

Sanchayita and the Graphical Law

Anindya Kumar Biswas*

Department of Physics;

North-Eastern Hill University,

Mawkynroh-Umshing, Shillong-793022.

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Abstract

We study the Sanchayita, one collection of poems, of Rabindranath Tagore. We draw the natural logarithm of the number of the titles of the poems of the Sanchayita, normalised, starting with a letter vs the natural logarithm of the rank of the letter, normalised. We conclude that the Sanchayita can be characterised by the magnetisation curve, $BW(c=0)$, of the Ising Model in the Bragg-Williams approximation in the absence of external magnetic field, H. $c = \frac{H}{\gamma^\epsilon} = 0$ with ϵ being the strength of coupling between two neighbouring spins in the Ising Model, γ representing the number of nearest neighbours of a spin, which very large.

* anindya@nehu.ac.in

a	á	i	í	u	ú	ṛi	e	é	ei	o	ó	ou	ka	kha	ga	gha	gna	cha	chha	ja	jha	nya	ṭa
27	15	2	0	13	0	1	5	0	1	1	0	0	22	7	10	3	0	10	5	12	2	0	0
ṭha	ḍa	ḍha	ṇa	ta	tha	da	dha	na	pa	pha	ba	bha	ma	ya	ra	la	va	sha	ṣha	sa	ha	ḷa	kṣha
1	0	1	0	6	0	23	4	24	53	2	39	11	30	8	8	4	0	12	0	39	9	0	0

TABLE I. Sanchayita titles: the odd rows represent letters of the Kannada alphabet,[2], in the serial order, omitting mostly non-zero entries, the even rows represent the number of the titles of the poems in the Sanchayita, [1].

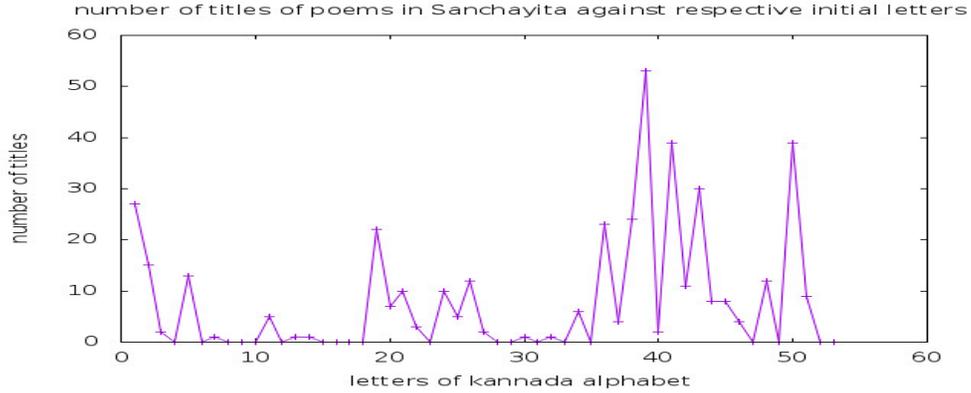


FIG. 1. The vertical axis is the number of the titles of the poems in the Sanchayita, [1]. The horizontal axis is the letters of the Bengali alphabet embedded in the Kannada alphabet. Letters are represented by the sequence number in the alphabet as it appears in the dictionary, [2].

I. INTRODUCTION

Rabindranath Thakur was a colossal figure in wide spectrum of literary activities spanning poetry, short stories, novels, dramas etc. in the pre-independence India. In the English speaking world he is known as Rabindranath Tagore. One of his collections of poems is Sanchayita, [1]. Poems of Sanchayita was originally composed in the Bengali language. The Sanchayita is read widely and has undergone many editions. We come across one, [1] and ask to us how many poems are there inside it. We start counting title after title and enlist the number of the titles of the poems starting with a bengali letter. The result is the table, I and the figure fig. 2. In the both, we have embedded the Bengali alphabet in the Kannada alphabet, [2]. To visualise we plot the number of the titles of the poems against the letters of the bengali alphabet embedded in the kannada alphabet in the kannada dictionary sequence,[2], in the adjoining figure, fig.3.

সঞ্চয়িতা (Sanchayita)

অ (a)	ঐ (ó)	ই (i)	ঈ (í)	উ (u)	ঊ (ú)
# 27	# 15	# 2	# 0	# 13	# 0
ঐ (ei)	এ (e)	এঁ (é)	ঐ (ei)	ও (o)	ওঁ (ó)
# 1	# 5	# 0	# 1	# 1	# 0
ঔ (ou)					
# 0					
ক (ka)	ক্খ (kha)	গ (ga)	গ্ঘ (gha)	গ্ণ (gna)	
# 22	# 7	# 10	# 3	# 0	
চ (cha)	চ্ছ (chha)	জ (ja)	জ্জ (jha)	জ্ণ (jña)	
# 10	# 5	# 12	# 2	# 0	
ট (ta)	ট্ঠ (tha)	ড (da)	ড্ঢ (dha)	ড্ণ (ña)	
# 0	# 1	# 0	# 1	# 0	
ঠ (tha)	ড্ঠ (tha)	ঢ (da)	ঢ্ঢ (dha)	ঢ্ণ (ña)	
# 6	# 0	# 23	# 4	# 24	
প (pa)	প্ফ (pha)	ব (ba)	ব্ভ (bha)	ব্ণ (bña)	
# 53	# 2	# 39	# 11	# 30	
য (ya)	য্য় (ya)	ল (la)	(va)	ল্ণ (lña)	
# 8	# 8	# 4	# 0	# 12	
য্ (sha)	স্ছ (ssa)	হ (ha)	(.a)	(.ksha)	
# 0	# 39	# 9	# 0	# 0	

FIG. 2. Number of the titles of the poems in the Sanchayita, starting with various letters of the bengali alphabet embedded in the kannada alphabet

Out of curiosity we ask to ourselves, is there a magnetic field pattern behind the Sanchayita? The answer is in the affirmative. The rest of the paper goes to elaborate on the affirmation. We have started considering magnetic field pattern in [3], in the languages we converse with. We have studied there, a set of natural languages, [3] 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, [4], 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,[5] and the basque language[6]. This was pursued by finding of the graphical law behind the Romanian language, [7], five more disciplines of knowledge, [8], Onsager core of Abor-Miri, Mising languages,[9], Onsager Core of Romanised Bengali language,[10], the graphical law behind the Little Oxford English Dictionary, [11], the Oxford Dictionary of Social Work and Social Care, [12], the Visayan-English Dictionary, [13], Garo to English School Dictionary, [14], Mursi-English-Amharic Dictionary, [15] and Names of Minor Planets, [16], A Dictionary of Tibetan and English, [17], Khasi English Dictionary, [18], Turkmen-English Dictionary, [19], Websters Universal Spanish-English Dictionary, [20], A Dictionary of Modern Italian, [21], Langenscheidt's German-English Dictionary, [22], Essential Dutch dictionary by G. Quist and D. Strik, [23], Swahili-English dictionary by C. W. Rechenbach, [24], Larousse Dictionnaire De Poche for the French, [25], the Onsager's solution behind the Arabic, [26], the graphical law behind Langenscheidt Taschenwörterbuch Deutsch-Englisch / Englisch-Deutsch, Völlige Neubearbeitung, [27], the graphical law behind the NTC's Hebrew and English Dictionary by Arie Comey and Naomi Tsur, [28], the graphical law behind the Oxford Dictionary Of Media and Communication, [29], the graphical law behind the Oxford Dictionary Of Mathematics, Penguin Dictionary Of Mathematics, [30], the Onsager's solution behind the Arabic Second part, [31], the graphical law behind the Penguin Dictionary Of Sociology, [32], behind the Concise Oxford Dictionary Of Politics, [33], a Dictionary Of Critical Theory by Ian Buchanan, [34], the Penguin Dictionary Of Economics, [35], the Concise Gojri-English Dictionary by Dr. Rafeeq Anjum, [36], A Dictionary of the Kachin Language by Rev.O.Hanson, [37], A Dictionary Of World History by Edmund Wright, [38], Ekagi-Dutch-English-Indonesian Dictionary by J. Steltenpool, [39], A Dictionary of Plant Sciences by Michael Allaby, [40], respectively. The graphical law was pursued more in Along the side of the Onsager's solution, the Ekagi

language ,[41], Along the side of the Onsager’s solution, the Ekagi language-Part Three, [42], Oxford Dictionary of Biology by Robert S. Hine and the Graphical law, [43], A Dictionary of the Mikir Language by G. D. Walker and the Graphical law, [44], A Dictionary of Zoology by Michael Allaby and the Graphical Law, [45], Dictionary of all Scriptures and Myths by G. A. Gaskell and the Graphical Law, [46], Dictionary of Culinary Terms by Philippe Pilibossian and the Graphical law, [47], A Greek and English Lexicon by H.G.Liddle et al simplified by Didier Fontaine and the Graphical law, [48], Learner’s Mongol-English Dictionary and the Graphical law, [49], Complete Bulgarian-English Dictionary and the Graphical law, [50], A Dictionary of Sindhi Literature by Dr. Motilal Jotwani and the Graphical Law, [51], Penguin Dictionary of Physics, the Fourth Edition, by John Cullerne, and the Graphical law, [52], Oxford Dictionary of Chemistry, the seventh edition and the Graphical Law, [53], A Burmese-English Dictionary, Part I-Part V, by J. A. Stewart and C. W. Dunn et al, head entries and the Graphical Law, [54], The Graphical Law behind the head words of Dictionary Kannada and English written by W. Reeve, revised, corrected and enlarged by Daniel Sanderson, [55], respectively.

The planning of the paper is as follows. We give an introduction to the standard curves of magnetisation of Ising model in the section II. In the section III, we describe the graphical law analysis of the titles of the poems of the Sanchayita, [1]. Sections IV, V are Acknowledgement and Bibliography respectively.

II. MAGNETISATION

A. Bragg-Williams approximation

Let us consider a coin. Let us toss it many times. Probability of getting head or, tale is half i.e. we will get head and tale equal number of times. If we attach value one to head, minus one to tale, the average value we obtain, after many tossing is zero. Instead let us consider a one-sided loaded coin, say on the head side. The probability of getting head is more than one half, getting tale is less than one-half. Average value, in this case, after many tossing we obtain is non-zero, the precise number depends on the loading. The loaded coin is like ferromagnet, the unloaded coin is like paramagnet, at zero external magnetic field. Average value we obtain is like magnetisation, loading is like coupling among the spins of

the ferromagnetic units. Outcome of single coin toss is random, but average value we get after long sequence of tossing is fixed. This is long-range order. But if we take a small sequence of tossing, say, three consecutive tossing, the average value we obtain is not fixed, can be anything. There is no short-range order.

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

Now let us imagine an arbitrary lattice, with each up spin assigned a value one and a down spin a value minus one, with an unspecified long-range order parameter defined as above by $L = \frac{1}{N}\sum_i\sigma_i$, where σ_i is i-th spin, N being total number of spins. L can vary from minus one to one. $N = N_+ + N_-$, where N_+ is the number of up spins, N_- is the number of down spins. $L = \frac{1}{N}(N_+ - N_-)$. As a result, $N_+ = \frac{N}{2}(1 + L)$ and $N_- = \frac{N}{2}(1 - L)$. Magnetisation or, net magnetic moment, M is $\mu\sum_i\sigma_i$ or, $\mu(N_+ - N_-)$ or, μNL , $M_{max} = \mu N$. $\frac{M}{M_{max}} = L$. $\frac{M}{M_{max}}$ is referred to as reduced magnetisation. Moreover, the Ising Hamiltonian,[56], for the lattice of spins, setting μ to one, is $-\epsilon\sum_{n,n}\sigma_i\sigma_j - H\sum_i\sigma_i$, where n.n refers to nearest neighbour pairs. The difference ΔE of energy if we flip an up spin to down spin is, [57], $2\epsilon\gamma\bar{\sigma} + 2H$, where γ is the number of nearest neighbours of a spin. According to Boltzmann principle, $\frac{N_-}{N_+}$ equals $exp(-\frac{\Delta E}{k_B T})$, [58]. In the Bragg-Williams approximation,[59], $\bar{\sigma} = L$, 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, $c = \frac{H}{\gamma\epsilon}$, $T_c = \gamma\epsilon/k_B$, [60]. $\frac{T}{T_c}$ 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 [57]. 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, [56],[57],[58],[59],[60], due to Bethe-Peierls, [61], reduced magnetisation varies with reduced temperature, for γ neighbours, in absence of external magnetic field, as

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

$\ln \frac{\gamma}{\gamma-2}$ for four nearest neighbours i.e. for $\gamma = 4$ is 0.693. For a snapshot of different kind of magnetisation curves for magnetic materials the reader is urged to give a google search "reduced magnetisation vs reduced temperature curve". In the following, we describe datas generated from the equation(1) and the equation(2) in the table, II, and curves of magnetisation plotted on the basis of those datas. BW stands for reduced temperature in Bragg-Williams approximation, calculated from the equation(1). BP(4) represents reduced temperature in the Bethe-Peierls approximation, for four nearest neighbours, computed from the equation(2). The data set is used to plot fig.3. Empty spaces in the table, II, 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, $\beta H = 0$)	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 II. 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 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.

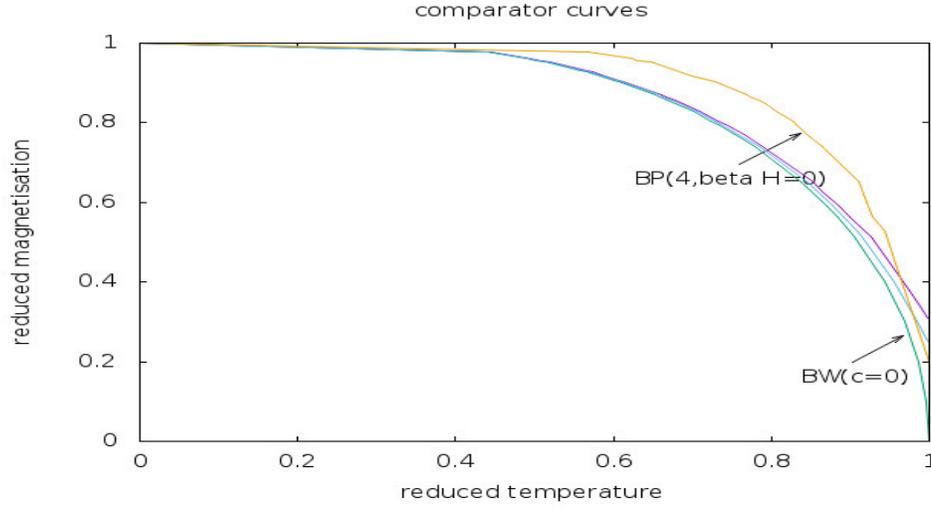


FIG. 3. Reduced magnetisation vs reduced temperature curves, for the Bragg-Williams approximation, in the absence (BW($c=0$)) and in the presence (BW($c=0.005$), BW($c=0.01$)) of magnetic field, $c = 0$, $c = \frac{H}{\gamma\epsilon} = 0.005$, $c = \frac{H}{\gamma\epsilon} = 0.01$, outwards; and in the Bethe-Peierls approximation, BP(4, $\beta H=0$), in the absence of magnetic field, for four nearest neighbours (outer in the top).

III. THE GRAPHICAL LAW ANALYSIS

For the purpose of exploring graphical law, we assort the letters according to the number of titles, in the descending order, denoted by f and the respective rank, [62], denoted by k . k is a positive integer starting from one. Minimum number of titles is one. The limiting rank, k_{lim} , is maximum rank, here it is twenty one and the limiting number of titles, is one. As a result both $\frac{\ln f}{\ln f_{max}}$ and $\frac{\ln k}{\ln k_{lim}}$ varies from zero to one. Then we tabulate in the adjoining table, III, and plot $\frac{\ln f}{\ln f_{max}}$ against $\frac{\ln k}{\ln k_{lim}}$ in the figure fig.4.

We then ignore the letter with which the highest number of titles start, tabulate in the adjoining table, III, and redo the plot, normalising the $\ln f$ s with next-to-maximum $\ln f_{nextmax}$, and starting from $k = 2$ in the figure fig.5. Normalising the $\ln f$ s with next-to-next-to-maximum $\ln f_{nextnextmax}$, we tabulate in the adjoining table, III, and starting from $k = 3$ we draw in the figure fig.6.

k	lnk	$\ln k / \ln k_{lim}$	f	lnf	$\ln f / \ln f_{max}$	$\ln f / \ln f_{nmax}$	$\ln f / \ln f_{nnmax}$
1	0	0	53	3.970	1	Blank	Blank
2	0.69	0.228	39	3.664	0.923	1	Blank
3	1.10	0.361	30	3.401	0.857	0.928	1
4	1.39	0.455	27	3.296	0.830	0.900	0.969
5	1.61	0.528	24	3.178	0.801	0.867	0.934
6	1.79	0.589	23	3.135	0.790	0.856	0.922
7	1.95	0.639	22	3.091	0.779	0.844	0.909
8	2.08	0.683	15	2.708	0.682	0.739	0.796
9	2.20	0.722	13	2.565	0.646	0.700	0.754
10	2.30	0.756	12	2.485	0.626	0.678	0.731
11	2.40	0.788	11	2.398	0.604	0.654	0.705
12	2.48	0.816	10	2.303	0.580	0.629	0.677
13	2.56	0.842	9	2.197	0.553	0.600	0.646
14	2.64	0.867	8	2.079	0.524	0.567	0.611
15	2.71	0.889	7	1.946	0.490	0.531	0.572
16	2.77	0.911	6	1.792	0.451	0.489	0.527
17	2.83	0.930	5	1.609	0.405	0.439	0.473
18	2.89	0.949	4	1.386	0.349	0.378	0.408
19	2.94	0.967	3	1.099	0.277	0.300	0.323
20	3.00	0.984	2	0.693	0.175	0.189	0.204
21	3.05	1	1	0	0	0	0

TABLE III. Titles of the poems of the Sanchayita: ranking, natural logarithm, normalisations

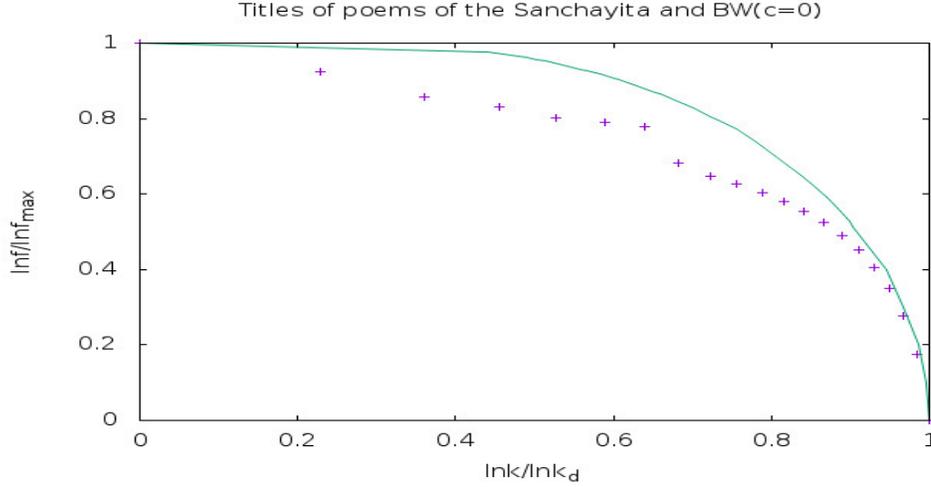


FIG. 4. The vertical axis is $\frac{\ln f}{\ln f_{max}}$ and the horizontal axis is $\frac{\ln k}{\ln k_{lim}}$. The + points represent the titles of the poems of the Sanchayita, with the fit curve being the Bragg-Williams curve in the absence of external magnetic field, H, with $c = \frac{H}{\gamma\epsilon} = 0$.

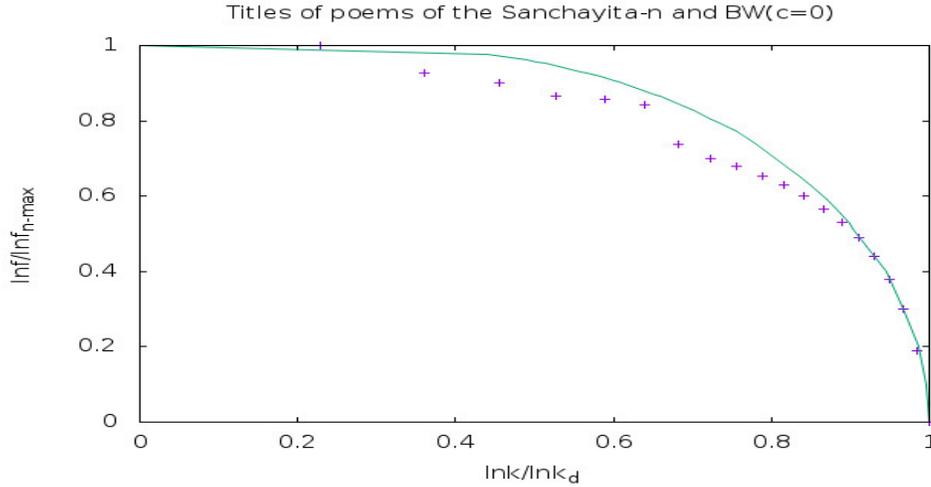


FIG. 5. The vertical axis is $\frac{\ln f}{\ln f_{n-max}}$ and the horizontal axis is $\frac{\ln k}{\ln k_{lim}}$. The + points represent the titles of the poems of the Sanchayita, with the fit curve being the Bragg-Williams curve in the absence of external magnetic field, H, with $c = \frac{H}{\gamma\epsilon} = 0$.

A. conclusion

From the figures (fig.4-fig.6), we observe that there is a curve of magnetisation, behind the titles of the poems of the Sanchayita, [1]. This is the magnetisation curve, BW(c=0), of the

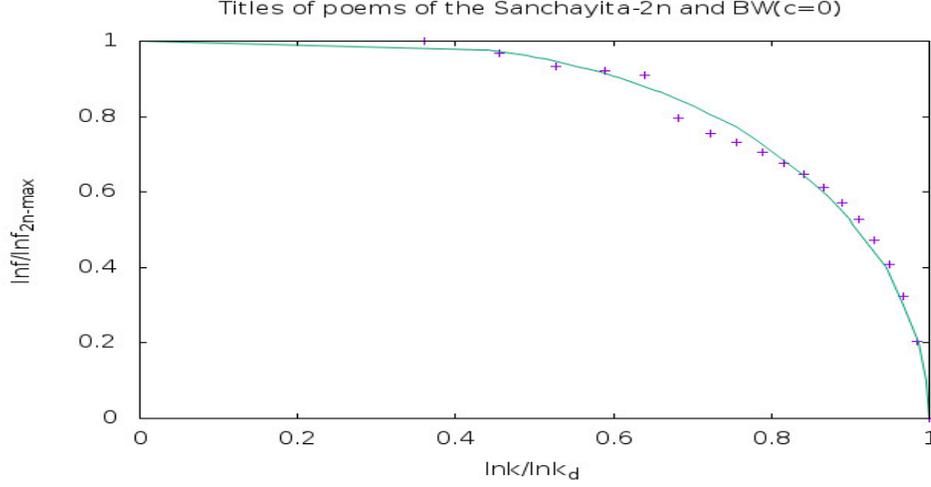


FIG. 6. The vertical axis is $\frac{\ln f}{\ln f_{2n-max}}$ and the horizontal axis is $\frac{\ln k}{\ln k_{lim}}$. The + points represent the titles of the poems of the Sanchayita, with the fit curve being the Bragg-Williams curve in the absence of external magnetic field, H , with $c = \frac{H}{\gamma\epsilon} = 0$.

Ising Model in the Bragg-Williams approximation in the absence of external magnetic field, H . $c = \frac{H}{\gamma\epsilon} = 0$ with ϵ being the strength of coupling between two neighbouring spins in the Ising Model, γ representing the number of nearest neighbours of a spin, which very large. Moreover, the associated correspondence is,

$$\frac{\ln f}{\ln f_{2n-max}} \longleftrightarrow \frac{M}{M_{max}},$$

$$\ln k \longleftrightarrow T.$$

k corresponds to temperature in an exponential scale, [63]. 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.

IV. ACKNOWLEDGEMENT

We have used the gnuplot for drawing the figures.

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