A Greek and English Lexicon by H.G.Liddell et al simplified by Didier Fontaine and the Graphical law

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Abstract

We study a Greek dictionary, A Greek and English Lexicon by H.G.Liddell et al simplified by Didier Fontaine. 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, $\beta H = 0.02$), i.e. the Bethe-Peierls curve in the presence of four nearest neighbours and little external magnetic field, H, with $\beta H = 0.02$. β is $\frac{1}{k_B T}$ where, T is temperature and k_B is the tiny Boltzmann constant.

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I. INTRODUCTION

Sorrounded by innumerable seashores with moderate climate, situated between 34^0 N and 42^0 N, Greece played a pivotal role in the development of the human civilisation. It is the place of one of the earliest written languages. In this article, we like a toddler, turn to this language, delve into a dictionary, A Greek and English Lexicon by H.G.Liddell et al simplified by Didier Fontaine,[1]. We count all entries one by one and probe for the magnetic field pattern. We have started considering magnetic field pattern in [2], in the languages we converse with. We have studied there, a set of natural languages, [2] and have found existence of a magnetisation curve under each language. We have termed this phenomenon as the Graphical law.

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

Critical Theory by Ian Buchanan, [33], the Penguin Dictionary Of Economics, [34], the Concise Gojri-English Dictionary by Dr. Rafeeq Anjum, [35], A Dictionary of the Kachin Language by Rev.O.Hanson, [36], A Dictionary Of World History by Edmund Wright, [37], Ekagi-Dutch-English-Indonesian Dictionary by J. Steltenpool, [38], A Dictionary of Plant Sciences by Michael Allaby, [39], respectively. The graphical law was pursued more in Along the side of the Onsager's solution, the Ekagi language ,[40], Along the side of the Onsager's solution, the Ekagi language-Part Three, [41], Oxford Dictionary of Biology by Robert S. Hine and the Graphical law, [42], A Dictionary of the Mikir Language by G. D. Walker and the Graphical law, [43], A Dictionary of Zoology by Michael Allaby and the Graphical Law, [44], Dictionary of all Scriptures and Myths by G. A. Gaskell and the Graphical Law, [45], Dictionary of Culinary Terms by Philippe Pilibossian and the Graphical law, [46], respectively.

We describe how the graphical law is hidden within a Greek dictionary, A Greek and English Lexicon by H.G.Liddell et al simplified by Didier Fontaine.[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 a Greek dictionary, A Greek and English Lexicon by H.G.Liddell et al simplified by Didier Fontaine,[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 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 $L = \frac{1}{N}\Sigma_i \sigma_i$, 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, $\mu N L$, $M_{max} = \mu N$. $\frac{M}{M_{max}} = L$. $\frac{M}{M_{max}}$ is referred to as reduced magnetisation. Moreover, the Ising Hamiltonian,[47], 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, [48], $2\epsilon\gamma\bar{\sigma} + 2H$, where γ is the number of nearest neighbours of a spin. According to Boltzmann principle, $\frac{N_-}{N_+}$ equals $exp(-\frac{\triangle E}{k_B T})$, [49]. In the Bragg-Williams approximation,[50], $\bar{\sigma} = L$, considered in the thermal average sense. Consequently,

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

where, $c = \frac{H}{\gamma\epsilon}$, $T_c = \gamma\epsilon/k_B$, [51]. $\frac{T}{T_c}$ 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 [48]. 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, [47],[48],[49],[50],[51], due to Bethe-Peierls, [52], 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, I, 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.1. Empty spaces in the table, I, mean corresponding point pairs were not used for plotting a line.

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

TABLE I. Reduced magnetisation vs reduced temperature 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 .

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

In the Bethe-Peierls approximation scheme , [52], reduced magnetisation varies with reduced temperature, for γ neighbours, in presence of external magnetic field, as

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

Derivation of this formula ala [52] is given in the appendix.

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

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

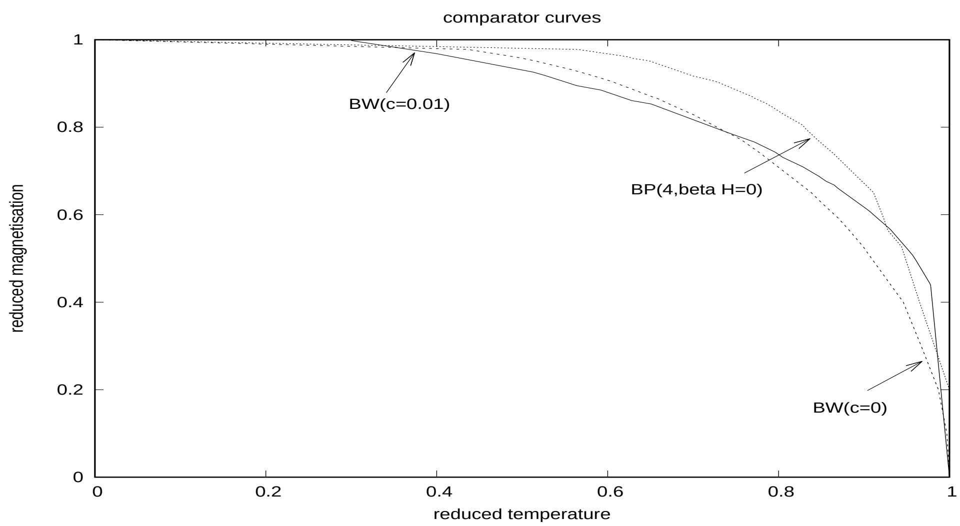

FIG. 1. Reduced magnetisation vs reduced temperature curves for Bragg-Williams approximation, in absence(dark) of and presence(inner in the top) of magnetic field, $c = \frac{H}{\gamma\epsilon} = 0.01$, and Bethe-Peierls approximation in absence of magnetic field, for four nearest neighbours (outer in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

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

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

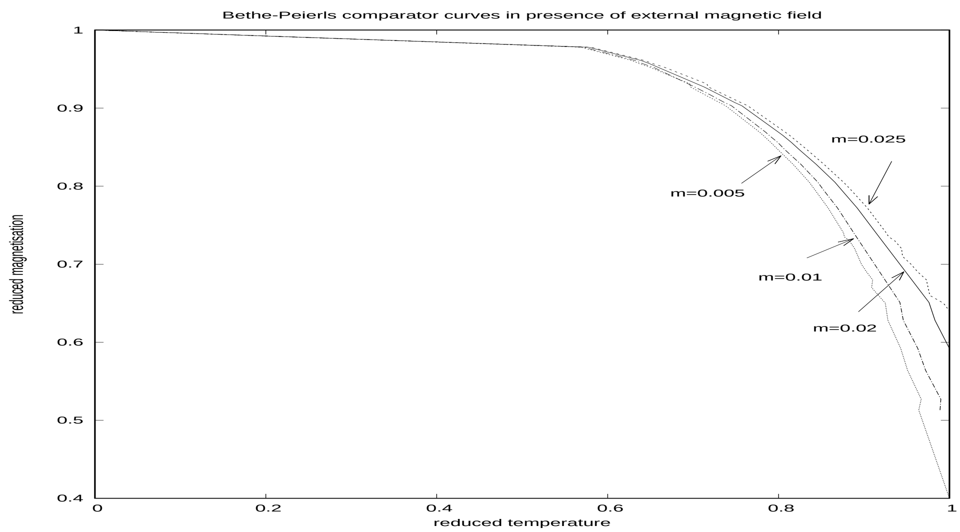

FIG. 2. Reduced magnetisation vs reduced temperature curves for Bethe-Peierls approximation in the presence of little external magnetic fields, for four nearest neighbours, with $\beta H = 2m$.

α	β	γ	δ	ϵ	ζ	η	θ	ι	κ	λ	μ	ν	ξ	o	π	ρ	σ	τ	υ	ϕ	χ	ψ	ω
5800	660	58	1409	4805	129	323	644	531	2726	863	1578	584	116	1316	83	262	2654	1194	1072	876	667	181	136

TABLE III. Greek dictionary entries

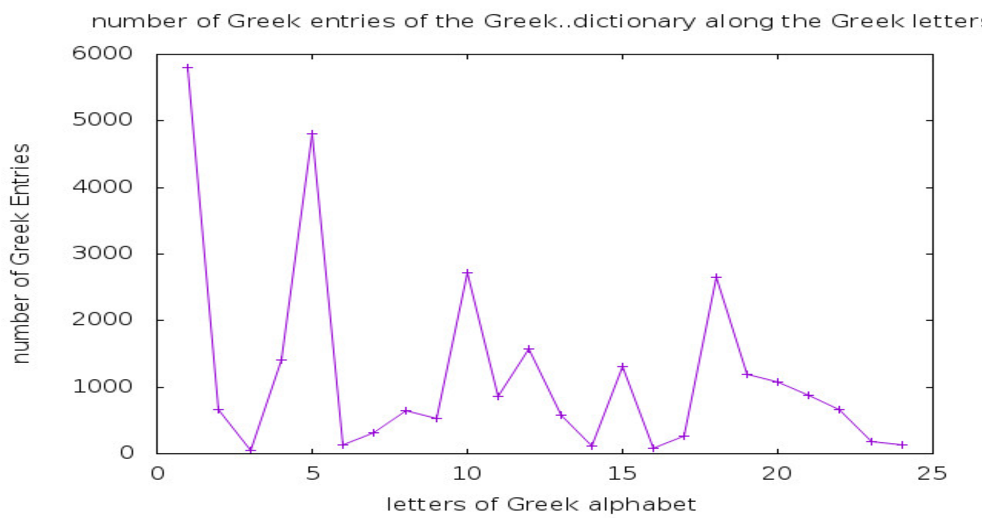

FIG. 3. The vertical axis is number of entries in the Greek dictionary,[1]. The horizontal axis is the letters of the Greek alphabet. Letters are represented by the sequence number in the alphabet.

III. ANALYSIS OF THE GREEK DICTIONARY

In a Greek dictionary, A Greek and English Lexicon by H.G.Liddell et al simplified by Didier Fontaine, [1], we have counted the entries, one by one from the beginning to the end, starting with different letters. The result is the table, III. Highest number of entries, five thousand eight hundred, starts with the letter α followed by entries numbering four thousand eight hundred five beginning with ϵ, two thousand seven hundred twenty six initiating with the letter κ. 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 words, in the descending order, denoted by f and the respective rank, [53], denoted by k. k is a positive integer starting from one. Moreover, we attach a limiting rank, k_{lim}, or, k_d and a limiting number of words. The limiting rank is maximum rank plus one, here it is twenty five and the limiting number of words is one. 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, IV, and plot $\frac{lnf}{lnf_{max}}$ against $\frac{lnk}{lnk_{lim}}$ in the

k	lnk	lnk/lnk_{lim}	f	lnf	lnf/lnf_{max}	lnf/lnf_{n-max}	lnf/lnf_{2n-max}	lnf/lnf_{3n-max}	lnf/lnf_{4n-max}	lnf/lnf_{5n-max}
1	0	0	5800	8.666	1	Blank	Blank	Blank	Blank	Blank
2	0.69	0.214	4805	8.477	0.978	1	Blank	Blank	Blank	Blank
3	1.10	0.342	2726	7.911	0.913	0.933	1	Blank	Blank	Blank
4	1.39	0.432	2654	7.884	0.910	0.930	0.997	1	Blank	Blank
5	1.61	0.500	1578	7.364	0.850	0.869	0.931	0.934	1	Blank
6	1.79	0.556	1409	7.251	0.837	0.855	0.917	0.920	0.985	1
7	1.95	0.606	1316	7.182	0.829	0.847	0.908	0.911	0.975	0.990
8	2.08	0.646	1194	7.085	0.818	0.836	0.896	0.899	0.962	0.977
9	2.20	0.683	1072	6.977	0.805	0.823	0.882	0.885	0.947	0.962
10	2.30	0.714	876	6.775	0.782	0.799	0.856	0.859	0.920	0.934
11	2.40	0.745	863	6.760	0.780	0.797	0.855	0.857	0.918	0.932
12	2.48	0.770	667	6.503	0.750	0.767	0.822	0.825	0.883	0.897
13	2.56	0.795	660	6.492	0.749	0.766	0.821	0.823	0.882	0.895
14	2.64	0.820	644	6.468	0.746	0.763	0.818	0.820	0.878	0.892
15	2.71	0.842	584	6.370	0.735	0.751	0.805	0.808	0.865	0.878
16	2.77	0.860	531	6.275	0.724	0.740	0.793	0.796	0.852	0.865
17	2.83	0.879	323	5.778	0.667	0.682	0.730	0.733	0.785	0.797
18	2.89	0.898	262	5.568	0.643	0.657	0.704	0.706	0.756	0.768
19	2.94	0.913	181	5.198	0.600	0.613	0.657	0.659	0.706	0.717
20	3.00	0.932	136	4.913	0.567	0.580	0.621	0.623	0.667	0.678
21	3.04	0.944	129	4.860	0.561	0.573	0.614	0.616	0.660	0.670
22	3.09	0.960	116	4.754	0.549	0.561	0.601	0.603	0.646	0.656
23	3.14	0.975	83	4.419	0.510	0.521	0.559	0.561	0.600	0.609
24	3.18	0.988	58	4.060	0.468	0.479	0.513	0.515	0.551	0.560
25	3.22	1	1	0	0	0	0	0	0	0

TABLE IV. Entries of the Greek dictionary : ranking, natural logarithm, normalisations

figure fig.4. 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.5. This programme we repeat up to $k = 6$ getting figures up to the figure fig.9.

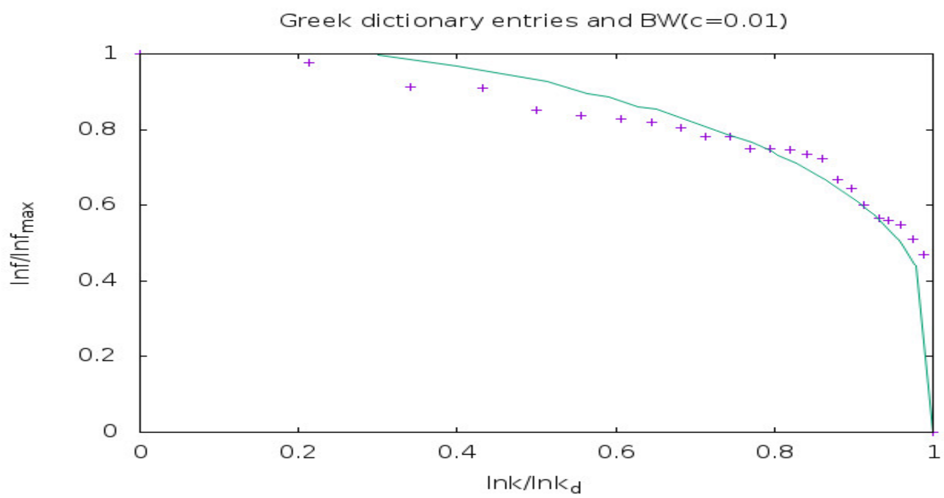

FIG. 4. The vertical axis is $\frac{lnf}{lnf_{max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the entries of the Greek dictionary with the fit curve being the magnetisation curve in the Bragg-Williams approximation, in the presence of external magnetic field, $c = \frac{H}{\gamma\epsilon} = 0.01$.

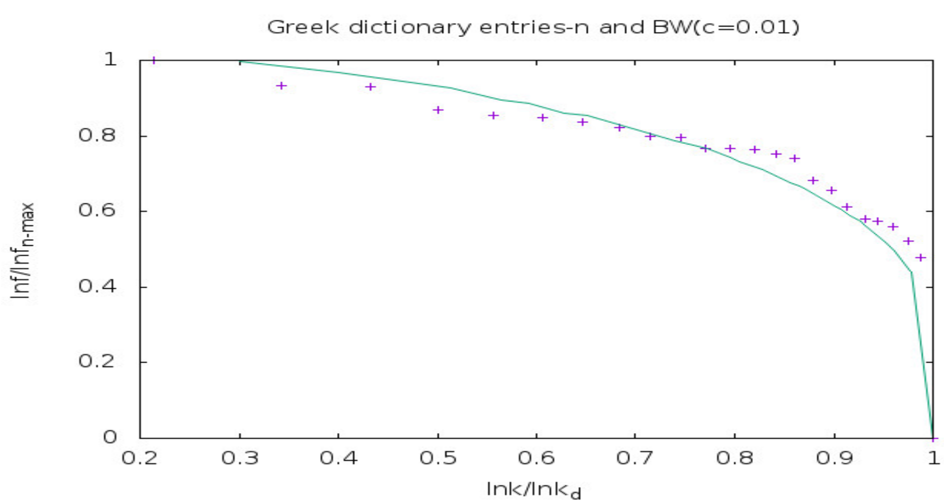

FIG. 5. The vertical axis is $\frac{lnf}{lnf_{n-max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the entries of the Greek dictionary with the fit curve being the magnetisation curve in the Bragg-Williams approximation, in the presence of external magnetic field, $c = \frac{H}{\gamma\epsilon} = 0.01$.

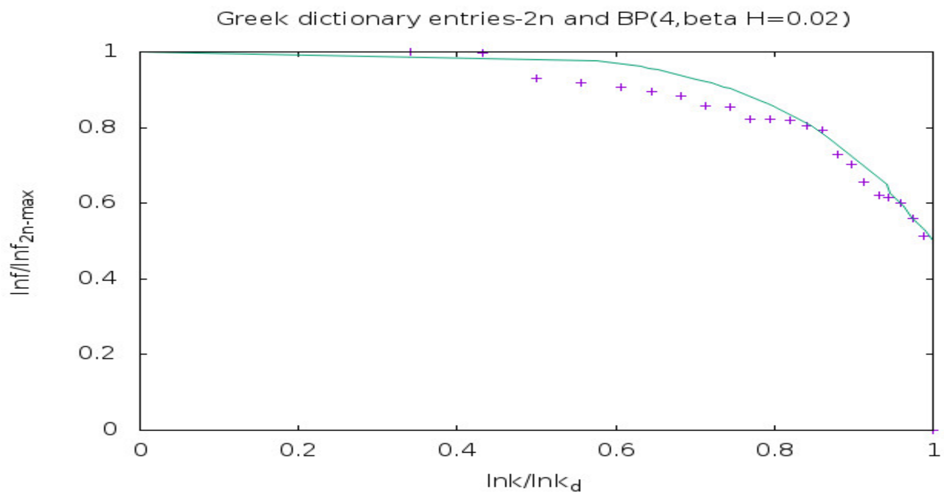

FIG. 6. The vertical axis is $\frac{lnf}{lnf_{2n-max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the entries of the Greek dictionary with the fit curve being the Bethe-Peierls curve in the presence of four nearest neighbours and little external magnetic field, $m = 0.01$ or, $\beta H = 0.02$.

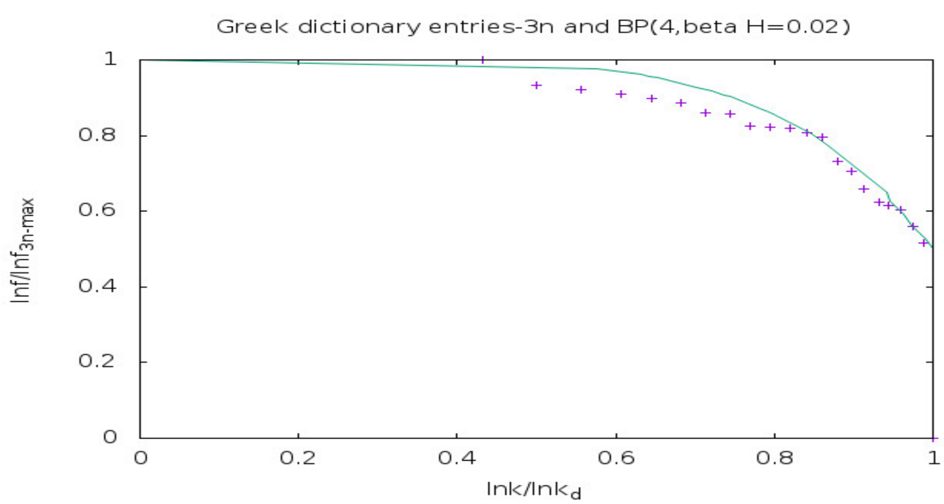

FIG. 7. Vertical axis is $\frac{lnf}{lnf_{3n-max}}$ and horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the words of the entries of the Greek dictionary with the fit curve being the Bethe-Peierls curve in the presence of four nearest neighbours and little external magnetic field, $m = 0.01$ or, $\beta H = 0.02$.

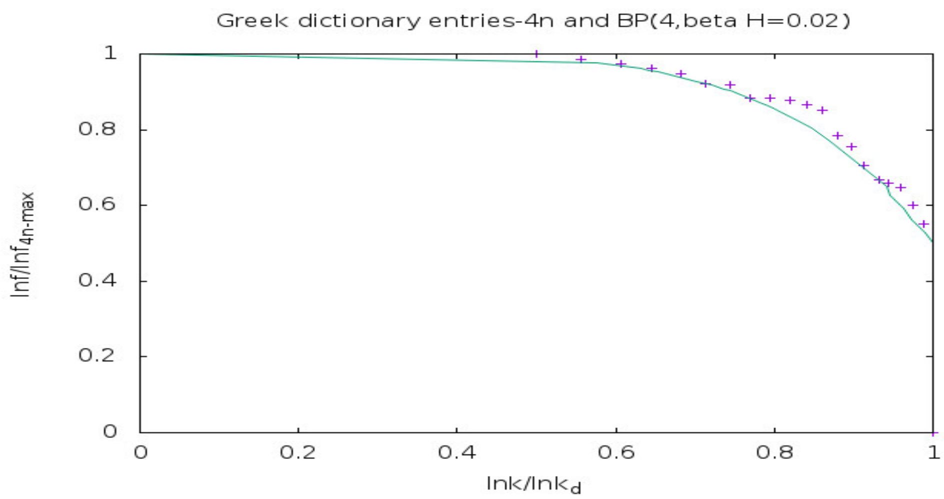

FIG. 8. Vertical axis is $\frac{lnf}{lnf_{4n-max}}$ and horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the words of the entries of the Greek dictionary with the fit curve being Bethe-Peierls curve in the presence of four nearest neighbours and little external magnetic field, $m = 0.01$ or, $\beta H = 0.02$.

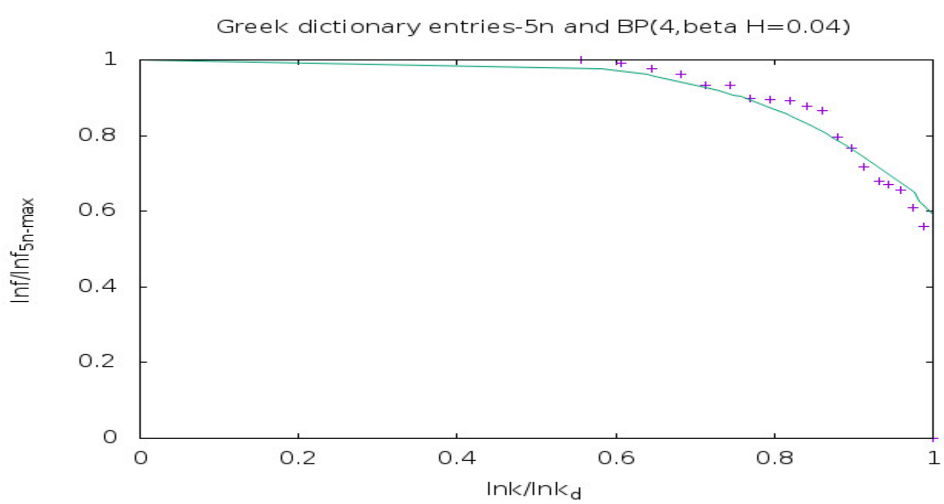

FIG. 9. Vertical axis is $\frac{lnf}{lnf_{5n-max}}$ and horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the words of the entries of the Greek dictionary with the fit curve being Bethe-Peierls curve in the presence of four nearest neighbours and little external magnetic field, $m = 0.02$ or, $\beta H = 0.04$.

A. conclusion

From the figures (fig.4-fig.9), we observe that there is a curve of magnetisation, behind the entries of the Greek dictionary,[1]. This is the magnetisation curve in the Bethe-Peierls approximation in the presence of four nearest neighbours and little external magnetic field, $m = 0.01$ or, $\beta H = 0.02$.

Moreover, the associated correspondance is,

$$\frac{lnf}{lnf_{3n-max}} \longleftrightarrow \frac{M}{M_{max}},$$

$$lnk \longleftrightarrow T.$$

k corresponds to temperature in an exponential scale, [54]. As temperature decreases, i.e. lnk decreases, f increases. The letters which are recording higher entries compared to those which have lesser entries are at lower temperature. As the Greek language expands, the letters like ...,κ, ϵ, α which get enriched more and more, fall at lower and lower temperatures. This is a manifestation of cooling effect, as was first observed in [55], in another way.

IV. ACKNOWLEDGMENT

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

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