The Onsager solution, The Hawaiian Language

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Abstract

We study the Hawaiian-English Dictionary composed by Mary Kawena Pukui and Samuel H. Elbert. We count all the Hawaiian entries initiating with different letters. 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. We find that the entries underlie a magnetisation curve. The magnetisation curve i.e. the graph of the reduced magnetisation vs the reduced temperature is the exact Onsager solution of the two dimensional Ising model in the the absence of external magnetic field.

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I. INTRODUCTION

In this article, we go over to the poetic Hawaiian Language. We study the Hawaiian-English Dictionary by Mary Kawena Pukui and Samuel H. Elbert, [1], composed way back in the year 1957 and brought out by the University of Hawaii. We look 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 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 in the references from [4] to [97].

The planning of the paper is as follows. We give an introduction to the relevant curve of magnetisation of Ising model, The Onsager solution, in the section II. In the section III, we describe the graphical law analysis of the entries of the Hawaiian-English Dictionary, [1]. Section IV is Acknowledgment. The last section is the Bibliography.

II. MAGNETISATION

The two dimensional Ising model, [98], in the absence of external magnetic field is prototype of an Ising model. In case of square lattice of planar spins, one spin interacts with four other nearest neighbour spins i.e. on an average to another one spin. Below a certain ambient temperature, denoted as T_c, the two dimensional array of spins reduces to a planar magnet with magnetic moment per site varying as a function of $\frac{T}{T_c}$. This function was inferred, [104], by Lars Onsager way back in 1948 and thoroughly deduced thereafter by C.N.Yang, [107]. This function we are referring to as Onsager solution. Moreover, systems, [105], showing behaviour like Onsager solution is rare to come across. Graphically, the Onsager solution appears as in fig.1.

To have a comprehension, 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

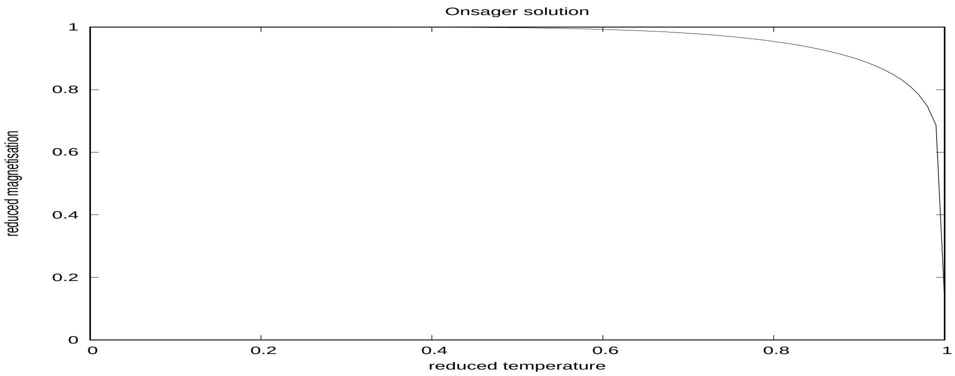

FIG. 1. Reduced magnetisation vs reduced temperature curves for exact solution of two dimensional Ising model, due to Onsager, in the the absence of external magnetic field

$N_- = \frac{N}{2}(1-L)$. Magnetisation or, net magnetic moment , M is $\mu\Sigma_i\sigma_i$ or, $\mu(N_+ - N_-)$ or, μNL, $M_{max} = \mu N$. $\frac{M}{M_{max}} = L$. $\frac{M}{M_{max}}$ is referred to as reduced magnetisation. Moreover, the Ising Hamiltonian,[98], 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.

At a temperature T, below a certain temperature called phase transition temperature, T_c, for the two dimensional Ising model in the absence of external magnetic field i.e. for H equal to zero, the exact, unapproximated, Onsager solution gives reduced magnetisation as a function of reduced temperature as, [104], [106], [107], [103],

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

and appears as in fig.1.

III. ANALYSIS OF ENTRIES OF THE HAWAIIAN-ENGLISH DICTIONARY BY MARY KAWENA PUKUI AND SAMUEL H. ELBERT

The Hawaiian language alphabet is composed of twelve letters. We count all the entries, [1], one by one from the beginning to the end, starting with different letters. The result is the table, I. We have counted two words everywhere the same excepting in a letter with different diacritical marks as different.

Highest number of entries, three thousand nine hundred seventy one, starts with the letter k followed by entries numbering three thousand three hundred forty four beginning with p,

letter	a	e	h	i	k	l	m	n	o	p	u	w
number	1638	340	2640	604	3971	1464	1993	828	1046	3344	761	548

TABLE I. The Hawaiian language entries: the first row represents letters of Hawaiian alphabet in the serial order, the second row is the respective number of entries, .

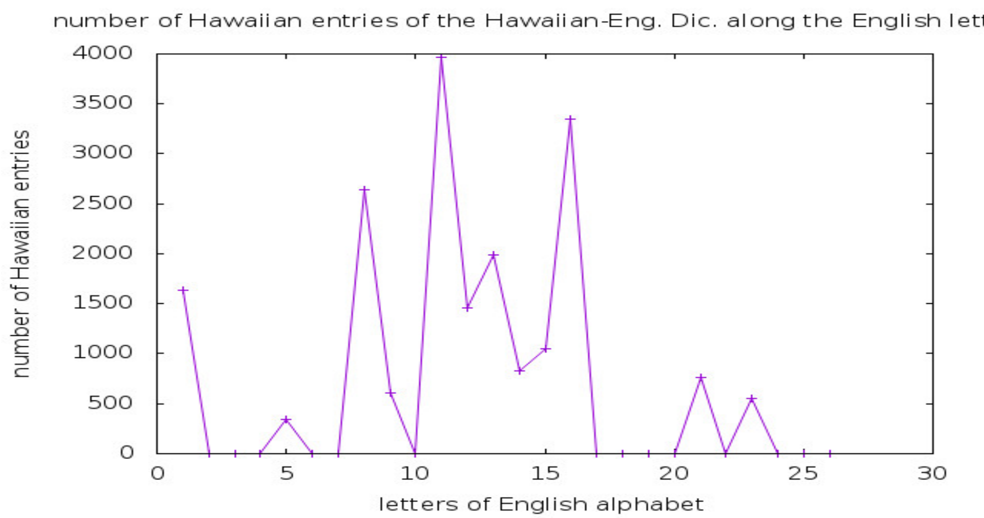

FIG. 2. The vertical axis is number of entries of the Hawaiian language and the the horizontal axis is the respective letters of the English alphabet. Letters are represented by the sequence number in the English alphabet beginning with a.

two thousand six hundred forty with the letter h etc. To visualise the pattern of change of number of entries along the the letters initiating with, we draw the number of entries vs. sequence number of the respective letters in the fig.2.

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, denoted by k, [108]. Moreover, we attach a limiting rank, k_{lim}, and a limiting number of entries. The limiting rank is maximum rank plus one, denoted as k_{lim} or, k_d. Here it is thirteen and the limiting number of entries is one. As a result, k is a positive integer starting from one and both $\frac{lnf}{lnf_{max}}$ and $\frac{lnk}{lnk_{lim}}$ varies from zero to one. Then we tabulate in the adjoining table, II and plot $\frac{lnf}{lnf_{max}}$ against $\frac{lnk}{lnk_{lim}}$ in the figure fig.3. We then ignore the letter with the highest number of entries, tabulate in the adjoining table, II and redo the plot, normalising the lnfs

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	3971	8.287	1	Blank	Blank	Blank	Blank	Blank
2	0.69	0.267	3344	8.115	0.979	1	Blank	Blank	Blank	Blank
3	1.10	0.430	2640	7.879	0.951	0.971	1	Blank	Blank	Blank
4	1.39	0.543	1993	7.597	0.917	0.936	0.964	1	Blank	Blank
5	1.61	0.629	1638	7.401	0.893	0.912	0.939	0.974	1	Blank
6	1.79	0.699	1464	7.289	0.880	0.898	0.925	0.959	0.985	1
7	1.95	0.762	1046	6.953	0.839	0.857	0.882	0.915	0.939	0.954
8	2.08	0.813	828	6.719	0.811	0.828	0.853	0.884	0.908	0.922
9	2.20	0.859	761	6.635	0.801	0.818	0.842	0.873	0.897	0.910
10	2.30	0.898	604	6.404	0.773	0.789	0.813	0.843	0.865	0.879
11	2.40	0.938	548	6.306	0.761	0.777	0.800	0.830	0.852	0.865
12	2.48	0.969	340	5.829	0.703	0.718	0.740	0.767	0.788	0.800
13	2.56	1	1	0	0	0	0	0	0	0

TABLE II. Entries of the Hawaiian-English Dictionary by Mary Kawena Pukui and Samuel H. Elbert: ranking, natural logarithms, normalisations

with next-to-maximum $lnf_{nextmax}$, and starting from $k = 2$ in the figure fig.4. This program then we repeat up to $k = 6$, resulting in figures up to fig.8.

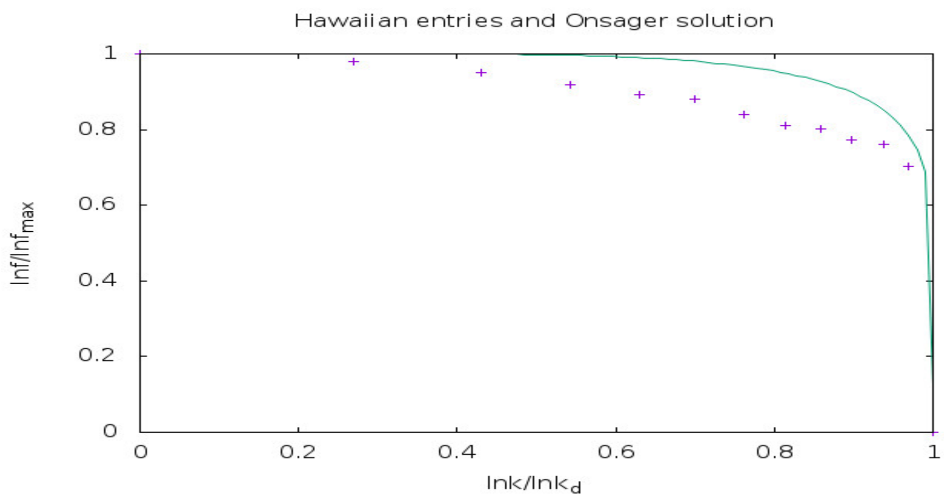

FIG. 3. The vertical axis is $\frac{lnf}{lnf_{max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the entries of the Hawaiian language The reference curve is the Onsager solution.

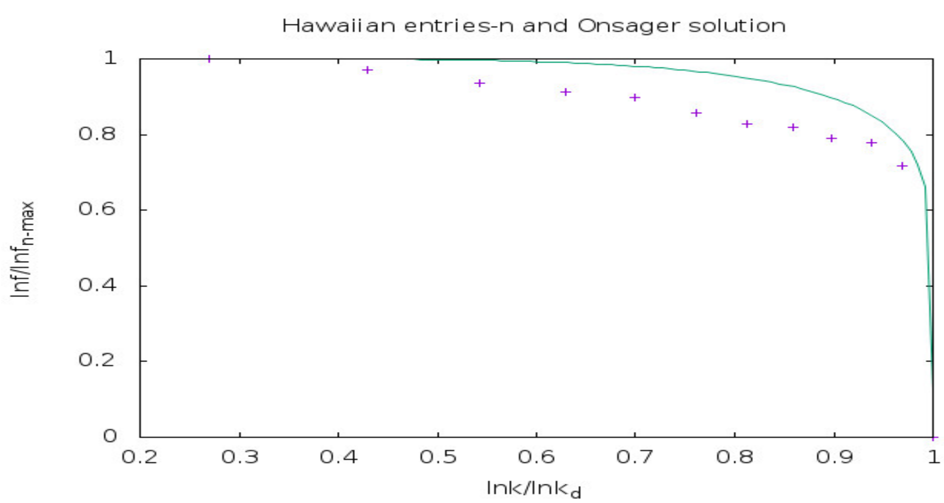

FIG. 4. The vertical axis is $\frac{lnf}{lnf_{n-max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the entries of the Hawaiian language The reference curve is the Onsager solution.

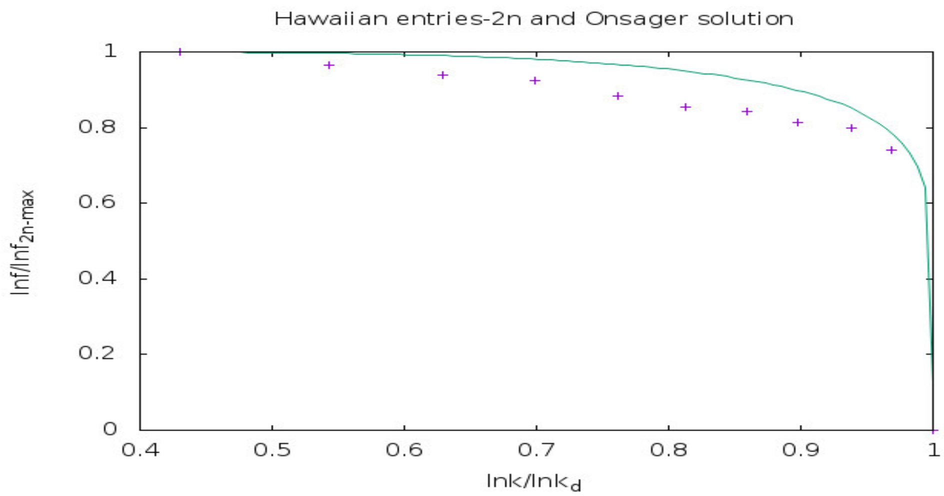

FIG. 5. The vertical axis is $\frac{lnf}{lnf_{2n-max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the entries of the Hawaiian language The reference curve is the Onsager solution.

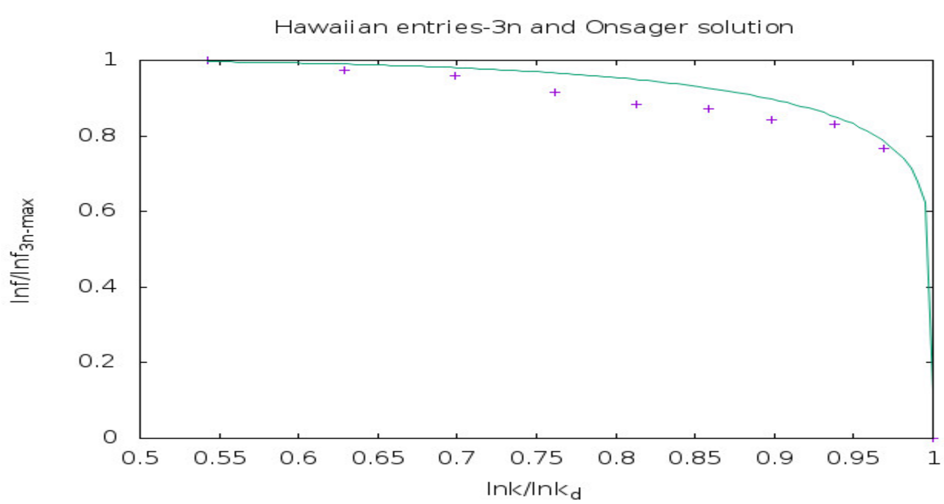

FIG. 6. The vertical axis is $\frac{lnf}{lnf_{3n-max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the entries of the Hawaiian language The reference curve is the Onsager solution.

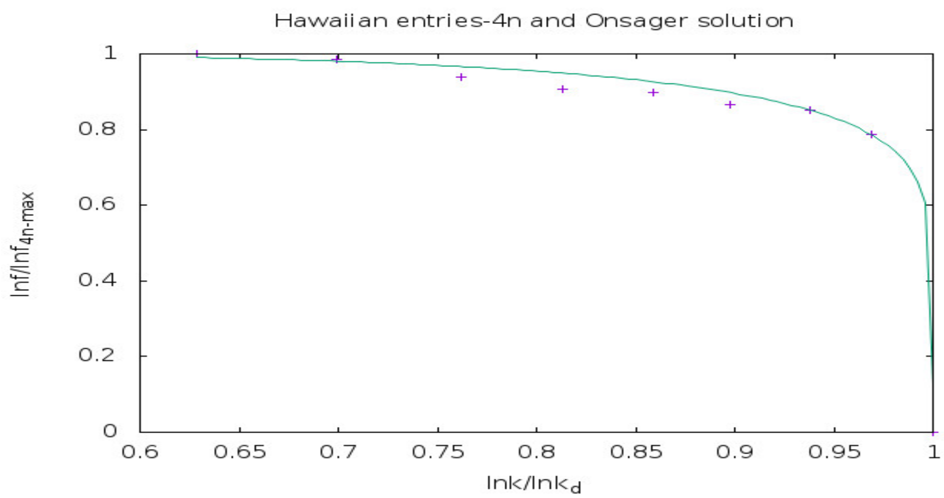

FIG. 7. The vertical axis is $\frac{lnf}{lnf_{4n-max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the entries of the Hawaiian language The reference curve is the Onsager solution.

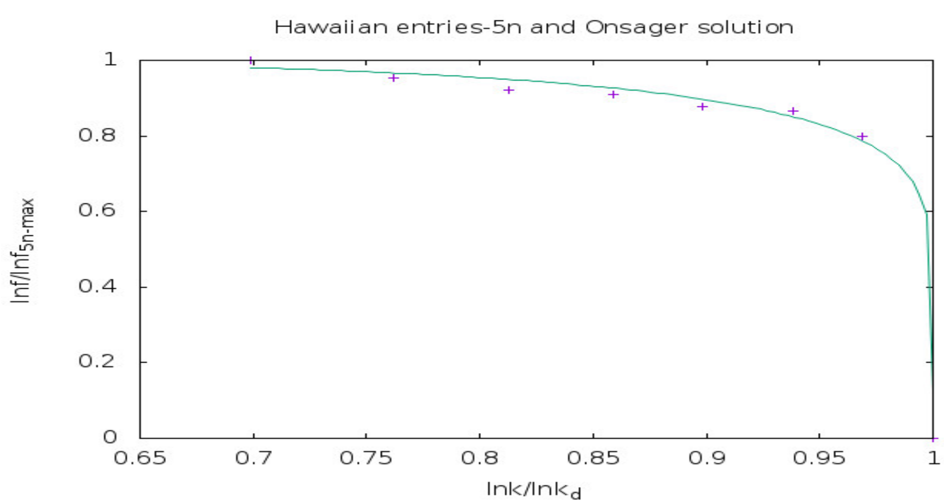

FIG. 8. The vertical axis is $\frac{lnf}{lnf_{5n-max}}$ and the horizontal axis is $\frac{lnk}{lnk_{lim}}$. The + points represent the entries of the Hawaiian language The reference curve is the Onsager solution.

A. conclusion

From the figures (fig.3-fig.8), we observe that the entries of the Hawaiian language, [1], underlies the Onsager solution.

Moreover, the associated correspondence is,

$$\frac{lnf}{lnf_{5n-max}} \longleftrightarrow \frac{M}{M_{max}},$$

$$lnk \longleftrightarrow T.$$

k corresponds to temperature in an exponential scale, [109].

IV. ACKNOWLEDGMENT

The author would like to thank the National Library(Government Of India), Kolkata, to allow us to use Hawaiian-English Dictionary by Mary Kawena Pukui and Samuel H. Elbert, [1], in its premises. We have used gnuplot for plotting the figures in this paper.

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