

**The Graphical Law behind the head words of Dictionary  
Kannada and English written by W. Reeve, revised, corrected  
and enlarged by Daniel Sanderson**

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**Abstract**

We study the head words of the Dictionary Kannada and English written by W. Reeve, revised, corrected and enlarged by Daniel Sanderson. We draw the natural logarithm of the number of head words, 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  $BW(c=0.01)$ , 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  $\epsilon$  being the strength of coupling between two neighbouring spins in the Ising Model,  $\gamma$  representing the number of nearest neighbours of a spin which very large. Moreover, we put forth a parallelism with a Bengali dictionary.

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## I. INTRODUCTION

Kannada or, Canarese is the language of the state of Karnataka of India. Kannada language alphabet consists of fifty three letters. A dictionary of Kannada language was composed and improved way back in the mid eighteen hundred by W. Reeve and Daniel Sanderson respectively, [1]. We study the magnetic field pattern behind the head entries of this dictionary, [1], in this article. We count all the head entries one by one. 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], 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], respectively.

In our first paper, [2], we have studied the Dictionary Kannada and English written by W. Reeve, revised, corrected and enlarged by Daniel Sanderson,[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  $BW(c=0.01)$ . Here, in this paper we leave behind the approximate method. We count thoroughly, one by one each head word. We conclude here, that the dictionary can be characterised by  $BW(c=0.01)$ ( with a  $BP(4,\beta H=0)$  core).

We describe how a graphical law is hidden within the head words of the Dictionary Kannada and English written by W. Reeve, revised, corrected and enlarged by Daniel Sanderson, [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 head words of the Dictionary Kannada and English written by W. Reeve, revised, corrected and enlarged by Daniel Sanderson, [1]. The section IV is comparison with the bengali language dictionary, [54],[4]. The section V is the reduced alphabet scheme, [9],

the Onsager core and the comparison with the bengali language dictionary, [54],[4]. The section VI is Acknowledgment. The last section is Bibliography.

## II. MAGNETISATION

### A. Bragg-Williams approximation

Let us consider a coin. Let us toss it many times. Probability of getting head or, tale is half i.e. we will get head and tale equal number of times. If we attach value one to head, minus one to tale, the average value we obtain, after many tossing is zero. Instead let us consider a one-sided loaded coin, say on the head side. The probability of getting head is more than one half, getting tale is less than one-half. Average value, in this case, after many tossing we obtain is non-zero, the precise number depends on the loading. The loaded coin is like ferromagnet, the unloaded coin is like para magnet, at zero external magnetic field. Average value we obtain is like magnetisation, loading is like coupling among the spins of the ferromagnetic units. Outcome of single coin toss is random, but average value we get after long sequence of tossing is fixed. This is long-range order. But if we take a small sequence of tossing, say, three consecutive tossing, the average value we obtain is not fixed, can be anything. There is no short-range order.

Let us consider a row of spins, one can imagine them as spears which can be vertically up or, down. Assume there is a long-range order with probability to get a spin up is two third. That would mean when we consider a long sequence of spins, two third of those are with spin up. Moreover, assign with each up spin a value one and a down spin a value minus one. Then total spin we obtain is one third. This value is referred to as the value of long-range order parameter. Now consider a short-range order existing which is identical with the long-range order. That would mean if we pick up any three consecutive spins, two will be up, one down. Bragg-Williams approximation means short-range order is identical with long-range order, applied to a lattice of spins, in general. Row of spins is a lattice of one dimension.

Now let us imagine an arbitrary lattice, with each up spin assigned a value one and a down spin a value minus one, with an unspecified long-range order parameter defined as above by  $L = \frac{1}{N}\sum_i\sigma_i$ , where  $\sigma_i$  is i-th spin, N being total number of spins. L can vary from minus one

to one.  $N = N_+ + N_-$ , where  $N_+$  is the number of up spins,  $N_-$  is the number of down spins.  $L = \frac{1}{N}(N_+ - N_-)$ . As a result,  $N_+ = \frac{N}{2}(1 + L)$  and  $N_- = \frac{N}{2}(1 - L)$ . Magnetisation or, net magnetic moment,  $M$  is  $\mu \sum_i \sigma_i$  or,  $\mu(N_+ - N_-)$  or,  $\mu N L$ ,  $M_{max} = \mu N$ .  $\frac{M}{M_{max}} = L$ .  $\frac{M}{M_{max}}$  is referred to as reduced magnetisation. Moreover, the Ising Hamiltonian,[55], for the lattice of spins, setting  $\mu$  to one, is  $-\epsilon \sum_{n.n} \sigma_i \sigma_j - H \sum_i \sigma_i$ , where n.n refers to nearest neighbour pairs. The difference  $\Delta E$  of energy if we flip an up spin to down spin is, [56],  $2\epsilon\gamma\bar{\sigma} + 2H$ , where  $\gamma$  is the number of nearest neighbours of a spin. According to Boltzmann principle,  $\frac{N_-}{N_+}$  equals  $\exp(-\frac{\Delta E}{k_B T})$ , [57]. In the Bragg-Williams approximation,[58],  $\bar{\sigma} = L$ , 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,  $c = \frac{H}{\gamma\epsilon}$ ,  $T_c = \gamma\epsilon/k_B$ , [59].  $\frac{T}{T_c}$  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 [56]. 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, [55],[56],[57],[58],[59], due to Bethe-Peierls, [60], reduced magnetisation varies with reduced temperature, for  $\gamma$  neighbours, in absence of external magnetic field, as

$$\frac{\ln \frac{\gamma}{\gamma-2}}{\ln \frac{factor-1}{factor^{\frac{\gamma-1}{\gamma}} - factor^{\frac{1}{\gamma}}}} = \frac{T}{T_c}; factor = \frac{\frac{M}{M_{max}} + 1}{1 - \frac{M}{M_{max}}} \quad (2)$$

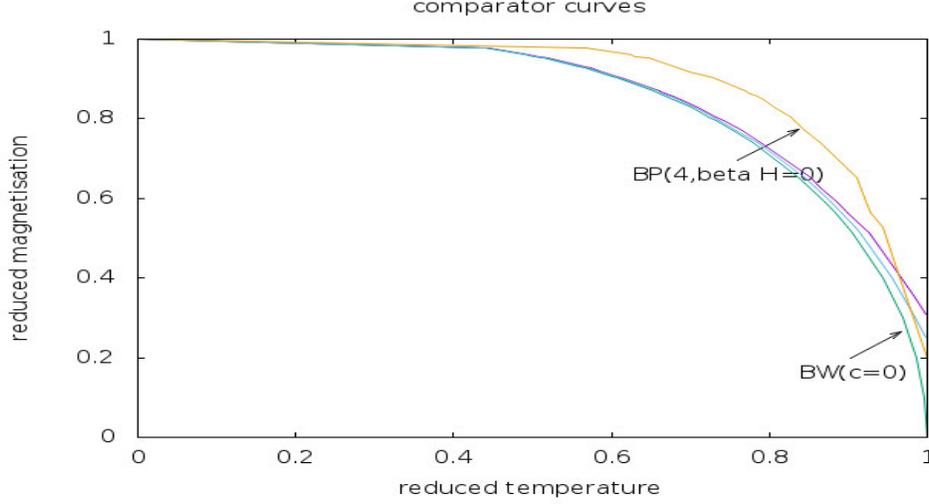


FIG. 1. Reduced magnetisation vs reduced temperature curves, for the Bragg-Williams approximation, in the absence (BW( $c=0$ )) and in the presence (BW( $c=0.005$ ), BW( $c=0.01$ )) of magnetic field,  $c = 0$ ,  $c = \frac{H}{\gamma\epsilon} = 0.005$ ,  $c = \frac{H}{\gamma\epsilon} = 0.01$ , outwards;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

$\ln \frac{\gamma}{\gamma-2}$  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.

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

TABLE I. Datas for Reduced temperature[ for the Bragg-Williams approximation, in the absence (BW(c=0)) and in the presence (BW(c=0.005), BW(c=0.01)) of magnetic field,  $c = 0$ ,  $c = \frac{H}{\gamma\epsilon} = 0.005$ ,  $c = \frac{H}{\gamma\epsilon} = 0.01$  respectively and in the Bethe-Peierls approximation, BP(4, $\beta H=0$ ), in the absence of magnetic field, for four nearest neighbours] vs reduced magnetisation. Reduced temperature is drawn along the x-axis and Reduced magnetisation 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.

a	á	i	í	u	ú	ṛi	e	é	ei	o	ó	ou	ka	kha	ga	gha	gna	cha	chha	ja	jha	nya	ṭa
3069	933	515	152	868	123	16	340	81	71	406	123	74	4538	196	2259	177	0	1281	149	1104	110	0	95
ṭha	ḍa	ḍha	ṇa	ta	tha	da	dha	na	pa	pha	ba	bha	ma	ya	ra	la	va	sha	ṣha	sa	ha	ḷa	kṣha
42	149	24	2	1891	23	1105	174	1459	2881	84	1597	347	2016	303	436	364	1257	596	27	1904	1511	2	9

TABLE II. Kannada head words: the odd rows represent letters of the Kannada alphabet,[1], in the serial order, omitting mostly non-zero entries, the even rows represent number of head words.

### III. ANALYSIS OF THE HEAD WORDS OF THE DICTIONARY KANNADA AND ENGLISH WRITTEN BY W. REEVE, REVISED, CORRECTED AND ENLARGED BY DANIEL SANDERSON

In the Dictionary Kannada and English written by W. Reeve, revised, corrected and enlarged by Daniel Sanderson , [1], we have counted all the head words, one by one from the beginning to the end, starting with different letters. For the letter ha, six pages 1026, 1027, 1030, 1031, 1034, 1035 are missing in the copy we have used. There for these six pages we have added number of head words one hundred eighty, on the basis of average number of head words locally being thirty par page, to the rest number of head words counted one by one, namely one thousand three hundred thirty one, yielding the total number of headwords, one thousand five hundred eleven. The result is the table, II and fig.2.

Dictionary Kannada and English

ಅ (a)	ಆ (ā)	ಇ (i)	ಊ (ī)	ಉ (u)	ಊ (ū)	
# 3069	# 933	# 515	# 152	# 868	# 123	
ಋ (ṛi)	ೠ (ṛ)	ಎ (é)	ಐ (ei)	ಋ (o)	ೠ (ó)	ಌ (ou)
# 16	# 340	# 81	# 71	# 406	# 123	# 74
ಕ (ka)	ಖ (kha)	ಗ (ga)	ಘ (gha)	ಙ (ṅha)	ಚ (cha)	ಛ (chha)
# 4538	# 196	# 2259	# 177	# 0	# 1281	# 149
ಜ (ja)	ಝ (jha)	ಞ (ña)	ಟ (ṭa)	ಠ (ṭha)	ಡ (ḍa)	ಢ (ḍha)
# 1104	# 110	# 0	# 95	# 42	# 149	# 24
ಠ (ṭa)	ಡ (ḍa)	ಢ (ḍha)	ತ (ta)	ಥ (tha)	ದ (da)	ಧ (dha)
# 2	# 1891	# 23	# 1105	# 174	# 1459	
ಪ (pa)	ಫ (pha)	ಬ (ba)	ಭ (bha)	ಮ (ma)	ಯ (ya)	
# 2881	# 84	# 1597	# 347	# 2016	# 303	
ಶ (ṣa)	ಷ (ṣha)	ಸ (sa)	ಸ (śha)	ಹ (ḥa)	ಸ (śa)	
# 436	# 364	# 1257	# 596	# 27	# 1904	
ಹ (ha)	ಱ (ḷa)	ಱ (ḷha)				
# 1511	# 2	# 9				

FIG. 2. Number of head words starting with various letters of the Kannada alphabet

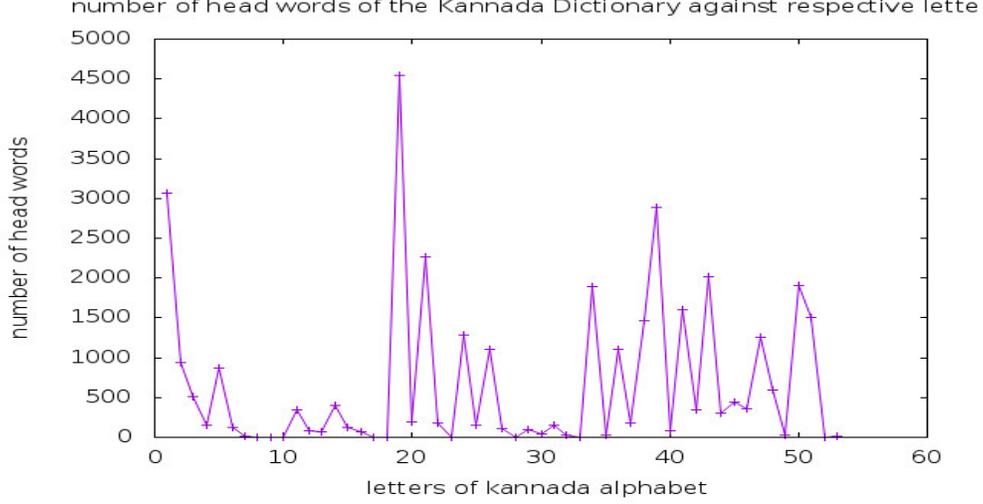


FIG. 3. The vertical axis is the number of head words of the Kannada Dictionary,[1]. The horizontal axis is the letters of the Kannada alphabet. Letters are represented by the sequence number in the alphabet as it appears in the dictionary, [1].

Highest number of head words, four thousand five hundred thirty eight, starts with the letter equivalent of English Ka, followed by head words numbering three thousand sixty nine beginning with the letter equivalent of English A, two thousand eight hundred eighty one with the letter equivalent of English Pa etc. To visualise we plot the number of head words against respective letters in the dictionary sequence,[1], in the adjoining figure, fig.3. For the purpose of exploring graphical law, we assort the letters according to the number of entries, in the descending order, denoted by  $f$  and the respective rank, [61], denoted by  $k$ .  $k$  is a positive integer starting from one. Moreover, the minimum non-zero number of head words is two. Hence, we attach a limiting word number one. The limiting rank is maximum rank plus one, here it is forty four. 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.4. We then ignore the letter with the highest of entries, tabulate in the adjoining table,III,and redo the plot, normalising the  $\ln f$ s with  $\ln f_{n-max}$ , and starting from  $k = 2$  in the figure fig.5. Normalising the  $\ln f$ s with  $\ln f_{2n-max}$ , we tabulate in the adjoining table,III, and starting from  $k = 3$  we draw in the figure fig.6. Normalising the  $\ln f$ s with  $\ln f_{3n-max}$  we record in the adjoining table,III, and plot starting from  $k = 4$  in the figure fig.7. In this way we obtain up to the figure fig.9.

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	4538	8.420	1	Blank	Blank	Blank	Blank	Blank
2	0.69	0.183	3069	8.029	0.954	1	Blank	Blank	Blank	Blank
3	1.10	0.290	2881	7.966	0.940	0.992	1	Blank	Blank	Blank
4	1.39	0.366	2259	7.723	0.917	0.962	0.969	1	Blank	Blank
5	1.61	0.425	2016	7.609	0.904	0.948	0.955	0.985	1	Blank
6	1.79	0.474	1904	7.552	0.897	0.941	0.948	0.978	0.993	1
7	1.95	0.514	1891	7.545	0.896	0.940	0.947	0.977	0.992	0.999
8	2.08	0.550	1597	7.376	0.876	0.919	0.926	0.955	0.969	0.977
9	2.20	0.581	1511	7.321	0.869	0.912	0.919	0.948	0.962	0.969
10	2.30	0.609	1459	7.286	0.865	0.907	0.915	0.943	0.958	0.965
11	2.40	0.634	1281	7.155	0.850	0.891	0.898	0.926	0.940	0.947
12	2.48	0.657	1257	7.136	0.848	0.889	0.896	0.924	0.938	0.945
13	2.56	0.678	1105	7.008	0.832	0.873	0.880	0.907	0.921	0.928
14	2.64	0.697	1104	7.007	0.832	0.873	0.880	0.907	0.921	0.928
15	2.71	0.716	933	6.838	0.812	0.852	0.858	0.885	0.899	0.905
16	2.77	0.733	868	6.766	0.804	0.843	0.849	0.876	0.889	0.896
17	2.83	0.749	596	6.390	0.759	0.796	0.802	0.827	0.840	0.846
18	2.89	0.764	515	6.244	0.742	0.778	0.784	0.808	0.821	0.827
19	2.94	0.778	436	6.078	0.722	0.757	0.763	0.787	0.799	0.805
20	3.00	0.792	406	6.006	0.713	0.748	0.754	0.778	0.789	0.795
21	3.04	0.805	364	5.897	0.700	0.734	0.740	0.764	0.775	0.781
22	3.09	0.817	347	5.849	0.695	0.728	0.734	0.757	0.769	0.774
23	3.14	0.829	340	5.829	0.692	0.726	0.732	0.755	0.766	0.772
24	3.18	0.840	303	5.714	0.679	0.712	0.717	0.740	0.751	0.757
25	3.22	0.851	196	5.278	0.627	0.657	0.663	0.683	0.694	0.699
26	3.26	0.861	177	5.176	0.615	0.645	0.650	0.670	0.680	0.685
27	3.30	0.871	174	5.159	0.613	0.643	0.648	0.668	0.678	0.683
28	3.33	0.881	152	5.024	0.597	0.626	0.631	0.651	0.660	0.665
29	3.37	0.890	149	5.004	0.594	0.623	0.628	0.648	0.658	0.663
30	3.40	0.899	123	4.812	0.571	0.599	0.604	0.623	0.632	0.637
31	3.43	0.908	110	4.700	0.558	0.585	0.590	0.609	0.618	0.622
32	3.47	0.916	95	4.554	0.541	0.567	0.572	0.590	0.599	0.603
33	3.50	0.924	84	4.431	0.526	0.552	0.556	0.574	0.582	0.587
34	3.53	0.932	81	4.394	0.522	0.547	0.552	0.569	0.577	0.582
35	3.56	0.940	74	4.304	0.511	0.536	0.540	0.557	0.566	0.570
36	3.58	0.947	71	4.263	0.506	0.531	0.535	0.552	0.560	0.564
37	3.61	0.954	42	3.738	0.444	0.466	0.469	0.484	0.491	0.495
38	3.64	0.961	27	3.296	0.391	0.411	0.414	0.427	0.433	0.436
39	3.66	0.968	24	3.178	0.377	0.396	0.399	0.411	0.418	0.421
40	3.69	0.975	23	3.135	0.372	0.390	0.394	0.406	0.412	0.415
41	3.71	0.981	16	2.773	0.329	0.345	0.348	0.359	0.364	0.367
42	3.74	0.988	9	2.197	0.261	0.274	0.276	0.284	0.289	0.291
43	3.76	0.994	2	0.693	0.082	0.086	0.087	0.090	0.091	0.092
44	3.78	1	1	0	0	0	0	0	0	0

TABLE III. The Kannada Dictionary head words: ranking, natural logarithm, normalisations

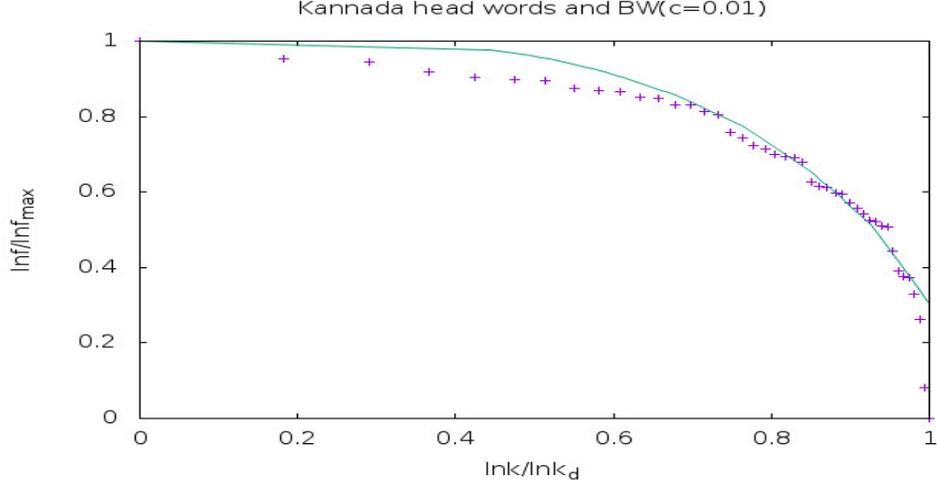


FIG. 4. The vertical axis is  $\frac{\ln f}{\ln f_{max}}$  and the horizontal axis is  $\frac{\ln k}{\ln k_{lim}}$ . The + points represent the head words of the Kannada dictionary, with the fit curve being the Bragg-Williams curve in the presence of external magnetic field,  $c = \frac{H}{\gamma\epsilon} = 0.01$ .

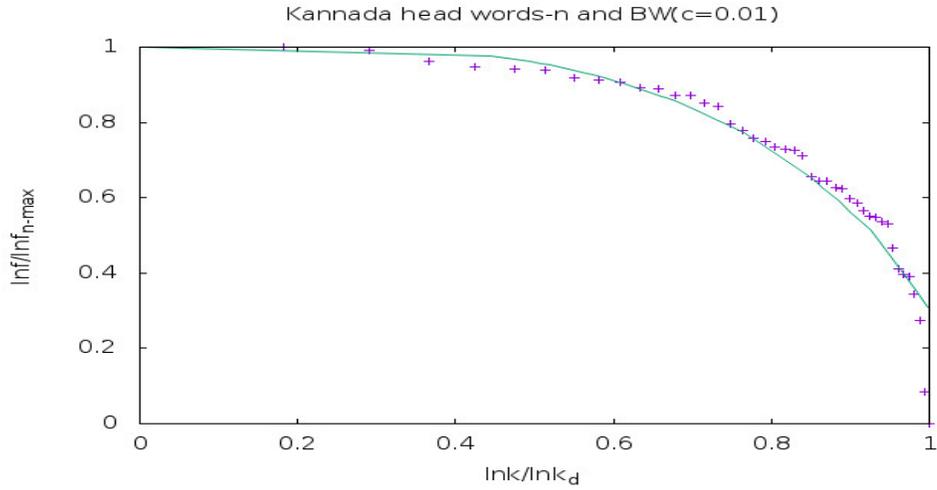


FIG. 5. The vertical axis is  $\frac{\ln f}{\ln f_{n-max}}$  and the horizontal axis is  $\frac{\ln k}{\ln k_{lim}}$ . The + points represent the head words of the Kannada dictionary, with the fit curve being the Bragg-Williams curve in the presence of external magnetic field,  $c = \frac{H}{\gamma\epsilon} = 0.01$ .

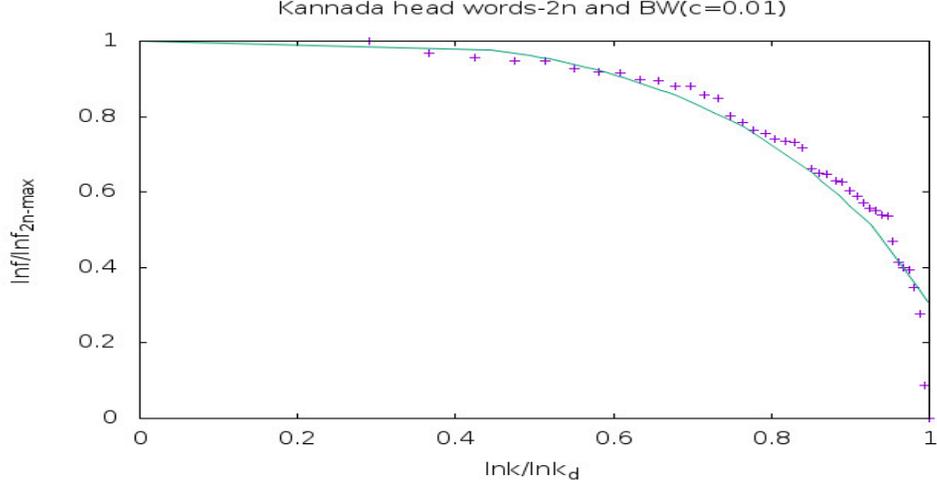


FIG. 6. The vertical axis is  $\frac{\ln f}{\ln f_{2n-max}}$  and the horizontal axis is  $\frac{\ln k}{\ln k_{lim}}$ . The + points represent the head words of the Kannada dictionary, with the fit curve being the Bragg-Williams curve in the presence of external magnetic field,  $c = \frac{H}{\gamma\epsilon} = 0.01$ .

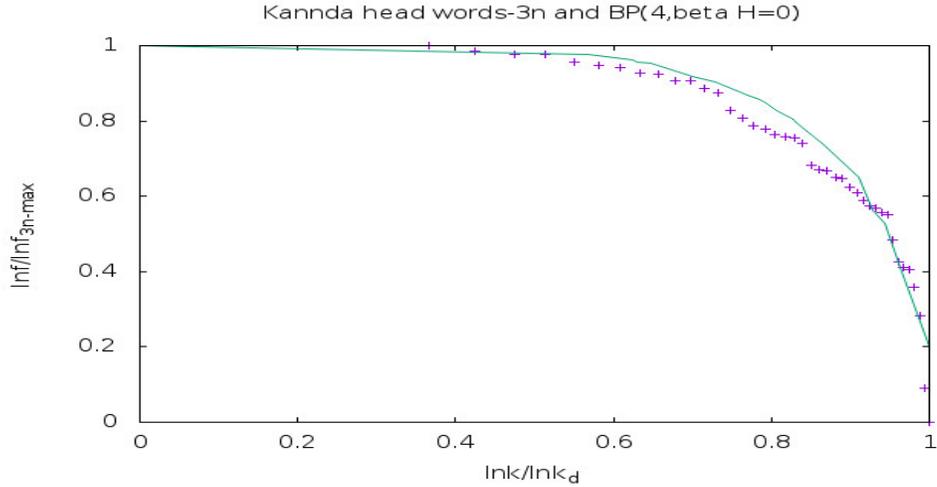


FIG. 7. The vertical axis is  $\frac{\ln f}{\ln f_{3n-max}}$  and the horizontal axis is  $\frac{\ln k}{\ln k_{lim}}$ . The + points represent the head words of the Kannada dictionary, with the fit curve,  $BP(4, \beta H = 0)$ , being the Bethe-Peierls curve in the presence of four nearest neighbours and no external magnetic field,  $m = 0$  or,  $\beta H = 0$ .

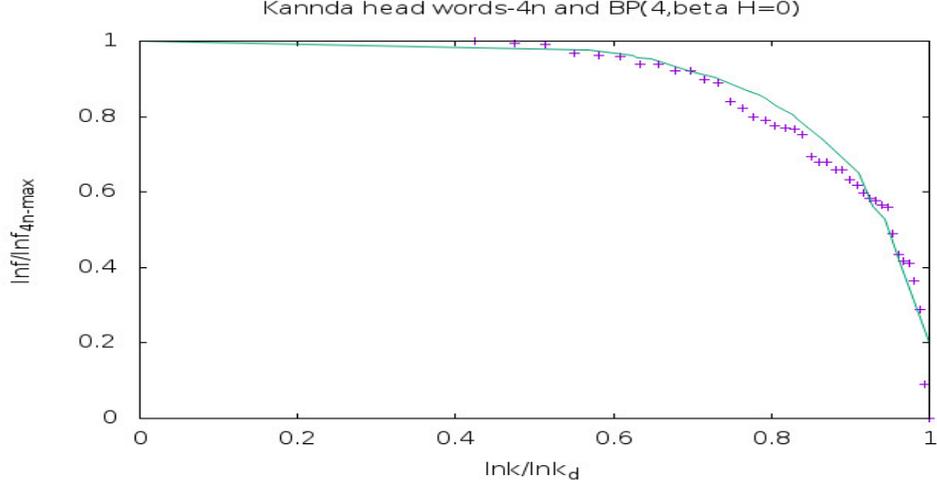


FIG. 8. The vertical axis is  $\frac{\ln f}{\ln f_{4n-max}}$  and the horizontal axis is  $\frac{\ln k}{\ln k_{lim}}$ . The + points represent the head words of the Kannada dictionary, with the fit curve,  $BP(4, \beta H = 0)$ , being the Bethe-Peierls curve in the presence of four nearest neighbours and no external magnetic field,  $m = 0$  or,  $\beta H = 0$ .

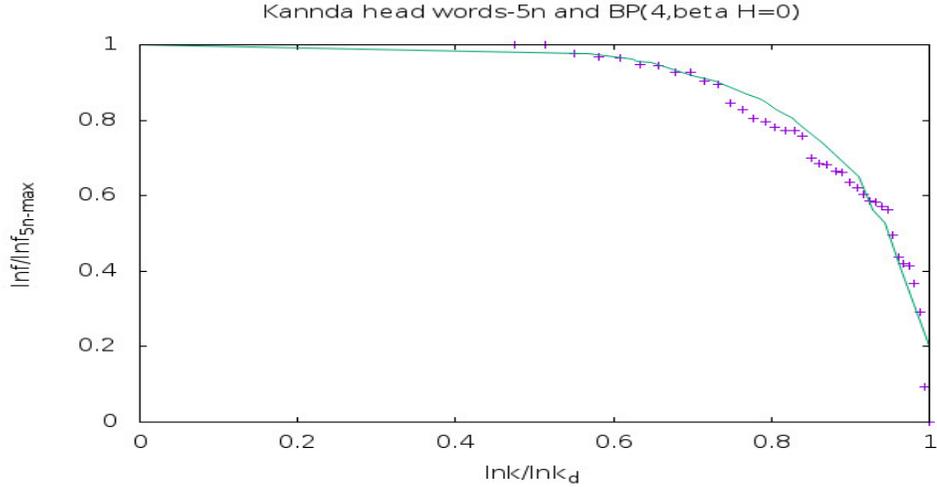


FIG. 9. The vertical axis is  $\frac{\ln f}{\ln f_{5n-max}}$  and the horizontal axis is  $\frac{\ln k}{\ln k_{lim}}$ . The + points represent the head words of the Kannada dictionary, with the fit curve,  $BP(4, \beta H = 0)$ , being the Bethe-Peierls curve in the presence of four nearest neighbours and no external magnetic field,  $m = 0$  or,  $\beta H = 0$ .

## A. conclusion

From the figures (fig.4-fig.9), we observe that there is a curve of magnetisation, behind the entries of the Kannada dictionary,[1]. 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,

$$\frac{\ln f}{\ln f_{n-max}} \longleftrightarrow \frac{M}{M_{max}},$$

$$\ln k \longleftrightarrow T.$$

$k$  corresponds to temperature in an exponential scale, [62]. As temperature decreases, i.e.  $\ln k$  decreases,  $f$  increases. The letters which are recording higher entries compared to those which have lesser entries are at lower temperature. As the Kannada language expands, the letters like .., .., pa, a,ka which get enriched more and more, fall at lower and lower temperatures. This is a manifestation of cooling effect, as was first observed in [63], in another way.

Nevertheless on successive normalisations, the Kannada language goes over to the magnetisation curve, BP(4, $\beta H = 0$ ). Hence, the Kannada language has a Bethe-Peierls core( in the presence of four nearest neighbours and in the absence of external magnetic field). Moreover, the bengali language dictionary, [54], we have studied before, [4], was having the same graphical law characterisation. To take the nearness to the forefront, in the next section, we put the Bengali language alphabet in the format of the Kannada language alphabet and compare the frequency of the words of the Bengali language, [54], with the frequency of the head words of the Kannada language, [1]. Conclusion is obvious. To make the proximity clearer, in the next to next section, we do the Romanisation as suggested by the Kannada dictionary, [1], for both the languages and do the frequency and the graphical law analysis leading to the inference that on successive higher normalisations both the languages almost go over to Onsager solution, in the reduced alphabet scheme, in the same way.

a	á	i	í	u	ú	ṛi	e	é	ei	o	ó	ou	ka	kha	ga	gha	gna	cha	chha	ja	jha	nya	ṭa
2595	1397	177	35	1034	30	25	237	0	28	113	0	30	2314	599	1157	316	0	988	350	895	235	0	236
ṭha	ḍa	ḍha	ṇa	ṭa	ṭha	ḍa	ḍha	ṇa	pa	pha	ba	bha	ma	ya	ra	la	va	sha	ṣha	sa	ha	ḷa	kṣha
137	191	134	0	1078	102	1392	515	1463	3196	392	3170	791	1773	356	737	434	0	955	47	2530	629	0	0

TABLE IV. Bengali words: the odd rows represent letters of the Kannada alphabet,[1], in the serial order, omitting mostly non-zero entries, the even rows represent number of Bengali words, [54].

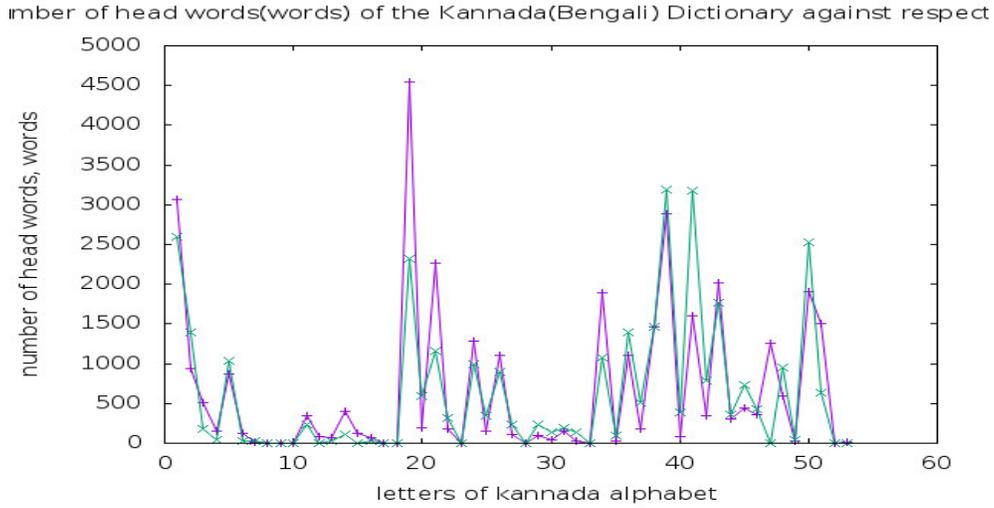


FIG. 10. The vertical axis is the number of head words( words), in red(green), of the Kannada(Bengali) Dictionary,[1]([54]). The horizontal axis is the letters of the Kannada alphabet. Letters are represented by the sequence number in the alphabet as it appears in the dictionary, [1].

#### IV. COMPARISON WITH BENGALI LANGUAGE

The result is the table, IV and the figure fig. 11.

To visualise we plot the number of head words, words against the respective letters in the dictionary sequence,[1], in the adjoining figure, fig.10.

বঙ্গীয় বর্ণ

অ (a)	আ (á)	ই (i)	ঈ (í)	
# 2595	# 1397	# 177	# 35	
উ (u)	ঊ (ú)	ঋ (ri)	ঌ (l)	঍ (é)
# 1034	# 30	# 25	# 237	# 0
ঐ (ei)	ঔ (o)	ও (ó)	ঔ (ou)	
# 28	# 13	# 0	# 30	
ক (ka)	খ (kha)	গ (ga)	ঘ (gha)	ঙ (nga)
# 2314	# 599	# 1157	# 316	# 0
চ (cha)	ছ (cha)	জ (ja)	ঝ (zha)	ঞ (nya)
# 988	# 350	# 895	# 235	# 0
ট (ta)	ঠ (tha)	ড (da)	ঢ (dha)	ণ (na)
# 236	# 137	# 191	# 134	# 0
ত (ta)	থ (tha)	দ (da)	ধ (dha)	ন (na)
# 1078	# 102	# 1392	# 515	# 1463
প (pa)	ফ (pha)	ব (ba)	ভ (bha)	ম (ma)
# 3196	# 392	# 3170	# 791	# 1773
য (ya)	র (ra)	ল (la)	ল (la)	শ (sha)
# 356	# 737	# 434	# 0	# 955
শ (sha)	স (sa)	হ (ha)	জ (ja)	ঝ (zha)
# 47	# 2530	# 629	# 0	# 0

FIG. 11. Number of words starting with various letters of the bengali alphabet

A	B	C	D	E	F	G	H	I	J	K	L	M
a+á	ba+bha	cha+chha	ḍa+ḍha+ḍa+dha	e+é+ei		ga+gha+gna	ha	i+í	ja+jha	ka+kha+kṣha	la+ḷa	ma
3069+933	1597+347	1281+149	149+24+1105+174	340+81+71		2259+177+0	1511	515+152	1104+110	4538+196+9	364+2	2016
4002	1944	1430	1452	492	0	2436	1511	667	1214	4743	366	2016
N	O	P	Q	R	S	T	U	V	W	X	Y	Z
nya+ṇa+na	o+ó+ou	pa+pha		ṛi+ra	sha+ṣha+sa	ta+tha+ṭa+ṭha	u+ú	va			ya	
0+2+1459	406+123+74	2881+84		16+436	596+27+1904	1891+23+95+42	868+123	1257			303	
1461	603	2965	0	452	2527	2051	991	1257	0	0	303	0

TABLE V. Head words of Kannada English Dictionary: the first and fifth rows represent letters of the English alphabet in the serial order, the second and sixth rows are the letters of the Kannada alphabet, the third and seventh rows are the respective number of head words in the Kannada dictionary, the fourth and eighth rows are the respective number of Kannada head words in the reduced alphabet scheme.

A	B	C	D	E	F	G	H	I	J	K	L	M
a+á	ba+bha	cha+chha	ḍa+ḍha+ḍa+dha	e+é+ei		ga+gha+gna	ha	i+í	ja+jha	ka+kha+kṣha	la+ḷa	ma
2595+1397	3170+791	988+350	191+134+1392+515	237+0+28		1157+316+0	629	177+35	895+235	2314+599+0	434+0	1773
3992	3961	1338	2232	265	0	1473	629	212	1130	2913	434	1773
N	O	P	Q	R	S	T	U	V	W	X	Y	Z
nya+ṇa+na	o+ó+ou	pa+pha		ṛi+ra	sha+ṣha+sa	ta+tha+ṭa+ṭha	u+ú	va			ya	
0+0+1463	113+0+30	3196+392		25+737	955+47+2530	1078+102+236+137	1034+30	0			356	
1463	143	3588	0	762	3532	1553	1064	0	0	0	356	0

TABLE VI. Words of Bengali Dictionary: the first and fifth rows represent letters of the English alphabet in the serial order, the second and sixth rows are the letters of the Kannada alphabet, the third and seventh rows are the respective number of words in the Bengali dictionary, the fourth and eighth rows are the respective number of the bengali words in the reduced alphabet scheme.

## V. REDUCED ALPHABET SCHEME

To visualise we plot the number of entries against the respective letters in the figures fig.12-fig.13 respectively. The graphical law analysis ensues with the table VII, figures (fig.14-fig.19) for the kannada language and the table VIII, figures (fig.20-fig.21) for the Bengali language respectively.

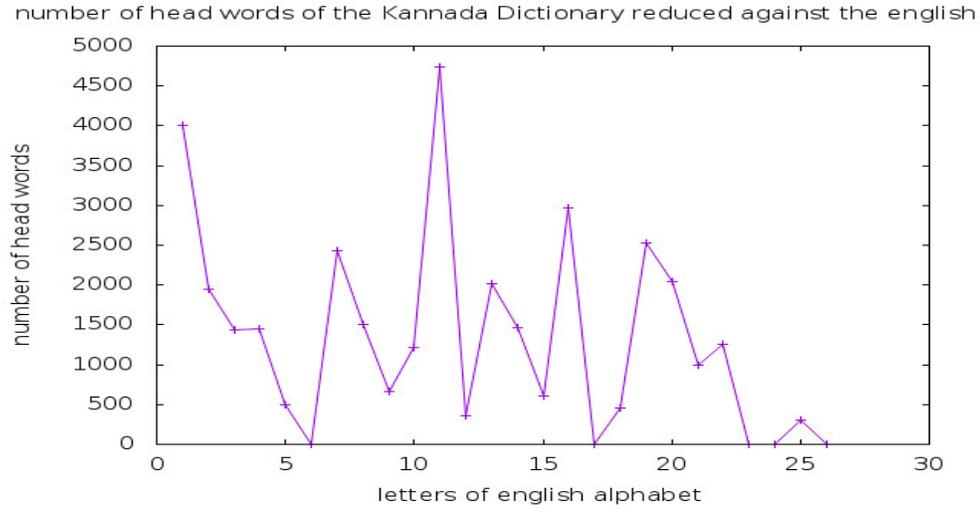


FIG. 12. The vertical axis is the number of head words of the Kannada Dictionary,[1], in the reduced alphabet scheme. The horizontal axis is the letters of the English alphabet. Letters are represented by the sequence number in the alphabet.

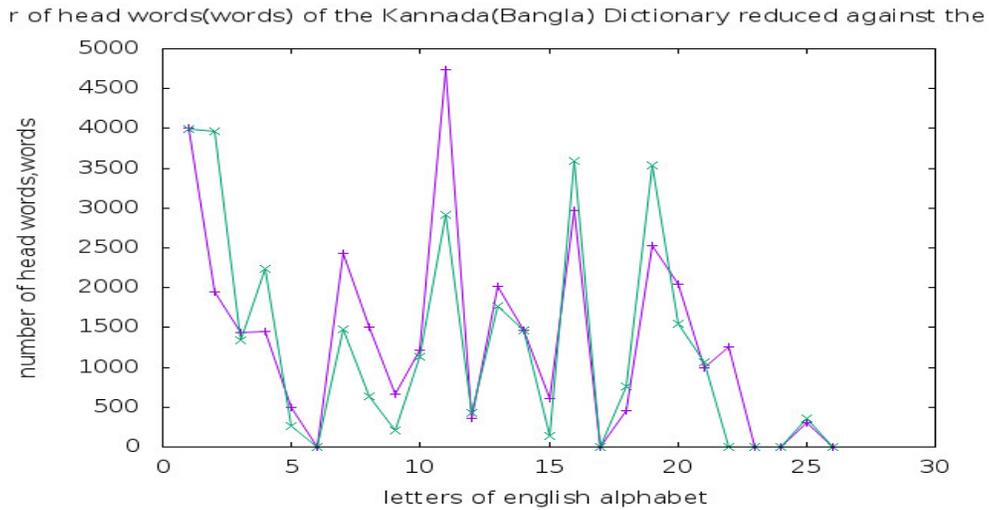


FIG. 13. The vertical axis is the number of head words(words), in red(green), of the Kannada(Bengali) Dictionary,[1]([54]), in the reduced alphabet scheme. The horizontal axis is the letters of the English alphabet. Letters are represented by the sequence number in the alphabet.

k	lnk	lnk/lnk <sub>lim</sub>	f	lnf	lnf/lnf <sub>max</sub>	lnf/lnf <sub>next-max</sub>	lnf/lnf <sub>nnmax</sub>	lnf/lnf <sub>nnnmax</sub>	lnf/lnf <sub>nnnnmax</sub>	lnf/lnf <sub>nnnnnmax</sub>
1	0	0	4743	8.464	1	Blank	Blank	Blank	Blank	Blank
2	0.69	0.223	4002	8.295	0.980	1	Blank	Blank	Blank	Blank
3	1.10	0.356	2965	7.995	0.945	0.964	1	Blank	Blank	Blank
4	1.39	0.450	2527	7.835	0.926	0.945	0.980	1	Blank	Blank
5	1.61	0.521	2436	7.798	0.921	0.940	0.975	0.995	1	Blank
6	1.79	0.579	2051	7.626	0.901	0.919	0.954	0.973	0.978	1
7	1.95	0.631	2016	7.609	0.899	0.917	0.952	0.971	0.976	0.998
8	2.08	0.673	1944	7.573	0.895	0.913	0.947	0.967	0.971	0.993
9	2.20	0.712	1511	7.321	0.865	0.883	0.916	0.934	0.939	0.960
10	2.30	0.744	1461	7.287	0.861	0.878	0.911	0.930	0.934	0.956
11	2.40	0.777	1452	7.281	0.860	0.878	0.911	0.929	0.934	0.955
12	2.48	0.803	1430	7.265	0.858	0.876	0.909	0.927	0.932	0.953
13	2.56	0.828	1257	7.136	0.843	0.860	0.893	0.911	0.915	0.936
14	2.64	0.854	1214	7.102	0.839	0.856	0.888	0.906	0.911	0.931
15	2.71	0.877	991	6.899	0.815	0.832	0.863	0.881	0.885	0.905
16	2.77	0.896	667	6.503	0.768	0.784	0.813	0.830	0.834	0.853
17	2.83	0.916	603	6.402	0.756	0.772	0.801	0.817	0.821	0.839
18	2.89	0.935	492	6.198	0.732	0.747	0.775	0.791	0.795	0.813
19	2.94	0.951	452	6.114	0.722	0.737	0.765	0.780	0.784	0.802
20	3.00	0.971	366	5.903	0.697	0.712	0.738	0.753	0.757	0.774
21	3.04	0.984	303	5.714	0.675	0.689	0.715	0.729	0.733	0.749
22	3.09	1	1	0	0	0	0	0	0	0

TABLE VII. Head words of the Kannada English dictionary in the reduced alphabet scheme: ranking,natural logarithm, normalisations

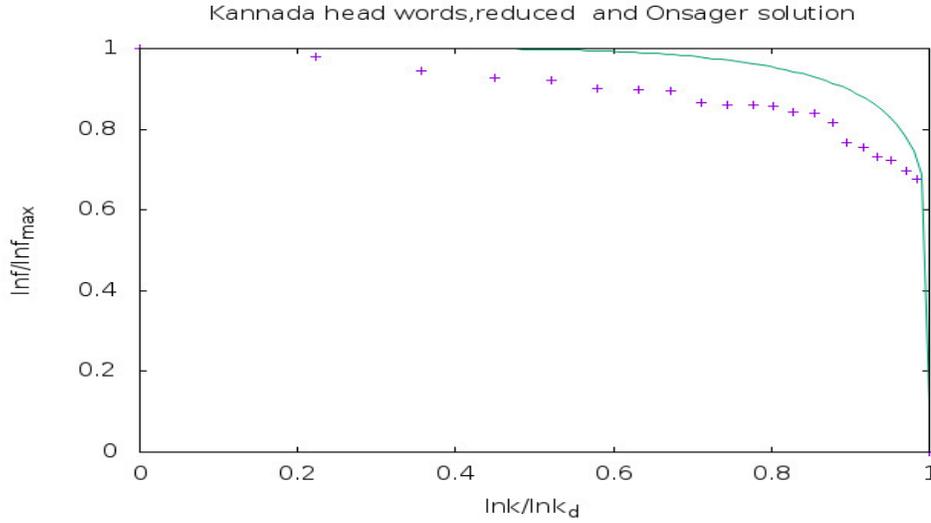


FIG. 14. Vertical axis is  $\frac{\ln f}{\ln f_{max}}$  and horizontal axis is  $\frac{\ln k}{\ln k_{lim}}$ . The + points represent the head words of the Kannada English dictionary in the reduced alphabet scheme. The uppermost curve is the Onsager solution.

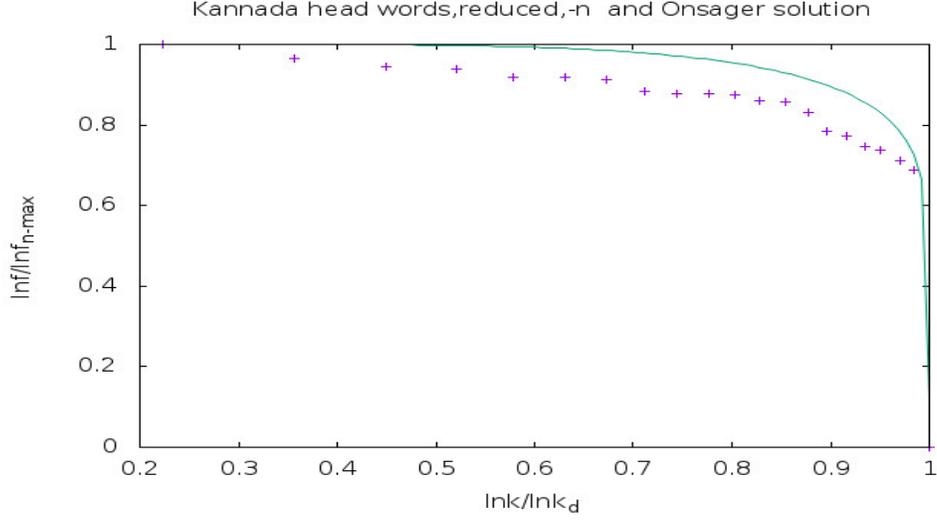


FIG. 15. Vertical axis is  $\frac{\ln f}{\ln f_{n-\max}}$  and horizontal axis is  $\frac{\ln k}{\ln k_{lim}}$ . The + points represent the head words of the Kannada English dictionary in the reduced alphabet scheme.  $c = \frac{H}{\gamma\epsilon} = 0.01$ . The uppermost curve is the Onsager solution.

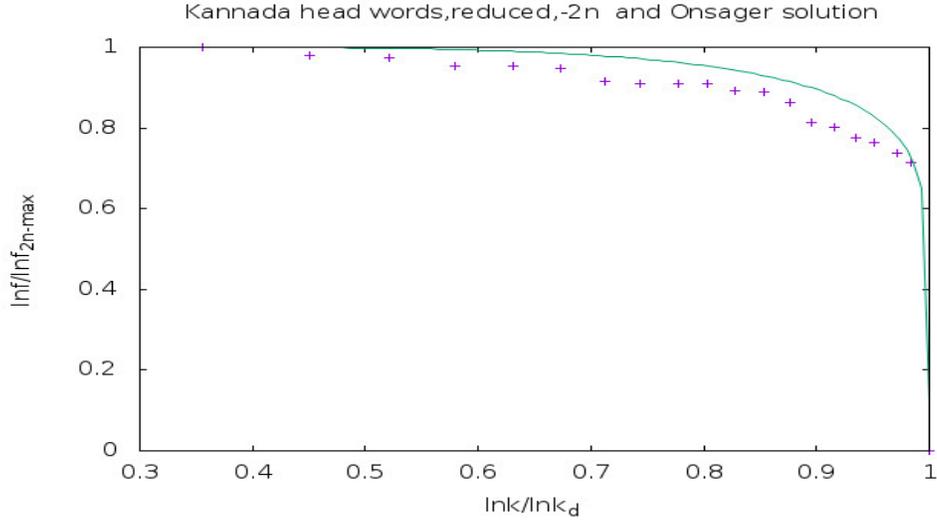


FIG. 16. Vertical axis is  $\frac{\ln f}{\ln f_{2n-\max}}$  and horizontal axis is  $\frac{\ln k}{\ln k_{lim}}$ . The + points represent the head words of the Kannada English dictionary in the reduced alphabet scheme. The uppermost curve is the Onsager solution.

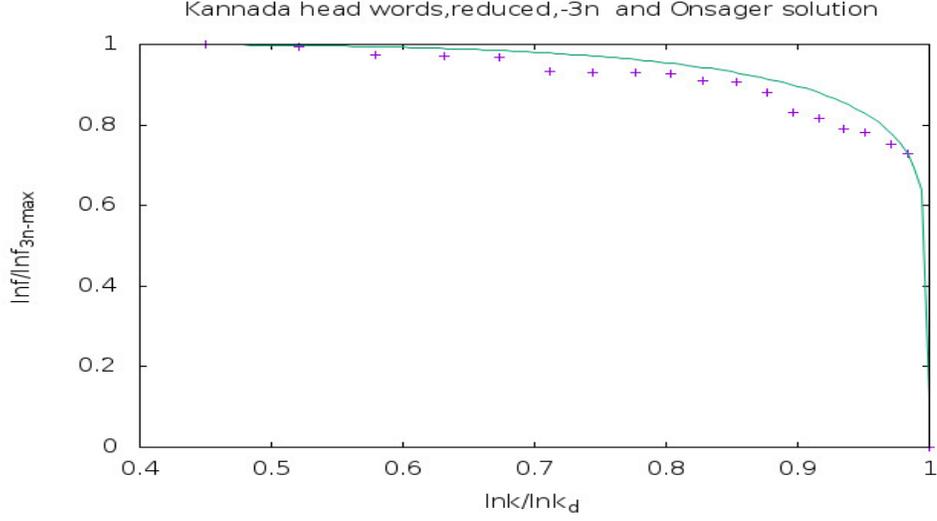


FIG. 17. Vertical axis is  $\frac{\ln f}{\ln f_{3n-max}}$  and horizontal axis is  $\frac{\ln k}{\ln k_{lim}}$ . The + points represent the head words of the Kannada English dictionary in the reduced alphabet scheme. The uppermost curve is the Onsager solution.

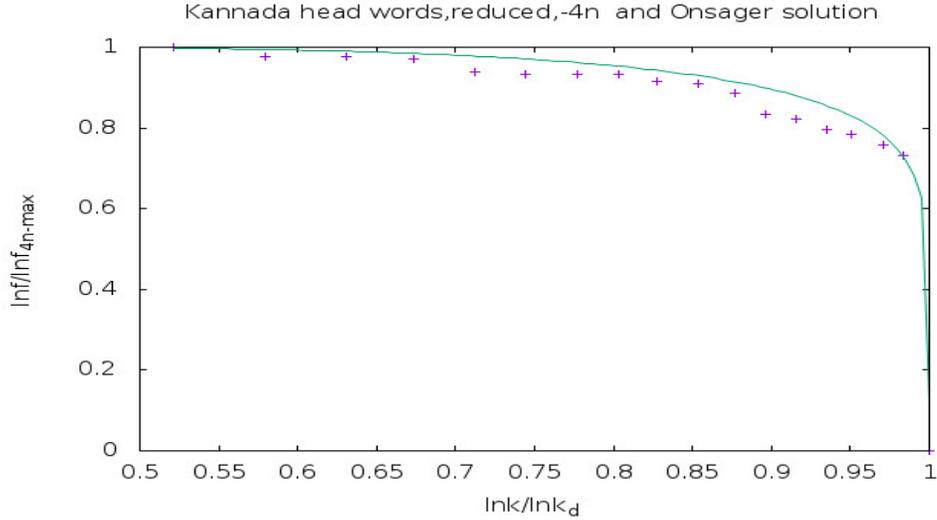


FIG. 18. Vertical axis is  $\frac{\ln f}{\ln f_{4n-max}}$  and horizontal axis is  $\frac{\ln k}{\ln k_{lim}}$ . The + points represent the head words of the Kannada English dictionary in the reduced alphabet scheme. The uppermost curve is the Onsager solution.

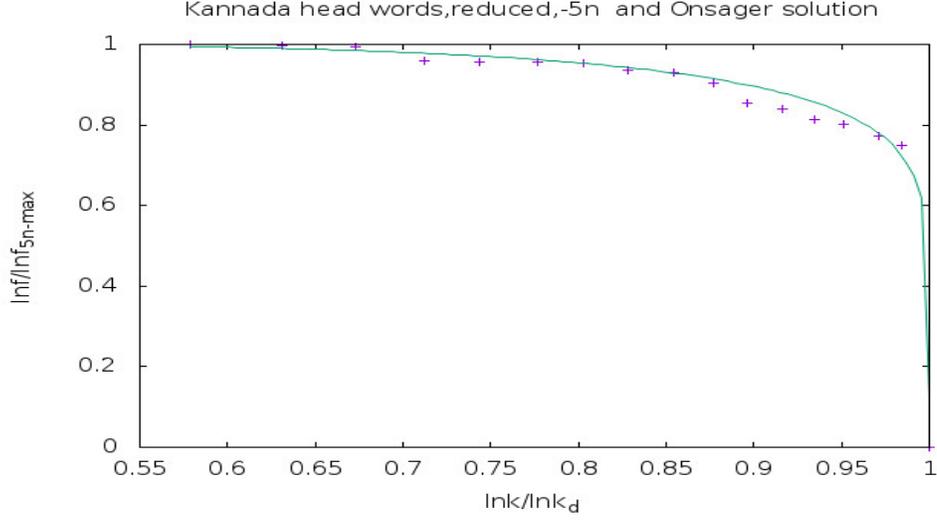


FIG. 19. Vertical axis is  $\frac{\ln f}{\ln f_{5n-max}}$  and horizontal axis is  $\frac{\ln k}{\ln k_{lim}}$ . The + points represent the head words of the Kannada English dictionary in the reduced alphabet scheme. The uppermost curve is the Onsager solution.

k	lnk	lnk/lnk <sub>lim</sub>	f	lnf	lnf/lnf <sub>max</sub>	lnf/lnf <sub>5nmax</sub>
1	0	0	3992	8.292	1	Blank
2	0.69	0.228	3961	8.284	0.999	Blank
3	1.10	0.361	3588	8.185	0.987	Blank
4	1.39	0.455	3532	8.170	0.985	Blank
5	1.61	0.528	2913	7.977	0.962	Blank
6	1.79	0.589	2232	7.711	0.930	Blank
7	1.95	0.639	1773	7.480	0.902	1
8	2.08	0.683	1553	7.348	0.886	0.982
9	2.20	0.722	1473	7.295	0.880	0.975
10	2.30	0.756	1463	7.288	0.879	0.974
11	2.40	0.788	1338	7.199	0.868	0.962
12	2.48	0.816	1130	7.030	0.848	0.940
13	2.56	0.842	1064	6.970	0.841	0.932
14	2.64	0.867	762	6.636	0.800	0.887
15	2.71	0.889	629	6.444	0.777	0.861
16	2.77	0.911	434	6.073	0.732	0.812
17	2.83	0.930	356	5.875	0.709	0.785
18	2.89	0.949	265	5.580	0.673	0.746
19	2.94	0.967	212	5.357	0.646	0.716
20	3.00	0.984	143	4.963	0.599	0.664
21	3.05	1	1	0	0	0

TABLE VIII. Words of the Bengali dictionary in the reduced alphabet scheme: ranking, natural logarithm, normalisations

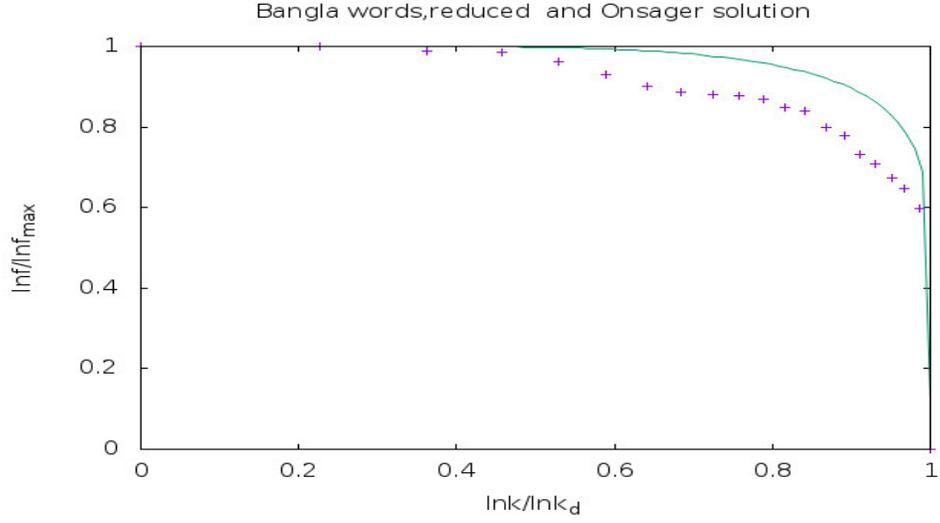


FIG. 20. Vertical axis is  $\frac{\ln f}{\ln f_{max}}$  and horizontal axis is  $\frac{\ln k}{\ln k_{lim}}$ . The + points represent the words of the Bengali dictionary in the reduced alphabet scheme. The uppermost curve is the Onsager solution.

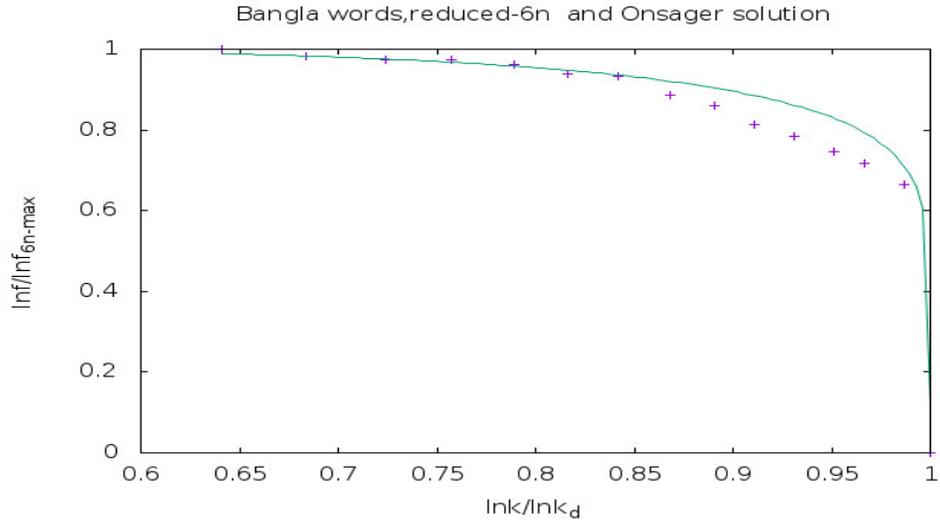


FIG. 21. Vertical axis is  $\frac{\ln f}{\ln f_{6n-max}}$  and horizontal axis is  $\frac{\ln k}{\ln k_{lim}}$ . The + points represent the words of the Bengali dictionary in the reduced alphabet scheme. The uppermost curve is the Onsager solution.

## VI. ACKNOWLEDGMENT

We have used gnuplot for plotting the figures in this paper. We would like to thank the nehu library for allowing us to use the Dictionary Kannada and English written by W. Reeve, revised, corrected and enlarged by Daniel Sanderson, [1].

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