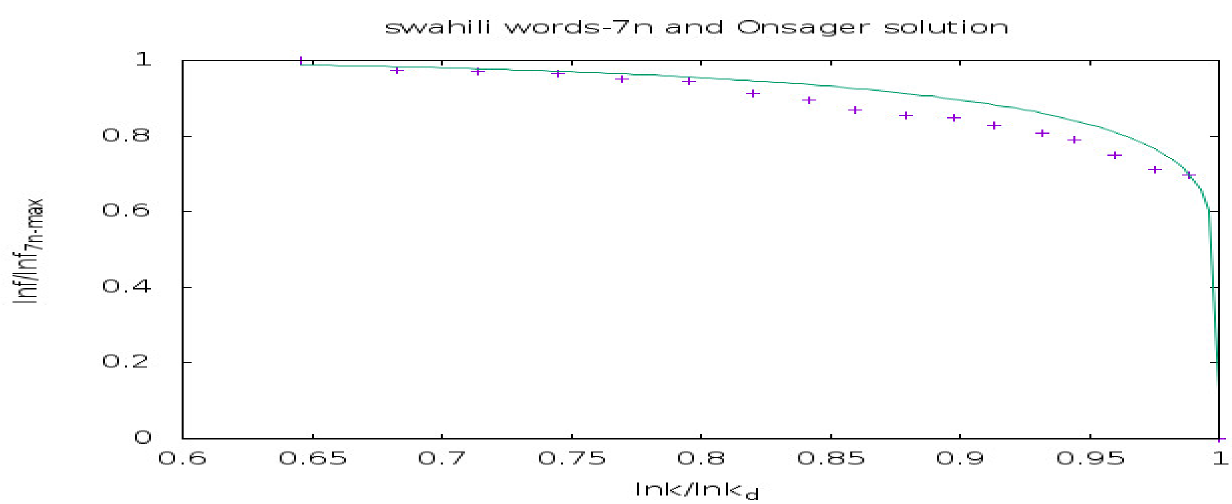

FIG. 14. The vertical axis is $\frac{lnf}{lnf_{7n-max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the words of the Swahili language. The reference curve is the Onsager solution.

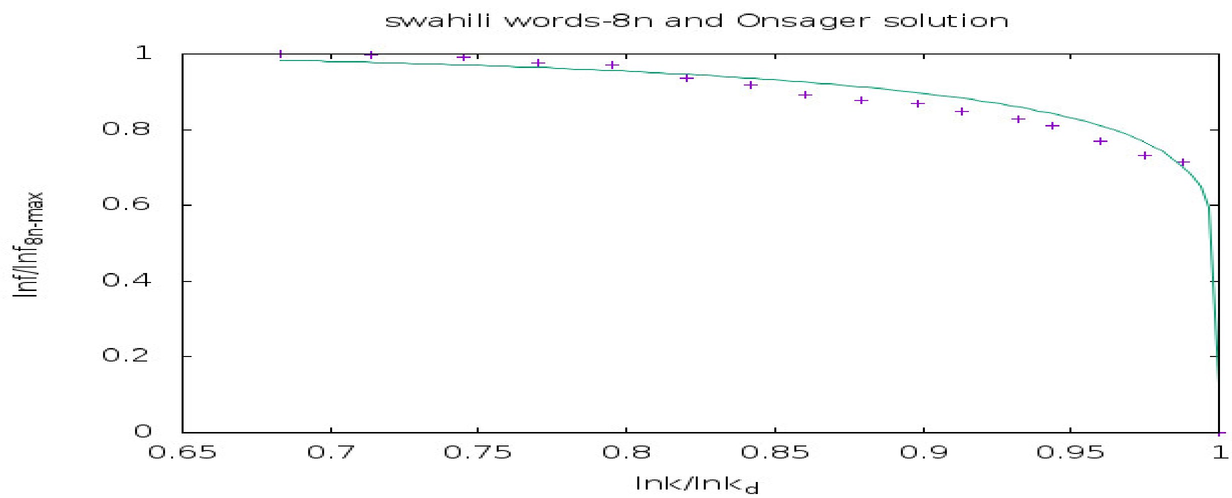

FIG. 15. The vertical axis is $\frac{lnf}{lnf_{8n-max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the words of the Swahili language. The reference curve is the Onsager solution.

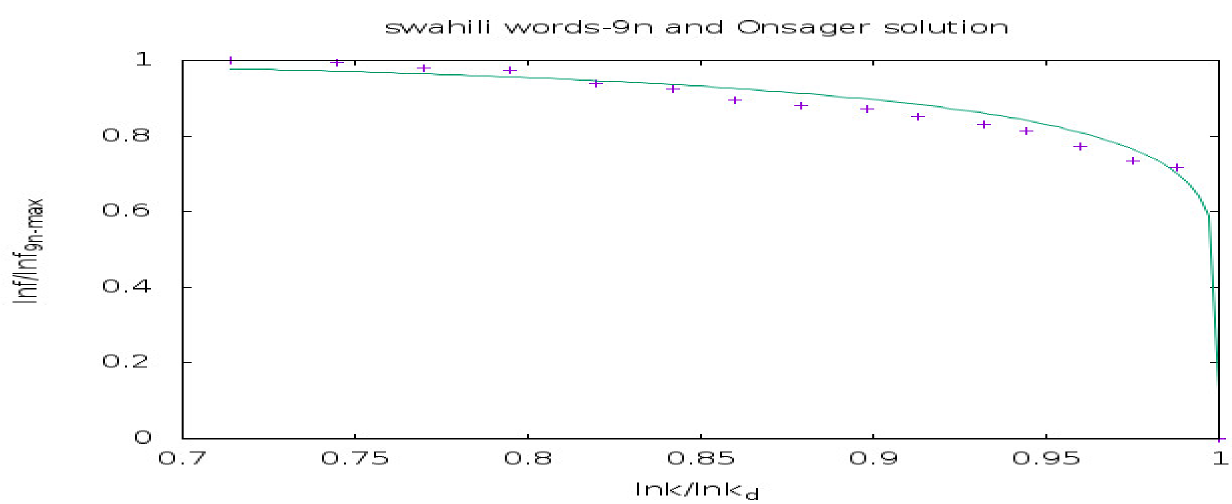

FIG. 16. The vertical axis is $\frac{lnf}{lnf_{9n-max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the words of the Swahili language. The reference curve is the Onsager solution.

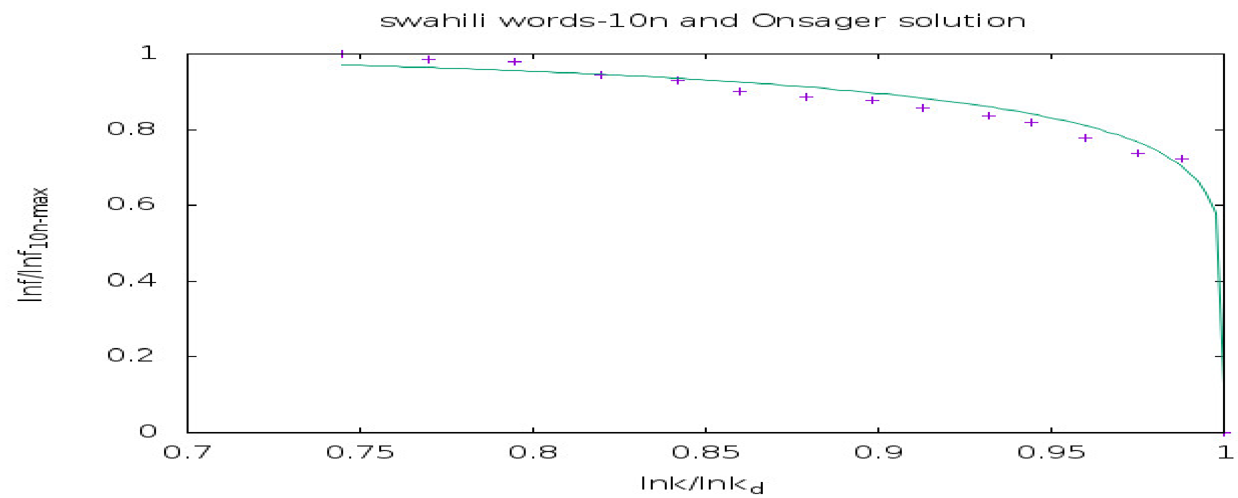

FIG. 17. The vertical axis is $\frac{lnf}{lnf_{10n-max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the words of the Swahili language. The reference curve is the Onsager solution.

A. conclusion

From the figures (fig.7-fig.17, we observe that there is a curve of magnetisation, behind the words of the Swahili language,[1]. This is the magnetisation curve, BP(4,βH=0.04), in the Bethe-Peierls approximation in the presence of little external magnetic field.
Moreover, the associated correspondence is,

$$\frac{lnf}{lnf_{4n-max}} \longleftrightarrow \frac{M}{M_{max}},$$
$$lnk \longleftrightarrow T.$$

k corresponds to temperature in an exponential scale, [33].
On the top of it, on successive higher normalisations, words of the Swahili language,[1] go over to the Onsager solution, in the figure 17.

IV. ACKNOWLEDGMENT

We have used gnuplot for plotting the figures in this paper. We have benefited from reading related pages of Wikipedia.

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