# An Arabic dictionary: "al-Mujam al-wáfi" or, "adhunik arabi-bangla abhidhan" and the Onsager's solution - Second part 

Anindya Kumar Biswas ${ }^{\text {T}}$<br>Department of Physics; North-Eastern Hill University, Mawkynroh-Umshing, Shillong-793022.

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#### Abstract

We continue to consult an Arabic dictionary: "al-Mujam al-wáf" or, "adhunik arabi-bangla abhidhan" by Dr. M. Fazlur Rahman. Here we count all the words initiating with a letter, including plural, feminine gender and appearing in other letters' sections. We draw the natural logarithm of the number of words, normalised, starting with a letter vs the natural logarithm of the rank of the letter. We find that the words 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 absence of external magnetic field.


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## I. INTRODUCTION

In this article, we continue to study magnetic field pattern behind the rich Arabic language. We study an Arabic dictionary: "al-Mujam al-wáfi" or, "adhunik arabi-bangla abhidhan" by Dr. M. Fazlur Rahman, [T]. 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 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, [回], the graphical law behind the Little Oxford English Dictionary, [II]], the Oxford Dictionary of Social Work and Social Care, [II], the VisayanEnglish 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, [■6], Khasi English Dictionary, [7], Turkmen-English Dictionary, [[8], Websters Universal Spanish-English Dictionary, [TY], A Dictionary of Modern Italian, [20], Langenscheidt's German-English Dictionary, [24], 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, [225], 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, [2.4], respectively.

We count all the words, [T], one by one from the beginning to the end, starting with different letters in this paper. We have left out the entries which appear starting with different letters in a section belonging to a particular letter in our previous paper, [25]. Here, we do that. Here we include also the plural and feminine gender words.

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 arabic words of the Arabic-Bengali dictionary, [T]. Section IV is Acknowledgment. The last section is the 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 longrange 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 $\sigma_{i}$ 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. $L=\frac{1}{N}\left(N_{+}-N_{-}\right)$. 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, $\mu\left(N_{+}-N_{-}\right)$or, $\mu N L, M_{\max }=\mu N . \frac{M}{M_{\max }}=L \cdot \frac{M}{M_{\max }}$ is referred to as reduced magnetisation. Moreover, the Ising Hamiltonian,[30], for the lattice of spins, setting $\mu$ 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, [3T], $2 \epsilon \gamma \bar{\sigma}+2 H$, where $\gamma$ is the number of nearest neighbours of a spin. According to Boltzmann principle, $\frac{N_{-}}{N_{+}}$ equals $\exp \left(-\frac{\Delta E}{k_{B} T}\right)$, [32]. In the Bragg-Williams approximation, [33], $\bar{\sigma}=L$, considered in the thermal average sense. Consequently,

$$
\begin{equation*}
\ln \frac{1+L}{1-L}=2 \frac{\gamma \epsilon L+H}{k_{B} T}=2 \frac{L+\frac{H}{\gamma \epsilon}}{\frac{T}{\gamma \epsilon / k_{B}}}=2 \frac{L+c}{\frac{T}{T_{c}}} \tag{1}
\end{equation*}
$$

where, $c=\frac{H}{\gamma \epsilon}, T_{c}=\gamma \epsilon / k_{B},[34] . \frac{T}{T_{c}}$ 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 [37]. 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 fieldIn the approximation scheme which is improvement over the Bragg-Williams, [30], [31], [33], [33], [34], due to Bethe-Peierls, [35], reduced magnetisation varies with reduced temperature, for $\gamma$ neighbours, in absence of external magnetic field, as

$$
\begin{equation*}
\frac{\ln \frac{\gamma}{\gamma-2}}{\ln \frac{\text { factor }-1}{\text { factor } \frac{\gamma-1}{\gamma}-\text { factor }^{\frac{1}{\gamma}}}}=\frac{T}{T_{c}} ; \text { factor }=\frac{\frac{M}{M_{\max }}+1}{1-\frac{M}{M_{\max }}} . \tag{2}
\end{equation*}
$$

| BW | $\mathrm{BWV}(\mathrm{c}=0.01)$ | BP(4, $3 \boldsymbol{\prime}=0)$ | reduced magnetisation |
| :---: | :---: | :---: | :---: |
| O | 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 data s 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 .
$\ln \frac{\gamma}{\gamma-2}$ 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 $(\mathbb{T})$ and the equation $(\mathbb{Z})$ in the table, 姩, 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( $\mathbb{T}$ ). $\mathrm{BP}(4)$ represents reduced temperature in the Bethe-Peierls approximation, for four nearest neighbours, computed from the equation([ป]). The data set is used to plot fig.Il. Empty spaces in the table, 政, mean corresponding point pairs were not used for plotting a line.


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 BethePeierls approximation in absence of magnetic field, for four nearest neighbours (outer in the top).

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

In the Bethe-Peierls approximation scheme, [35], reduced magnetisation varies with reduced temperature, for $\gamma$ neighbours, in presence of external magnetic field, as

$$
\begin{equation*}
\frac{\ln \frac{\gamma}{\gamma-2}}{\ln \frac{\text { factor }-1}{e^{\frac{2 \beta H}{\gamma}} \text { factor } \frac{\gamma-1}{\gamma}-e^{-\frac{2 \beta H}{\gamma}} \text { factor } \frac{1}{\gamma}}}=\frac{T}{T_{c}} ; \text { factor }=\frac{\frac{M}{M_{\max }}+1}{1-\frac{M}{M_{\max }}} . \tag{3}
\end{equation*}
$$

Derivation of this formula Ala [35] is given in the appendix of [7].
$\ln \frac{\gamma}{\gamma-2}$ for four nearest neighbours i.e. for $\gamma=4$ is 0.693 . For four neighbours,

$$
\begin{equation*}
\frac{0.693}{\ln \frac{\text { factor }-1}{e^{\frac{2 \beta H}{\gamma}} \text { factor } \frac{\gamma-1}{\gamma}}-e^{-\frac{2 \beta H}{\gamma}} \text { factor } \frac{1}{\gamma}}=\frac{T}{T_{c}} ; \text { factor }=\frac{\frac{M}{M_{\max }}+1}{1-\frac{M}{M_{\max }}} . \tag{4}
\end{equation*}
$$

In the following, we describe data $s$ in the table, 收, generated from the equation( $\mathbb{\pi}$ ) and curves of magnetisation plotted on the basis of those data s. $\mathrm{BP}(\mathrm{m}=0.03)$ 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 $(\mathbb{H})$. $\mathrm{BP}(\mathrm{m}=0.025)$ 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 $(\pi)$. $\mathrm{BP}(\mathrm{m}=0.02)$ 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 $(\mathbb{Z}) . \mathrm{BP}(\mathrm{m}=0.01)$ 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 $(\mathbb{T})$. $\mathrm{BP}(\mathrm{m}=0.005)$ 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 $(\mathbb{Z})$. The data set is used to plot fig. $[$ ]. Similarly, we plot fig.[3]. Empty spaces in the table, 四, mean corresponding point pairs were not used for plotting a line.

| $B P(m=0.03)$ | BP(mme 0.025$)$ | BP(m=0.02) | $B P(m=0.01)$ | BP(me $=0.005$ ) | reduced magnotisation |
| :---: | :---: | :---: | :---: | :---: | :---: |
| $\bigcirc$ | $\bigcirc$ | 0 | $\bigcirc$ | 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 presence of little external magnetic fields


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


FIG. 3. Reduced magnetisation vs reduced temperature curves for Bethe-Peierls approximation in presence of little external magnetic fields, for four nearest neighbours, with $\beta H=2 \mathrm{~m}$.

## D. Onsager solution

At a temperature T , below a certain temperature called phase transition temperature, $T_{c}$, for the two dimensional Ising model in 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, [36], [37], [38], [35],

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

Graphically, the Onsager solution appears as in fig.T].


FIG. 4. Reduced magnetisation vs reduced temperature curves for exact solution of two dimensional Ising model, due to Onsager, in absence of external magnetic field

| letter | alif | bā | tā | s̈ā | jeem | hā | khā | dā | zāl | rā | zāy | seen | sheen | sād |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| number | 8947 | 2098 | 3851 | 359 | 1525 | 2224 | 1461 | 1169 | 365 | 1877 | 714 | 2009 | 1494 | 1120 |
| splitting | $7090+680+335+842$ | 1914+184 | $3835+16$ | $349+10$ | $1498+27$ | $2167+57$ | $1422+39$ | $1149+20$ | $350+15$ | $1842+35$ | $708+6$ | $1981+28$ | $1473+21$ | $1108+12$ |
| letter | dād | tā | zā | ain | gain | fā | qāf | kāf | lām | meem | noon | hā | wāw | yā |
| number | 478 | 816 | 177 | 2454 | 1004 | 1535 | 1887 | 1302 | 1154 | 9038 | 2205 | 921 | 1276 | 290 |
| splitting | $470+8$ | $812+4$ | $175+2$ | $2314+140$ | $980+24$ | $1453+82$ | $1859+28$ | $1275+27$ | $1073+81$ | $8948+90$ | $2179+26$ | 906+15 | $1256+20$ | 276+14 |

TABLE III. Arabic entries: the first row represents letters of the Arabic alphabet in the serial order, the second row is the respective number of entries, the third row describes the splitting of entries.

## III. ANALYSIS OF WORDS OF THE ARABIC-BENGALI DICTIONARY

The Arabic language alphabet is composed of twenty eight letters. We count all the words, [T], one by one from the beginning to the end, starting with different letters. We have left out the entries which appear starting with different letters in a section belonging to a particular letter in our previous paper, [25]. Here, we do that. Here we include also the plural and feminine gender words. The result is the table, 皿. To clarify, we have counted all entries initiating with Alif form the section for the letter Alif. The number is seven thousand ninety. Second, we have enlisted all entries initiating with Alif form the sections for the letters B $\bar{a}, T \bar{a}, . ., Y \bar{a}$. Then we have removed from the list entries already appearing in the section belonging to Alif. Then we have counted the number of the entries in that list. The number is six hundred eighty plus three hundred thirty five plus eight hundred forty two. As a result total number of words beginning with Alif is eight thousand nine hundred and forty seven. This exercise was then followed for the letters Bā, Tā,..,Yā. The result is the table, III.

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. ${ }^{[1]}$.

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, denoted by $k$. Moreover, we attach a limiting rank, $k_{\text {lim }}$, and a limiting number of words. The limiting rank is maximum rank plus one, denoted as $k_{\text {lim }}$ or, $k_{d}$. Here it is twenty nine and the limiting number of words is one. As a result, $k$ is a positive integer starting from one and both $\frac{\operatorname{lnf}}{\ln f_{\max }}$ and $\frac{\ln k}{\ln k_{l i m}}$ varies from zero to one. Then we tabulate in the adjoining table, $\mathbb{T}$ and plot $\frac{\operatorname{lnf}}{\ln f_{\text {max }}}$ against $\frac{\ln k}{\ln k_{l i m}}$ in the figure fig.[6]. We then ignore the letter with the highest


FIG. 5. The vertical axis is number of entries of Arabic and the horizontal axis is the respective letters of the Arabic alphabet. Letters are represented by the sequence number in the alphabet beginning with Alif.
number of words, tabulate in the adjoining table, $\mathbb{D}$ and redo the plot, normalising the $\ln f_{\mathrm{s}}$ with next-to-maximum $\ln f_{\text {nextmax }}$, and starting from $k=2$ in the figure fig. $[7$. This program then we repeat up to $k=6$, resulting in figures up to fig.[2].

| k | lnk | $\operatorname{lnk} / \operatorname{lnk} k_{\text {lim }}$ | f | $\operatorname{lnf}$ | $\operatorname{lnf} / \ln f_{\text {max }}$ | $\operatorname{lnf} / \ln f_{n-\max }$ | $\operatorname{lnf} / \ln f_{2 n-\max }$ | $\operatorname{lnf} / \ln f_{3 n-\max }$ | $\operatorname{lnf} / \ln f_{4 n-\max }$ | $\operatorname{lnf} / \ln f_{5 n-\max }$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 0 | 0 | 9038 | 9.109 | 1 | Blank | Blank | Blank | Blank | Blank |
| 2 | 0.69 | 0.205 | 8947 | 9.099 | 0.999 | 1 | Blank | Blank | Blank | Blank |
| 3 | 1.10 | 0.326 | 3851 | 8.256 | 0.906 | 0.907 | 1 | Blank | Blank | Blank |
| 4 | 1.39 | 0.412 | 2454 | 7.805 | 0.857 | 0.858 | 0.945 | 1 | Blank | Blank |
| 5 | 1.61 | 0.478 | 2224 | 7.707 | 0.846 | 0.847 | 0.934 | 0.987 | 1 | Blank |
| 6 | 1.79 | 0.531 | 2205 | 7.698 | 0.845 | 0.846 | 0.932 | 0.986 | 0.999 | 1 |
| 7 | 1.95 | 0.579 | 2098 | 7.649 | 0.840 | 0.841 | 0.926 | 0.980 | 0.992 | 0.994 |
| 8 | 2.08 | 0.617 | 2009 | 7.605 | 0.835 | 0.836 | 0.921 | 0.974 | 0.987 | 0.988 |
| 9 | 2.20 | 0.653 | 1887 | 7.543 | 0.828 | 0.829 | 0.914 | 0.966 | 0.979 | 0.980 |
| 10 | 2.30 | 0.682 | 1877 | 7.537 | 0.827 | 0.828 | 0.913 | 0.966 | 0.978 | 0.979 |
| 11 | 2.40 | 0.712 | 1535 | 7.336 | 0.805 | 0.806 | 0.889 | 0.940 | 0.952 | 0.953 |
| 12 | 2.48 | 0.736 | 1525 | 7.330 | 0.805 | 0.806 | 0.888 | 0.939 | 0.951 | 0.952 |
| 13 | 2.56 | 0.760 | 1494 | 7.309 | 0.802 | 0.803 | 0.885 | 0.936 | 0.948 | 0.949 |
| 14 | 2.64 | 0.783 | 1461 | 7.287 | 0.800 | 0.801 | 0.883 | 0.934 | 0.946 | 0.947 |
| 15 | 2.71 | 0.804 | 1302 | 7.172 | 0.787 | 0.788 | 0.869 | 0.919 | 0.931 | 0.932 |
| 16 | 2.77 | 0.822 | 1276 | 7.151 | 0.785 | 0.786 | 0.866 | 0.916 | 0.928 | 0.929 |
| 17 | 2.83 | 0.840 | 1169 | 7.064 | 0.775 | 0.776 | 0.856 | 0.905 | 0.917 | 0.918 |
| 18 | 2.89 | 0.858 | 1154 | 7.051 | 0.774 | 0.775 | 0.854 | 0.903 | 0.915 | 0.916 |
| 19 | 2.94 | 0.872 | 1120 | 7.021 | 0.771 | 0.772 | 0.850 | 0.900 | 0.911 | 0.912 |
| 20 | 3.00 | 0.890 | 1004 | 6.912 | 0.759 | 0.760 | 0.837 | 0.886 | 0.897 | 0.898 |
| 21 | 3.04 | 0.902 | 921 | 6.825 | 0.749 | 0.750 | 0.827 | 0.874 | 0.886 | 0.887 |
| 22 | 3.09 | 0.917 | 816 | 6.704 | 0.736 | 0.737 | 0.812 | 0.859 | 0.870 | 0.871 |
| 23 | 3.14 | 0.932 | 714 | 6.571 | 0.721 | 0.722 | 0.796 | 0.842 | 0.853 | 0.854 |
| 24 | 3.18 | 0.944 | 478 | 6.170 | 0.677 | 0.678 | 0.747 | 0.791 | 0.801 | 0.802 |
| 25 | 3.22 | 0.955 | 365 | 5.900 | 0.648 | 0.648 | 0.715 | 0.756 | 0.766 | 0.766 |
| 26 | 3.26 | 0.967 | 359 | 5.883 | 0.646 | 0.647 | 0.713 | 0.754 | 0.763 | 0.764 |
| 27 | 3.30 | 0.979 | 290 | 5.670 | 0.622 | 0.623 | 0.687 | 0.726 | 0.736 | 0.737 |
| 28 | 3.33 | 0.988 | 177 | 5.176 | 0.568 | 0.569 | 0.627 | 0.663 | 0.672 | 0.672 |
| 29 | 3.37 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

TABLE IV. Arabic words: ranking, natural logarithm, normalisations


FIG. 6. The vertical axis is $\frac{\ln f}{\ln f_{\text {max }}}$ and the horizontal axis is $\frac{l n k}{\ln k_{l i m}}$. The + points represent the words of the Arabic language with the lower line being the Bethe-Peierls curve, $\mathrm{BP}(4, \beta H=0)$, with four nearest neighbours, in the absence of external magnetic field. The uppermost curve is the Onsager solution.


FIG. 7. The vertical axis is $\frac{\operatorname{lnf}}{\ln f_{n e x t-m a x}}$ and the horizontal axis is $\frac{\operatorname{lnk}}{\ln k_{l i m}}$. The + points represent the words of the Arabic language with the lower line being the Bethe-Peierls curve, $\mathrm{BP}(4, \beta H=0)$, with four nearest neighbours, in the absence of external magnetic field. The uppermost curve is the Onsager solution.


FIG. 8. The vertical axis is $\frac{\operatorname{lnf}}{\ln f_{n \text { nextnext-max }}}$ and the horizontal axis is $\frac{\ln k}{\operatorname{lnk} k_{l i m}}$. The + points represent the words of the Arabic language with the lower line being the Bethe-Peierls curve, $\operatorname{BP}(4, \beta H=$ 0.02 ), with four nearest neighbours, in the presence of little external magnetic field. The uppermost curve is the Onsager solution.


FIG. 9. The vertical axis is $\frac{\operatorname{lnf}}{\ln f_{n \text { nextnextnext-max }}}$ and the horizontal axis is $\frac{\operatorname{lnk}}{\ln k_{l i m}}$. The + points represent the words of the Arabic language with the lower line being the Bethe-Peierls curve, $\mathrm{BP}(4, \beta H=0.1)$, with four nearest neighbours, in the presence of little magnetic field, $\mathrm{m}=0.05$ or, $\beta H=0.1$. The uppermost curve is the Onsager solution.


FIG. 10. The vertical axis is $\frac{\operatorname{lnf}}{\ln f_{3 n-m a x}}$ and the horizontal axis is $\frac{\operatorname{lnk}}{\ln k_{l i m}}$. The + points represent the words of the Arabic language with the fit curve being the Onsager solution.


FIG. 11. The vertical axis is $\frac{\operatorname{lnf}}{\ln f_{4 n-\text { max }}}$ and the horizontal axis is $\frac{\operatorname{lnk}}{\ln k_{l i m}}$. The + points represent the words of the Arabic language with the fit curve being the Onsager solution.


FIG. 12. The vertical axis is $\frac{\operatorname{lnf}}{\ln f_{5 n-m a x}}$ and the horizontal axis is $\frac{\operatorname{lnk}}{\ln k_{l i m}}$. The + points represent the words of the Arabic language with the fit curve being the Onsager solution.

## A. conclusion

From the figures (fig. 6 -fig. [2]), we observe that the words of the Arabic language, [ $[7]$, underlies the Onsager solution.
Moreover, the associated correspondence is,

$$
\begin{aligned}
\frac{\ln f}{\ln f_{4 n-\max }} & \longleftrightarrow \frac{M}{M_{\max }}, \\
\ln k & \longleftrightarrow T .
\end{aligned}
$$

k corresponds to temperature in an exponential scale, [40].

## IV. ACKNOWLEDGMENT

We have used gnuplot for plotting the figures in this paper. We have benefitted from consultation of the book, [47]. We would like to thank the nehu library for allowing us to use the book.
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Words starting with ' (Gsmms) from the ather letters' cutions.












(1)

(1)

[किषु, [Gण-जिषण ] P247, [बणु-बणुछ] P251,

[जाण- रूब्या











[अल - (-)


[बल्N-कित] $P 377$, [जल वाउया'] 382 ,






 (1)



















 0 路










 [बत-बिzक्र], [बन-बिचाधर्डा०] 5533 ,






 [ बान्त- बा बा०] 5559 (1)














 [जाल - कारोn] P618, [आM-mनन] P618, [GMM-minmir],






 1





 [aro- व्याजनूल नातफो] +673 , [ज्या25-याशि] $p-675$, [G15-25నनन]P678, [ जान $Q$ $6 \operatorname{ain}$ nे $\left.2 \operatorname{lo}_{0}\right]+681$,


















[आल-2गाके2ा2], [जल-2णनीबतन] $P 749$, [जल-20ाठित्रिया5T2] $P 750$, ©

[am-253T2] P753,


 (1) $2,10,0$


 (D)





 [बल-कूपत्र] 5790 , [ज्याल-कादो०], [बल -कामीठ], [जल बूाता]
 (\%.) © \&








$$
409+2
$$




[anल-क्रिणन], [जल-किणाूत मूक्षपूप] +823 ,


 , 835 , [anन-यामधादाक] $P 837$, [anN बार20] $584 \theta$,


 ©















 (1) ${ }^{2}$











(1)











 (1) मानाब चुण चरी] P1003

 (1) (1)








[जनल - बूणाओ




(1) 4 (1) याo a (1052, [0vin $+1{ }^{2}$

(1)





























 [बतम Q






O entrius from all euctions.- correspending to alif.
(n-t induding pluar + teminin ginder)














[CITH20] P444

[घिबनाना $P 457$, [घाईें], [घार्ये]]. [घा/2n]] $P 462, \%$






 (1)


























































 34








 (1)

$$
\# 335
$$

Words starting with 1 [Gimmes] from the other Letlors' (considering plural a feminine gender). sections.














[013] P337,
(1)



[दूरी] +352 .





 [वाजT], [क्रम्नर2], [का NTה] 8377 , [Dित, [1], [क्रति] 9379 ,
 [का30], [क्र (1320], [का3 (1) ${ }^{\circ}$ (1) $P 382$, [का N] P383, [कोर], (1) [कीजा] P384,
[ ज7.2] $p 389,[$ रि० ], [रिण] $p 391,[$ रिण 10 , 5392 ,

 $\left[\begin{array}{c}20 \\ 0,1\end{array}\right] 400,\left[\begin{array}{c}\text { सक्का } 2]\end{array}\right] p 401,[$ (1), [1,
 [R2, $] P 405$, [2णी/os], [2ज्ञा0] p406, [र्डा3या2],
[1)





 [ 213272$],[21325],[213 \mathrm{~m}],[215 \mathrm{~h}]+428,[21323]$, (10 13$]$,

 [gबi











 $\left[\begin{array}{c}\text { h2 } \\ 0\end{array}\right],\left[\begin{array}{c}h ी \pi \\ \text { hै }\end{array} \mathrm{P} 486\right.$,

 [21N1人], [यिश 0 ] 5494, [2130] P495,


 [किकाड0
[者






 $\left[\begin{array}{c}\text { गे } 0 \\ 0\end{array}\right],\left[\begin{array}{cc}\text { गे } 20 \\ 0\end{array}\right],\left[\begin{array}{c}\text { गी० }\end{array}\right],[$ गीन $] P 534$,


 [2ी], [2ी0], [2ौ0] $P 549$,













 $p 587$ [ कबत, [ड्रायक] $P 588$, [ जीध], [ जोटि] 5589 ,
 [लिणे], [लाश्र०] ए598, [ mाकाण], [mाjकात], [m/णाएँ' F 599 ,






 [M/13nt P619, $[$ (i)



























































 (1)
(2)
(1) (1)
(1)



 [-2ing







 [ल13.], [लाउया] P864,






(1) (1)

Q

 [मीmet] P1059.














(1)

 [2130], [23 nt p1125, [21327], [211डs] p1126, [यर्शमित] p1128.











 मा157, [उयारण] PII5s. (1) '0' (8)
 (2)


Wards starting with $Y\left(x_{1}\right)$ from other litters's rections









 P297, [किण-जाये जेष] $P 306$, [कि०- जातर्रण] +329 ,























 [右-साइ?], [ िि-बाओालिरी], $837,[$ बिल - कूच कार $]+841$,













$$
\neq 129+1
$$

Wonds starling witt $ب$ [J才] from The ather Lithess sections





[aणाता (2) $P 22$, [20न किएण



P306, [बिठ-च्जामि किते $] P 520$.

$$
\begin{aligned}
\# 21 \times 2+12= & 42+12=54 \\
T \cdot+a 1 \# 129+54 & =183+1 \\
+1 & =184
\end{aligned}
$$

Words starling with $\because(01)$ from ather Lithers' sections.




 \# 11

Wouds starting with. b 1 of ] frum ather litters gutians



$$
\begin{aligned}
T . t a 1 \# 2+1 & =3+1 \\
& =4
\end{aligned}
$$

wouds starting with $\dot{\mathscr{y}}$ (पूT'] fu.m Ther Lithers' Rention

[ द्राविल कालन] P377. \#3


$$
\text { (2) } 1 \cdot+01 \# 3+7=10
$$

$$
\# 7
$$

Wonds starting with $\omega(5 h)$ from ather lithers' futtions




(2)
(2) $\# 6$

$$
\text { T.tal } \# 6+6 \# 12
$$

Words etorting with (. (ुरी०) from the ather litter s'sections





[ara, 32728 ] P38

$$
\begin{array}{rl}
\# & 2 \times 9+5 \\
& =23 \\
\text { Total \#4+23} & =27
\end{array}
$$

words starting with C (21) fu.m the other litars lation






 [यद्रालू० कालिr], P659, [M,


 [277,

$$
\# 32
$$



 [सम्न सूपूपूयियार] P363
womds starting with (21) frow the ather lithers' suitions


 \#6
 [ orre-2 218$]$ P1s2
(2)

$$
\begin{gathered}
\# 9 \\
\text { Total \#6+9=15}
\end{gathered}
$$

words stating with $\dot{\tau}$ ( ©r from the ather Litters's sutions



$$
\begin{aligned}
& \text { [a1y) 2012 (2)] } P 57 \\
& \text { \# } 2 \times 14+7=35 \\
& \text { Total \# } 4+35=39
\end{aligned}
$$

Words starting with $\perp$ ( $n / m$ ) from the other lithers' Sutions

 [माॅया बर्टेजन] +1160 , \# 6


\# 14

$$
\text { Tatal \# } 6+14=20
$$

Wonds starting with io ( TTh $^{\prime}$ ) from the other Litters' cections

 [arade] pll, [armani6] pll \# 4 (2) (2)

$$
\text { T.tal \# } 4+4=8
$$

Wouds starting with ; (znlw) flow the Ther lithers' gection,



 [2ाश7न ड्रूमात] P564; \# 12

(1)
(1)

Total \# $12+3=15$
words starting wich ; $(2 \pi)$ from the Ther le Mors' feiline

 Tatal \# $1+5=6$
wouds starting witw b $(v)$ fu-m the sthen lethers'sections
[252zunr द्वाnt 4 ]p807. \# 1
[arizano] pll6 \# 1

Words starting with $J$ (J) frow the ather Letters" gectime






(2)

Total\# $5+30 \quad \# 2 \times 13$
Worids starting with $\mathrm{VW}($ sita) from the othor Lithers suttions




 [ars,210] P96,
[खात्रालि],
[लाइर 2ान], [खाक्राधाइ].
[बाइडh] 996
(1)
 (2)
(1)
(1)
[आबाताहJ], [अब्राइ] P100
(2)
(1)

$$
\# 2 \times 4+7
$$

\# 15

$$
\text { Total \# } 13+15=28
$$

words starting with wiol (vita) form the other lithers'fertions

 \#6
[armory] p103, [almait] p104, [armaro], [almy d20] p105,
 [mptिors दमात् $P 654$,

$$
\# 2 \times 4+5
$$

Total \# $6+15=21$

$$
\begin{equation*}
=15 \tag{1}
\end{equation*}
$$

wirds starting with $\dot{\varepsilon}$ (sाrरत) pum the other leters' gections







$$
\# 16
$$


 (1)
(1)

$$
\# 8
$$

$$
\text { Total } \# 16+8=24
$$

Woreds starting with E (जरेन) from the other Letlers' ections.






 [6 वान्ता चरचयितारिद कित] $P 240$, [6बाला बूसमा2] $P 243$,













 [6 बनि 2512 नु मिया 2]P518, [6 बात चविया 2 ], [6बलाख तो $s]+533-34$,










 [6 बला गापा वित्र प्रातरि] 5922 , [6वाला आगुपिय यात्गतन] +929 ,







 P 1136 , ['बाला उयाला। ] P 1145 , [G बालाल किलt'] P1155,
 [न्गाल ट्याक्रोज] P1163;





[G्बाल्त जाइए जाञित] $\triangle 741$
(1)

$$
\begin{aligned}
& \# 2 \times 5+13 \\
& =10+13 \\
& =23 \\
\text { T.tal } & 117+23 \\
& =140
\end{aligned}
$$

Words starting with io (201) frow the ather letters' sutions.

 [ [िक्ल बrदnt] P110, [ सिल जनालाव] P127,



[20t OलT 25t20] P318, [20ी दूजा ग1] P351,










 [20ी नुग्राणित ताय, Q] P792, [यीक्ष लाउ] P863,

 [ 2ोt-小Tक, 33) [ डी जिरोंरिशे] $p 1084$, [युीरि N1254] p1089,





 [ [ यी जईंता किता सडिशी] P1165


(i)
[arrian] 161
(1)
(1)

$$
\# 9+1
$$

$$
\begin{aligned}
& \text { Total \# } 70+9= 79+1+1+1 \\
&+1+1 \\
&+1=80+1+1 \\
&=81+1 \\
&=82
\end{aligned}
$$

Wands starting with $\ddot{\theta}(₹ 120)$ from the ather hitters' sition
[ वृष्ला आंउयातिरी] P192, [ वातनूल किजाया०] p377,





$\$ 13$

(1)

(1)

(2)
\# 15
Total \# $13+15=28$

Wouds starting with si (बTrs) from the ther lithers' section.




 \# 14
[तूला रू13 कित] $\& 1164$,


(2)
(2)

$$
\# 2 \times 6+1
$$

\# 13
Total \# $14+13$ \# 27

Wonds starting with $I$ (mIs) from the other lithers gections.








 [ला बहा वी $p 718$, [ला एिल 6 रू! उ2ालज] $p 726$, [लि-सायाणि], [किते-जायT2] $P 730$, [ जT डानु2ा], [ जT जाञ,32才] $P 736$,

 [ला मूसवष्तित जार] $P 877$, [लाईत्रा जारद आठन काइालिए] $P 877$,






 [ति- उयक्रिशी] $P 1152$, [लि-बमि अयालि उयाश जारिन] $P 155$, [ला रूचाइ गागो] P1164,


(2) (2)

[लार्तापूर्य पू ganr2] $P 470$

$$
\begin{aligned}
& \# 2 \times 8+5 \\
& \# 16+5 \\
& \# 21
\end{aligned}
$$

$$
\text { Total \# } 60+21=81
$$

Words starting with $P($ sीo $)$ frow the other Litters'sections









 [अवुत किलक्री] P379, [ होता का उनी] P383.






[ कीते ब्रो 6 anकि2े] $P 552$, [संबाज उसला ज्ञार] $P 575$,




 [विए नोगिलि] $P 786$





 [मिन, रेगांकिरी] P 1165 .

$$
\# 73+1
$$

$$
+1
$$


 (2)

[नुग्र जार] $P 810$.
(1)

$$
\begin{aligned}
& \# 2 \times 4+7 \\
& =15
\end{aligned}
$$

$$
\begin{array}{rl}
\text { T.tal } \# & 73+15 \\
=2 & 88+2 \\
= & 8990
\end{array}
$$

Words storting witt $\dot{U}\left(\mathrm{a}_{\mathrm{a}}\right.$. frum the other lithers' sections


[ति बनलूn हूर्ण aा2] $p 888$, [निक्रागतूल हूरूकीत] $p 905$,





$$
\begin{aligned}
& \# 2 \times 7+2+3 \\
& =19 \\
\text { Total } \# 7+19 & =26
\end{aligned}
$$

Words storiting with 9 (32n3) from the .ther Liturs' retions




[327ला3] +863 , [3था गिल - gूतात्रागा2] +1027 ,
[ उयायीक्त तारिक 6 aा2] P1065, [ उ2ग त्रिक हैत तिणन] P 1087 ,
[30ा 2ालून्धा वाणुगत] $P 1122$,

$$
\# 14
$$


(2)
[ 321 (i)
\# 6

$$
\text { Total } \# 14+6=20
$$

words starting with 5 (201) fun The other Litters' factions.





$$
\begin{aligned}
& \text { \# } 13
\end{aligned}
$$

$$
\begin{aligned}
& \text { Total \# } 13+1=14 \text {. }
\end{aligned}
$$


[^0]:    * anindya@nehu.ac.in

