

*Article*

## A Thermodynamic Methodology for Evaluating Friendship Relations Stability

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### Abstract

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This paper presents a molecular potential model to describe the human interactions in interpersonal relationships. We propose that friendship relations can be accurately evaluated by an intermolecular force model via a simulation method using a set of individual personality characters such as emotion intelligent, introvert and extrovert dimensions as the necessary input data. Because the internal states of the human are not directly observable, the human behavior models requires the necessary human's internal state information which is determined through an indirect estimation process. Because there are various roles for peoples across different relationships, the objective of this work is an effective effort to address the friendship satisfaction factors and consequently relationship stability. The proposed model is examined for a university-students union as a case study. As a result, using personality assessment tests, the proposed model can be successfully used to predict the stability of human friendships in the different multicultural social networks.

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Keywords: human interactions, friendship, relationship stability, molecular potential model

## Introduction

In recent years, there has been an increasing attempt towards understanding how people react to situation and how to respond appropriately. The knowledge of human interactions is a key to success in different activities, e.g. business, friendship, marriage and life (Carrington et al., 2005; Pale et al., 2006). Due to the complexity of human interactions, in many cases, human behavior is typically modeled only at the level of a single person (Liao et al., 2006; Huynh et al., 2008). However, studies on the factors that keep people together are always of interest to the social scientists (Kelley, 1978; Hicks et al., 1970; Gatica-Perez, 2009). Of course, the stability prediction of human friendship relations and consequently the global social behavior are strongly related to the individual personality factors of single persons, e.g. the emotional intelligent, introvert and extrovert dimensions. These may be depended on the different factors such as gender, age, religion, culture, history and background relations especially in the first decade of life. However, the mutual effects of the local individual behavior and global social structure make the human behavior representation as a complex topic.

For simplicity, the global social structure may be considered as a collection of independent persons, dyad (a single pair), small interacting group and multiple people relationships (Pentland, 2007; Gibson, 2005). Therefore, this approach shows a quantitative way to study the role played by individual human personality and human interactions in shaping the kind of aggregate behavior observed at a population level in social structures. Therefore, as a key element in analyzing human behavior in social systems, a hypothetical molecular system containing single and aggregated (dimmer, trimmer and polymer) molecules can be considered. The molecular system containing interacting particles can be used to estimate the social system behavior via a simulation method.

From the thermodynamic viewpoint, the average number of molecular aggregates in a system containing different size of aggregated molecules is related to the size, shape and polarity of molecules as well as the molecular interactions. The average number of molecular aggregates, aggregate stability and consequently the thermodynamic state and behavior of the system can be evaluated by using the statistical thermodynamic theories (Mohsen-Nia and Modarress, 2007). The simulation method as proposed in this work creates a molecular thermodynamics-based model which considers an interaction potential to describe several features of social behavior especially friendship relations. This approach may be roughly named 'human thermodynamics'. The term 'human thermodynamics' has been first recorded by C.G. Darwin (Thomson, 1952), in which collections of interacting humans with different individual personality are considered as the thermodynamic system.

There are various categorical subfields of thermodynamics applied to the study of human existence. The history of human thermodynamics traces the timeline of the theoretical insight

involved in the application development of molecular interactions and the laws of thermodynamics in the understanding of the human life process, both independent persons and interacting groups (Darwin, 1952; Thims, 2007).

The numbers of distinct divisional ‘branches’ of human thermodynamics are introduced by interdisciplinary researchers. Johann Goethe (1799) introduced relationship thermodynamics to explain the relationship of physics and love in human societies (Adler, 1990; Swales, 2002). Cessations thermodynamics was initiated by Ludwig Colding (1843) to study what thermodynamics has to say about death. The use of thermodynamics to explain religious theory was initiated by James Joule (Joule, 1847) and later by Richard Owen as religious thermodynamics (Colding, 1843; Owen, 1849). Hermann Gossen used proto-thermodynamics concepts, such as energy and force, for the study of the use of thermodynamics to model economies as energy systems involving economic exchanges (Gossen, 1983). Philosophical thermodynamics was proposed by Gustave Hirn (1856) to study of the philosophical implications of thermodynamics (Hirn, 1868). The use of thermodynamics in social theory was studied by Henry Carey as sociological thermodynamics (Carey, 1958-1959). Francois Massieu introduced ethics thermodynamics for applying the use of thermodynamics in theories of ethics and the difference between right and wrong (Massieu, 1869).

The subject of how thermodynamics applied to the understanding of human states of happiness was studied by August Krönig as happiness thermodynamics (Krönig, 1856). Sigmund Freud (1895) used psychological thermodynamics to study of the thermodynamics of the mind or mental states (Freud, 1895). Leslie White (1943) used the thermodynamics in anthropology. He focused to study of the comparison of different cultures applied to financial matters such as debts, wealth, and interest (Erickson et al. 2003). Karl-Henrik Robèrt introduced sustainability thermodynamics to use of thermodynamics models in development of sustainability theories (Robèrt 1991). Racial thermodynamics is applied to study of the thermodynamic explanations of racism or race by Richard Delgado (Delgado, 1990). Jurgen Mimkes (1994) proposed integration and segregation thermodynamics to study of the use of phase diagrams and solution thermodynamics logic in the explanation of the integrations and segregations behaviors of mixed cultures or people (Mimkes, 1995). The framework of human statistical thermodynamics and human chemical thermodynamics were applied in generalized outline and basic principles to the study of human existence by Libb Thims (Thims, 2008).

A connected field is that of human physics, which defines people as particles and crowds as fluids or flows of particles, and studies phenomenon such as crowd behavior, inclusive of abnormal states such as emergency panic behaviors, e.g. fire evacuation movements, such as discussed in the work of Xiaoshan Pan (Pan et al., 2005).

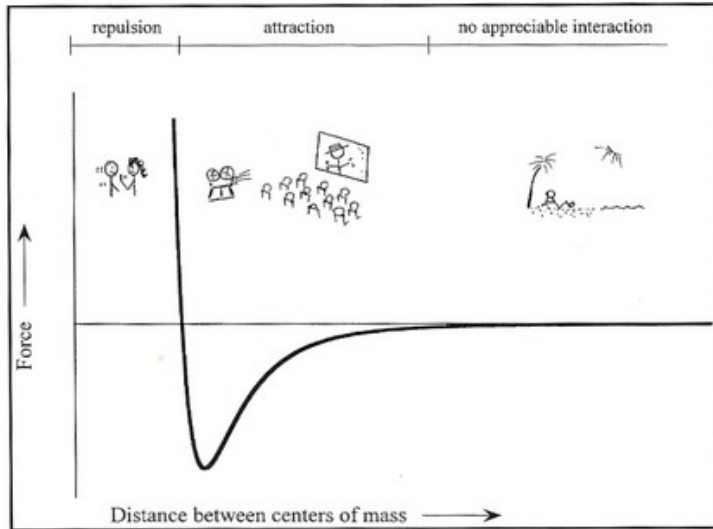
In this direction, the following study employs a mixture of these models. To facilitate comprehension, the following is a human thermodynamics variables table, constructed in the style of Irving Fisher's 1892 physical economics variable table, made by lead author Mohsen Mohsen-Nia, is representively descriptive of the variables used in this article:<sup>1</sup>

### Social System Variables Table

Molecular Thermodynamics	Human Thermodynamics
Particle	Individual
System	Social system is viewed a set of people who obey same political, economic, cultural and social rules.
Density, $\rho$	Population per unit area
Volume, $V$	Social freedom
Temperature, $T$	Social excitement, which is a measure of the society's motivation
Pressure, $p$	Social pressure is really a measure of existence of different rules, e.g. political, economic, cultural and social rules which should be obeyed by all people in such system to avoid totally chaotic systems.
Heat, $Q$	Heat is a form of energy that is sustained by the difference of society excitement between the two systems as a driving force.
Internal energy, $U$	Internal energy is the amount of energy which is stored in a society and accounts for the movements of people which constitutes the society.

In continuation, in later centuries quantitative scientific methods have grown to study of human behavior, social interactions and important motivational role of commitment and reciprocity of exchanges on social relationships stability by reducing the problem to its simplest components. Considering the relationship stability as a topic of major interest in the study of interpersonal relationships and social satisfactions, the proposed model indicates to evaluate the friendship stability by using single person's personality factors as the input data.

In regard to the present study, to give some historical precedence, the first to introduce the concept of an 'interhuman potential', modeling pairs of humans interacting socially 'similar to that of insignificant molecules', was Venezuelan-born English chemical engineer and thermodynamics professor Erich Muller.



**Figure 1:** Erich Muller's 1998 Lennard-Jones stylized interhuman potential attraction repulsion model, with positive values for force being indicative of repulsion and negative values of attraction. [3]

In his 1998 *Chemical Education Engineering* article "Human Societies: A Curious Application of Thermodynamics", Muller employed the Lennard-Jones potential model, a mathematically simple model first proposed in 1924 by English mathematical physicist John Lennard-Jones that approximates the interaction between a pair of neutral atoms or molecules, to explain social attractive and repulsive force, in terms of molecular thermodynamics. [2]

Muller illustrates his interhuman potential diagram pictorially, as shown adjacent (figure 1), which he captions as follows:

"The solid line shows in a qualitative way the intermolecular force for two simple molecules as a function of the distance of their centers. A positive value indicates repulsion among molecules, and a negative value, attraction. The relation to human interactions is evident. An isolated individual (the sunbather) is at peace without interactions from other humans. Nevertheless, he may come relatively close to other individuals for certain occasions (like going to movies). Too close an encounter [as occurs during a fight], however, usually leads to repulsion."

This paper, similar to Muller's original model, presents the results of a questionnaire and interview style study of 69 college subjects, the data of which is interpreted in terms of a Lennard-Jones potential attraction repulsion model.

## Theoretical framework

The theoretical structure of this study is based on the molecular interactions in a thermodynamic system and their influences on the phase stability and phase transitions of different fluid mixtures e.g. binary mixtures containing different types of molecules. In other words, we assume that molecules experience intermolecular repulsive and attractive forces as well as external forces e.g., resulting from electric and magnetic fields. So, accounting for molecular interactions, ultimately creates an opportunity for predictions of the thermodynamic phase behavior. Typical

evaluations require an accurate model for the intermolecular potential for describing the interaction between two particles in a specific field force. The intermolecular potential depends not only on their separation distance but also on their temporary and permanent characteristics.

The resulting particle trajectory in such systems can be completely used for describing the human relations and friendship stability prediction. Factors such as love, commitment, relationship satisfaction, religion and social culture can be consider as the external forces that affect the human interactions. So, the quantitative analyzing of the interpersonal relationship may be achieved by introducing an effective interpersonal potential model.

Factors that influence relationship stability have been studied by various researchers. Factors such as love (Gruenbaum, 1976), marital satisfaction (Lenthall, 1977; Levinger, 1966), and life-cycle stage (Rollins and Feldman, 1970) have been found to be associated with stability of relationships. Much of the research on relationship stability has actually focused on marital stability, thus there are limiting knowledge of the factors that are associated with stable relationships. Therefore, in this work, the effects of these factors are globally considered for determining the interpersonal potential model and its parameters.

## Methodology

The subjects participating in this study were volunteer undergraduate students of chemistry department at the Shiraz University (Iran) in December, 2010. They were together at least for three years. The sixty nine subjects completed the first questionnaire and interview schedule. Nine of these subjects did not complete the second questionnaire and interview. The subjects ranged in age from 21 to 26, with a mean age of 22.8. There were 22 (37%) male subjects and 38 (63%) female subjects.

The friendship and reciprocity of exchange with each friend were measured in a team work project in the physical chemistry laboratory by using an interview schedule and visual inspection. The interview was conducted by a same-sex interviewer, and the subject was asked questions about his or her happiness in the friendship and reciprocity of exchange in order to examine the level of friendship stability. Subjects also indicated the degree of personal commitment to each relationship, stability of each friendship was assessed by determining whether the friendship maintained for the project's work collaboration.

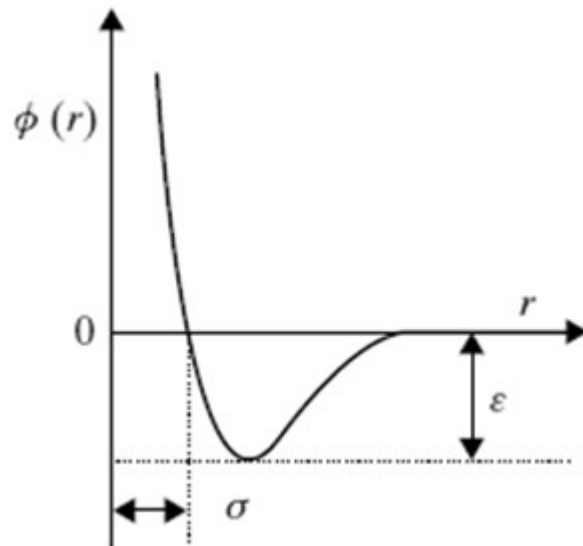
Subjects also completed two questionnaires as the personality and emotional intelligent tests. In this research work, the Eysenck Personality Questionnaire (EPQ) (Eysenck, 1975) and emotionally intelligent test (Bar on) (Bar-On, 2000) which were normalized for Iranian society were used as the personal and emotional intelligent tests respectively.

The results of the personality and emotional intelligent tests are used for determining the parameters of the proposed interpersonal potential model. Thus the quality and stability of friendship can be evaluated by the interpersonal potential model by using the individual personality and emotional intelligent data.

To avoid unwarranted complications, it proves useful to restrict our choice to those models established for no more than two independent parameters (e.g., Lennard Jones molecular potential model). The Lennard–Jones (L-J) potential for a pseudo-pure system is defined by:

$$\phi(r) = 4\epsilon \left[ \left( \frac{\sigma}{r} \right)^{12} - \left( \frac{\sigma}{r} \right)^6 \right]$$

where, for a molecular system,  $\epsilon$  is the depth of the potential well,  $\sigma$  is the finite distance at which the inter-particle potential is zero and  $r$  is the distance between the particles. [2] The schematic diagram of L-J model is shown in Figure 2 (adjacent). As an interpersonal potential model,  $\epsilon$  indicates the energy at the bottom of the potential well that accounts for human attraction, while  $\sigma$  provides a barrier for human repulsion. The parameter values can be established for any person by applying the EPQ and Bar-on test results.



**Figure 2:** schematic diagram of the interpersonal L-J potential model.

In a personality test, we are talking about what makes that person different from other people, perhaps even unique. This aspect of personality is called individual differences. Instance, some people are neurotic, others are not; some people are more introverted, others more extroverted; and so on. The difference of EPQ test score is considered as  $r$  in the potential model. The difference of extroversion personality characteristics from the EPQ and the arithmetic average of emotion intelligent from Bar-on test are respectively considered as the barrier human repulsion ( $\sigma$ ) and the energy parameter ( $\epsilon$ ) as presented in the potential model. In this manner, the interpersonal potential can be detected for evaluating the friendship quality as a measure of the value and importance of human friendship with a particular person in a specific society. So, it means that the stability of friendship can be predicted by interpretation of the proposed interpersonal potential model.

## Results

Preliminary analyses were performed to obtain descriptive data on the subjects participated in this study. Ninety-five percent of the friendships for both male and female subjects were same-sex friendships. According to our results, 79% of the friendships were stable. This difference was not attributed to the subjects. Male friendships did not differ significantly on stability from female friendships. According to our results from this study, the friendship stability did not show a meaningful difference for either males or females relations. The detailed results are presented in Table 1 (below). Totally, our results indicate that the method is able to achieve 90% accuracy at predicting friendship stability of subjects reviewed in this study.

Although, the friendship stability has a significant impact on social satisfaction, considering the complexity, there is no a reliable practical model for the friendship behavior evaluation. Nevertheless, this work proposes a molecular thermodynamics based model to describe the friendship stability. This study indicates that although the commitment, social culture, religion and economic situation are important factors in friendship stability study but they can globally evaluated in term of the potential representing the human interactions. As a result, this study recommends that friendship relations should be truly identified by the interpersonal potential model for evaluating the friendship satisfaction and estimating the friendship stability.

Type of friendship	Friendship Stability		
	Very stable	Stable	Unstable
Men-Men	14%	81%	5%
Women-Women	50%	40%	10%
Women-Men	0%	100%	0%

**Table 1:** obtained results of the friendship stability for different type of relations.

## Reviewers

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<http://tiny.cc/3ulli>



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