Political Map of Northeast India and the Graphical Law

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Abstract

We study the names of the places in the Political Map of Northeast India. We draw the natural logarithm of the number of names, normalised, starting with a letter vs the natural logarithm of the rank of the letter, normalised. We conclude that the Political Map of Northeast India 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, with $c = \frac{H}{\gamma\epsilon} = 0$.

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I. INTRODUCTION

"Aag gibon khuje pabi,
chhute chhute aay,
..."
———Bhupen Hazarika.

Whether it is Gossaigaon or, Kajalgaon, Pandu or, Jogighopa, Phulbari or, Churachandpur, Sadiya or, Dimapur, Imphal or, Dharmanagar, Kohima or, Itanagar as one enters in this part of India full of paddy fields alternating with green forests, from above appearing like one after another golf courts set at different levels sequentially, one cannot be left awestuck by the pristine natural beauty in this sub Himalayan terrain. Life also springs up from highly spersed population in the Arunachal Pradesh to densely populated lower Assam, Tripura in consonance with the whim of the nature, fragrance of the flowers, colours of the sky, temperature of the air. To know better, we go over to a Political Map of Northeast India. This is the Political Map of Northeast India, [1], designed, cartographed and published by TTK Healthcare Limited Publication Division. We go over from place to place in this map. We study the names of the places. We count the names of the places in the Political Map of Northeast India, one by one, to 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, [3], into dictionaries of five disciplines of knowledge and found the existence of a curve of magnetisation under each discipline. This was followed by finding of the graphical law in references from [4] to [78].

We describe how the graphical law is hidden within the names of places appearing in the Political Map of Northeast India, [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 analysis of the names of the places of the Political Map of Northeast India [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,[80], 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, [81], $2\epsilon\gamma\bar{\sigma} + 2H$, where γ is the number of nearest neighbours of a spin. According to Boltzmann principle, $\frac{N_-}{N_+}$ equals $exp(-\frac{\triangle E}{k_BT})$, [82]. In the Bragg-Williams approximation,[83], $\bar{\sigma} = L$, considered in the thermal average sense. Consequently,

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

where, $c = \frac{H}{\gamma\epsilon}$, $T_c = \gamma\epsilon/k_B$, [84]. $\frac{T}{T_c}$ 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 [81]. 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, [80],[81],[82],[83],[84], due to Bethe-Peierls, [85], reduced magnetisation varies with reduced temperature, for γ neighbours, in absence of external magnetic field, as

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

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

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 .

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.

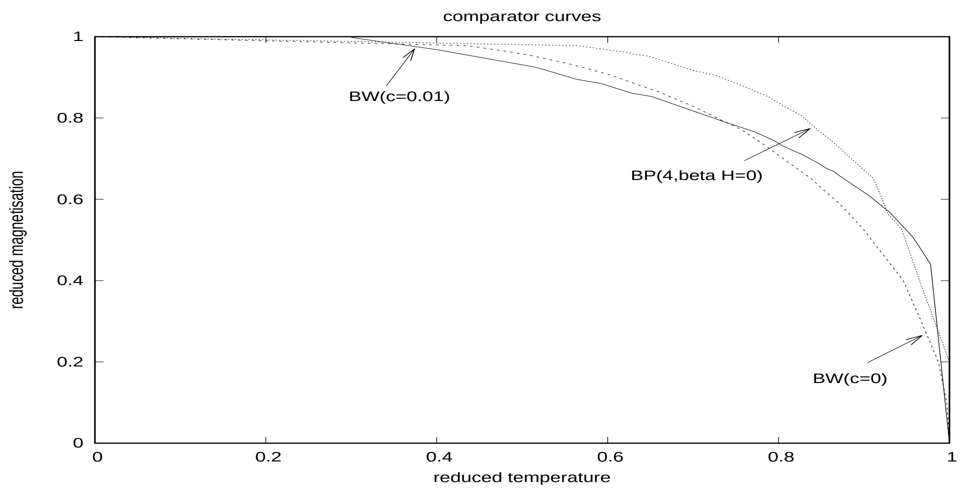

FIG. 1. Reduced magnetisation vs reduced temperature curves for the Bragg-Williams approximation, in the absence(broken line) of, BW(c=0) and the presence(inner in the top) of, BW(c=0.01), the external magnetic field, $c = \frac{H}{\gamma\epsilon} = 0.01$, and the Bethe-Peierls approximation in the absence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

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Tripura	4	4	0	3	0	0	0	1	0	1	8	1	3	1	0	1	0	1	4	2	1	1	0	0	0	0
Mizoram	2	4	5	4	1	0	0	6	0	0	9	9	4	2	0	6	0	5	14	15	1	2	1	0	0	4
Manipur	0	3	6	0	0	0	1	4	1	2	14	4	10	3	0	9	1	0	8	10	1	0	2	0	2	0
Nagaland	1	2	8	2	0	0	0	1	0	0	4	7	6	6	0	6	0	1	7	4	0	1	2	0	1	1
Meghalaya	3	8	4	6	0	0	1	0	0	3	3	2	10	4	0	4	0	10	8	3	2	0	1	0	0	1
Arunachal	13	17	9	20	3	0	5	6	2	8	22	18	22	22	0	8	0	13	19	18	0	2	5	0	11	1
Assaam	14	50	12	39	1	2	15	15	1	16	33	22	28	17	1	12	0	18	29	14	3	0	0	0	0	0
NorthEast	37	88	44	74	5	2	22	33	4	30	93	63	83	55	1	46	1	48	89	66	8	6	11	0	14	7

TABLE II. The number of the names of the places of the different states separately and taken together of the Northeast India along the English letters, in the Political Map of the Northeast India, [1].

III. ANALYSIS OF THE NAMES OF THE PLACES THE POLITICAL MAP OF NORTHEAST INDIA

Counting one by one the names of the places in the Political Map of Northeast India, [1], starting with different letters, leads us to the table, II.

For the purpose of exploring graphical law, we assort the letters according to the number of names of the places, in the descending order, denoted by f and the respective rank, denoted by k. k is a positive integer starting from one. The lowest value of f is one. The corresponding rank, k, denoted as k_{lim} is twenty four. As a result both $\frac{lnf}{lnf_{max}}$ and $\frac{lnk}{lnk_{lim}}$ varies from zero to one. Then we tabulate in the adjoining table, III and plot $\frac{lnf}{lnf_{max}}$ against $\frac{lnk}{lnk_{lim}}$ in the figure fig.2. We then ignore the letter with the highest number of names of places, tabulate in the adjoining table, III and redo the plot, normalising the lnfs with next-to-maximum lnf_{n-max}, and starting from $k = 2$ in the figure fig.3. This program then we repeat up to $k = 6$, resulting in figures up to fig.7.

k	lnk	lnk/lnk_{lim}	f	lnf	lnf/lnf_{max}	lnf/$lnf_{next-max}$	lnf/lnf_{2nmax}	lnf/lnf_{3nmax}	lnf/lnf_{4nmax}	lnf/lnf_{5nmax}
1	0	0	93	4.533	1	Blank	Blank	Blank	Blank	Blank
2	0.69	0.217	89	4.489	0.990	1	Blank	Blank	Blank	Blank
3	1.10	0.346	88	4.477	0.988	0.997	1	Blank	Blank	Blank
4	1.39	0.437	83	4.419	0.975	0.984	0.987	1	Blank	Blank
5	1.61	0.506	74	4.304	0.949	0.959	0.961	0.974	1	Blank
6	1.79	0.563	66	4.190	0.924	0.933	0.936	0.948	0.974	1
7	1.95	0.613	63	4.143	0.914	0.923	0.925	0.938	0.963	0.989
8	2.08	0.654	55	4.007	0.884	0.893	0.895	0.907	0.931	0.956
9	2.20	0.692	48	3.871	0.854	0.862	0.865	0.876	0.899	0.924
10	2.30	0.723	46	3.829	0.845	0.853	0.855	0.866	0.890	0.914
11	2.40	0.755	44	3.784	0.835	0.843	0.845	0.856	0.879	0.903
12	2.48	0.780	37	3.611	0.797	0.804	0.807	0.817	0.839	0.862
13	2.56	0.805	33	3.497	0.771	0.779	0.781	0.791	0.813	0.835
14	2.64	0.830	30	3.401	0.750	0.758	0.760	0.770	0.790	0.812
15	2.71	0.852	22	3.091	0.682	0.689	0.690	0.699	0.718	0.738
16	2.77	0.871	14	2.639	0.582	0.588	0.589	0.597	0.613	0.630
17	2.83	0.890	11	2.398	0.529	0.534	0.536	0.543	0.557	0.572
18	2.89	0.909	8	2.079	0.459	0.463	0.464	0.470	0.483	0.496
19	2.94	0.925	7	1.946	0.429	0.434	0.435	0.440	0.452	0.464
20	3.00	0.943	6	1.792	0.395	0.399	0.400	0.406	0.416	0.428
21	3.04	0.956	5	1.609	0.355	0.358	0.359	0.364	0.374	0.384
22	3.09	0.972	4	1.386	0.306	0.309	0.310	0.314	0.322	0.331
23	3.14	0.987	2	0.693	0.153	0.154	0.155	0.157	0.161	0.165
24	3.18	1	1	0	0	0	0	0	0	0

TABLE III. The names of the places of the Political Map of Northeast India: ranking, natural logarithms, normalisations

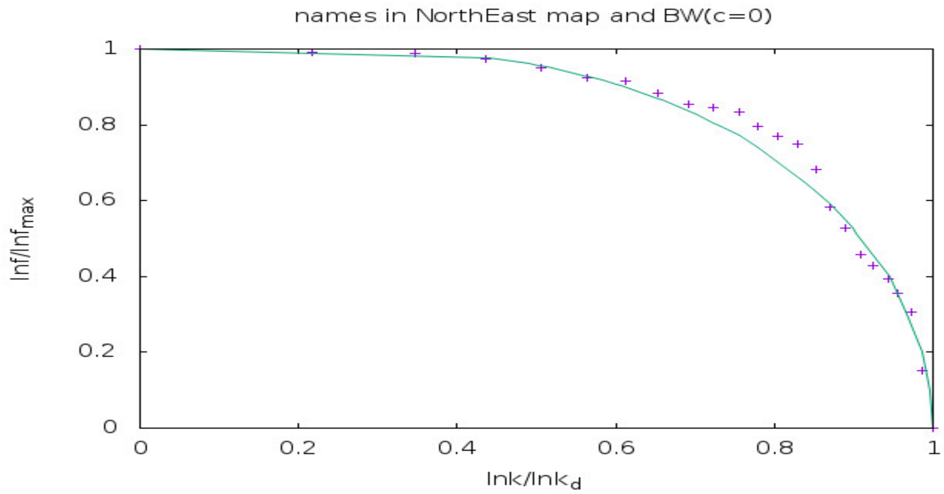

FIG. 2. The vertical axis is $\frac{lnf}{lnf_{max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the names of the places in the Political Map of Northeast India,[1],, with the fit curve being the Bragg-Williams curve of the Ising Model, in the absence of external magnetic field, $c = \frac{H}{\gamma\epsilon} = 0$.

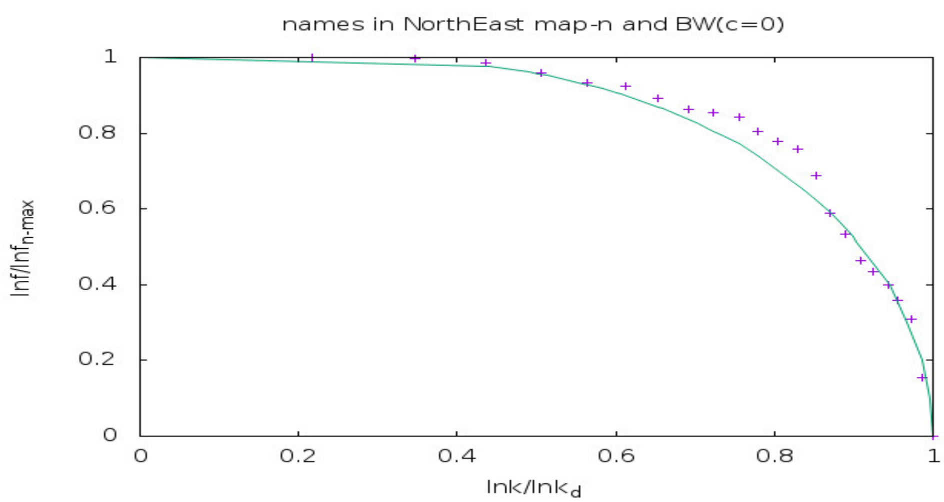

FIG. 3. The vertical axis is $\frac{lnf}{lnf_{n-max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the names of the places in the Political Map of Northeast India,[1],, with the fit curve being the Bragg-Williams curve of the Ising Model, in the absence of external magnetic field, $c = \frac{H}{\gamma\epsilon} = 0$.

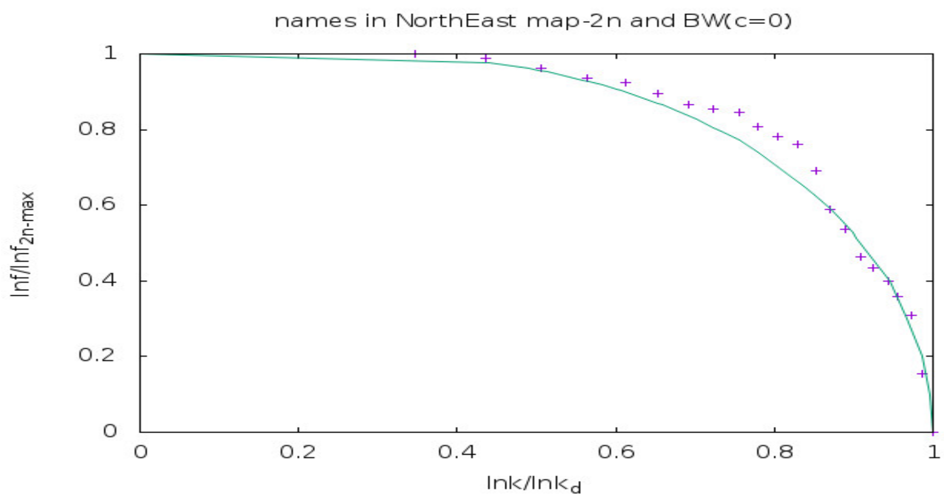

FIG. 4. The vertical axis is $\frac{lnf}{lnf_{2n-max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the names of the places in the Political Map of Northeast India,[1],, with the fit curve being the Bragg-Williams curve of the Ising Model, in the absence of external magnetic field, $c = \frac{H}{\gamma\epsilon} = 0$.

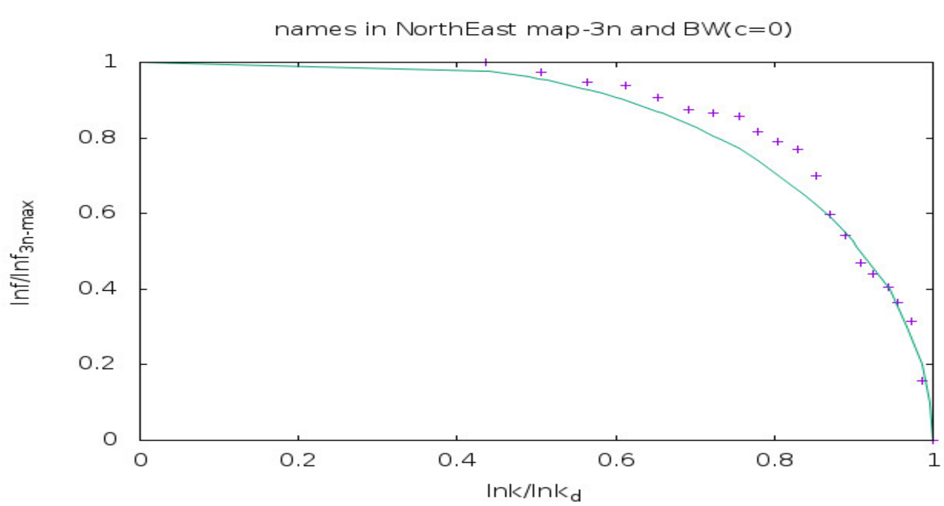

FIG. 5. The vertical axis is $\frac{lnf}{lnf_{3n-max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the names of the places in the Political Map of Northeast India,[1],, with the fit curve being the Bragg-Williams curve of the Ising Model, in the absence of external magnetic field, $c = \frac{H}{\gamma\epsilon} = 0$.

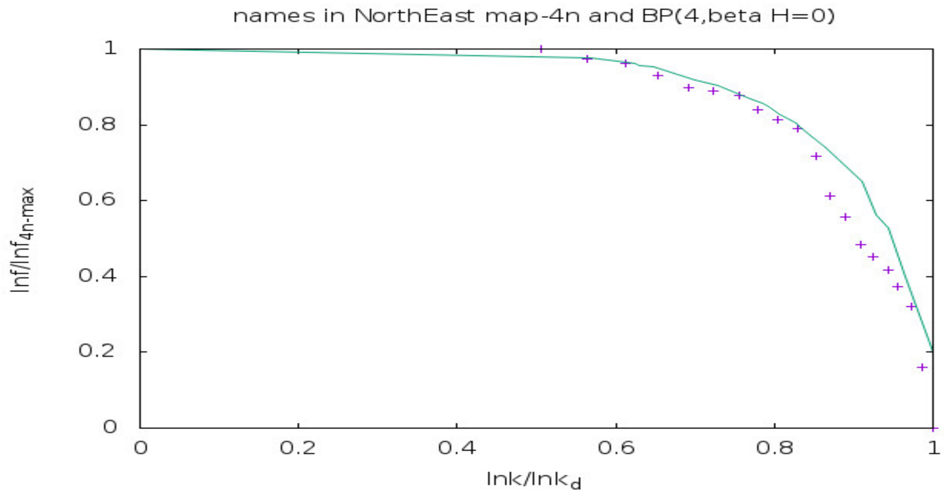

FIG. 6. The vertical axis is $\frac{lnf}{lnf_{4n-max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the names of the places in the Political Map of Northeast India with the fit curve being the Bethe-Peierls curve, BP(4,$\beta H = 0$), of the Ising Model, in the presence of four nearest neighbours and in the absence of external magnetic field, $m = 0$ or,$\beta H = 0$.

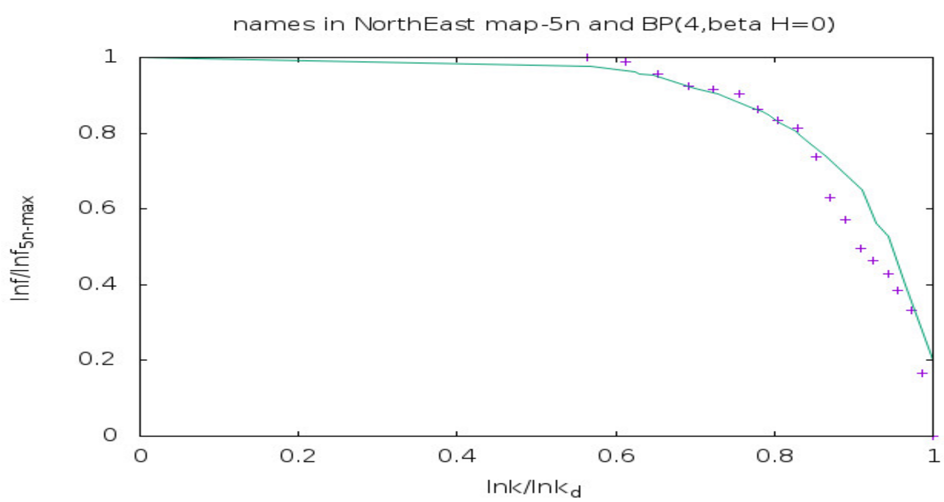

FIG. 7. The vertical axis is $\frac{lnf}{lnf_{5n-max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the names of the places in the Political Map of Northeast India with the fit curve being the Bethe-Peierls curve, BP(4,$\beta H = 0$), of the Ising Model, in the presence of four nearest neighbours and in the absence of external magnetic field, $m = 0$ or,$\beta H = 0$.

A. conclusion

From the figures (fig.2-fig.7), we observe that there is a curve of magnetisation, behind the names of the places, in the Political Map of Northeast India,[1], This is the magnetisation curve in the Bragg-Williams approximation of the Ising model, BW(c=0), in the absence of external magnetic field, $c = \frac{H}{\gamma\epsilon} = 0$.

Moreover, the associated correspondence is,

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

$$lnk \longleftrightarrow T.$$

k corresponds to temperature in an exponential scale, [86].

This result should be seen in the background of the reference, [55].

IV. ACKNOWLEDGMENT

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

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[1] Political Map of Northeast India, designed, cartographed and published by TTK Healthcare Limited-Publications Division, www.ttkmaps.com, © Government of India, copyright 2023, Head office: Kamakhya Commercial, 1st floor, opposite HariSabha, C.K.Road, Panbazar, Guwahati-01; Northeast India Map MC1382.

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