*Journal of Thermal Analysis, Vol. 43 (1995) 521-537*

# BINARY ALLOYS AS A MODEL FOR THE MULTICULTURAL SOCIETY

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## Abstract

The model of regular solutions, that may be applied to binary alloys (e.g. Au–Pt, Si–Ge) has been compared to binary societies: blacks – non-blacks in the US, catholics – non-catholics, foreigners – German citizen. The excellent agreement of phase diagrams and intermarriage data encourages a calculation of the multicultural society by functions of thermodynamics: Solubility corresponds to integration, miscibility gap to segregation, free enthalpy to happiness and temperature to tolerance of a society. Only a high level of tolerance will integrate ghettos and lead to a peaceful multicultural society.

**Keywords:** integration, intermarriage, segregation, tolerance

## Introduction

The new freedom in Eastern Europe did not bring peace to all countries, instead it has initiated war in some former states of Yugoslavia and the Soviet Union. Czechoslovakia has separated and the reunited Germany shows problems of integration of east and west and a strong polarization between right wing radicals and foreigners. Many other countries have problems of integration, the large hispanic migration has cooled down the melting pot USA. A general interest is focused on the problems of multicultural societies, many questions are raised: Why do societies segregate, how many people of a minority can be integrated, which measures will promote integration, how will a multicultural society develop? How are freedom and peace coupled?

These questions could be answered by models of statistical thermodynamics, if the objects of integration were atoms. Phase diagrams showing integration (solubility) or segregation (miscibility gaps) are familiar in the metallurgy of alloys. Figure 1A shows solid brass with 58% Cu and 42% Zn after tempering at 800°C. The alloy has segregated into light and dark areas of alpha and beta brass, each containing different compositions of copper and zinc.

Figure 1B shows parts of Bosnia/Yugoslavia in 1991. The population has segregated into different areas marked light or dark, each containing a different

*0368–4466/95/ $ 4.00*

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composition of Serbs, Croats, Moslems and others. Figures 1A and 1B look very similar. These structural similarities may indicate a similarity in mathematical models for both figures. For this reason we will try to apply the model of regular *A–B* alloys to *A–B* societies. We will find intermarriage data of blacks in the US, catholics and foreigners in Germany to correspond to phase diagrams of alloys, indicating that the statistical model of regular alloys may indeed be applied to people in specific situations.

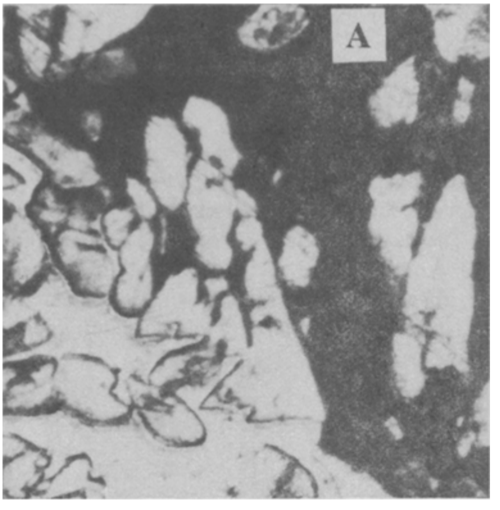


**Fig. 1A** Alpha and beta phases in brass (58% Cu, 42% Zn)

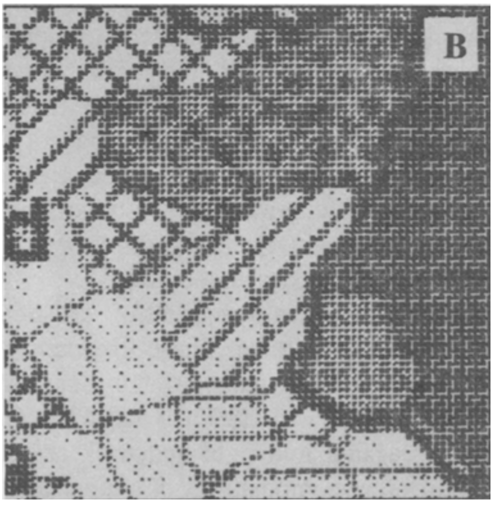


**Fig. 1B** Distribution of Bosnic and Serbic people in Yugoslavia 1991. Dierke Weltatlas,

## The regular binary solution

The model of regular $A$–$B$ solutions is based on the probability of mixing two partners $A$ and $B$ [1, 2],

$$G(x,T) = -T[x\ln x + (1-x)\ln(1-x)] + 2\varepsilon x(1-x) \quad (1)$$

$$\varepsilon = (E_{AB} + E_{BA} - E_{AA} - E_{BB}) \quad (2)$$

The meaning of the functions (1,2) depends on the particular system observed.

### Alloys

$G(x,T)$ is the (negative) Gibbs enthalpy of the regular binary alloy, (e.g. gold and platinum, silicon and germanium) and the sum of the contribution of each atom of the alloy. An $A$–$B$ alloy will be stable, if $G(x,T)$ is at its maximum. $G(x,T)$ will depend on the composition $x$ of the alloy and on temperature $T$, $\varepsilon$ is the resulting positive or negative attractive energy between $A$–$A$, $A$–$B$, $B$–$A$ and $B$–$B$ neighbors. For strong $A$–$B$ attraction $\varepsilon$ will be positive, strong $A$–$A$ or $B$–$B$ attraction will lead to a negative sign of $\varepsilon$.

### Societies

In this paper we will try to interpret $G(x,T)$ as general happiness of a binary society (e.g. girls and boys, blacks and non-blacks, catholics and non-catholics, citizen and foreigners). $G(x,T)$ is the sum of happiness of each individual person in the specific society. A society may be expected to be stable, if the general happiness $G(x,T)$ is at a maximum. Again $x$ is the percentage of one group, usually the minority. $T$ may be regarded as mutual tolerance of the society, as will be discussed, below, $\varepsilon$ will be the resulting sympathy, apathy or antipathy between neighbors $A$–$B$, $B$–$A$, $A$–$A$ and $B$–$B$.

### *Order and sympathy, $\varepsilon>0$*

### Crystal

In rock salt the attraction of sodium (Na) and chloride (Cl) ions is much stronger than the attraction between Na–Na or Cl–Cl, and $\varepsilon>0$ applies. Figure 2A may be interpreted as the (negative) Gibbs or free enthalpy of NaCl as a function of concentration $x$ of Na ions. $G(x,T)$ reaches a maximum at $x=0.5$. This is the stable composition of NaCl crystals. Figure 2B shows the distribution of Na and Cl ions. Due to the strong Na–Cl attraction rock salt crystallizes into an ordered *ABAB* structure.

Societies

1. In square dancing the attraction of boys and girls as dancing partners is much stronger than the attraction between partners of the same sex. The value of $\varepsilon$ is positive, we have sympathy between boys and girls in the dance. Figure 2A may be interpreted as general happiness $G(x,T)$ as a function of the percentage $x$ of girls. The general happiness in Fig. 2A will be low, if there are too few or too many girls, and will be at maximum for even numbers of boys and girls, $x = 0.5$. Figure 2B shows the distribution of boys and girls in the square dance. Due to the strong attraction of boys and girls the square dance group will be in an ordered *ABAB* state.

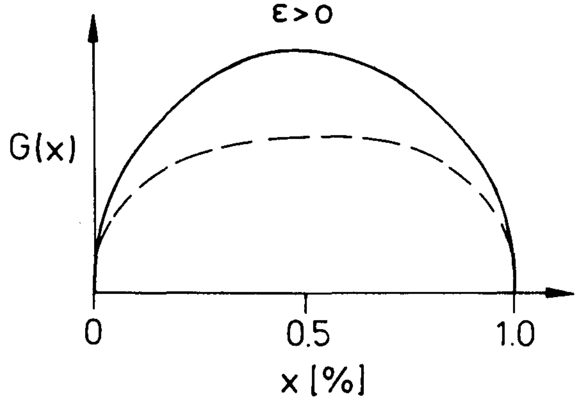


**Fig. 2A** 1. Negative free enthalpy of rock salt as function of composition;
2. General happiness of a square dance group as a function of percentage of girls

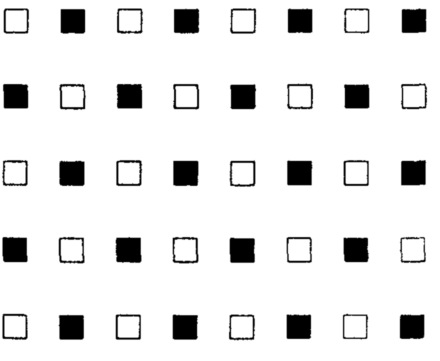

**Fig. 2B** 1. The ordered crystal: sodium and chlorine in rock salt;
2. The ordered society: girls and boys at square dance

2. A group of white tourists is visiting a village fair with wonderful masks in Kenia. White buyers are attracted more to black sellers than white buyers are to white buyers or black sellers to black sellers, we have $\varepsilon>0$. The general happiness (including economic gain) of Fig. 2A will be low, if there are few sellers or few buyers. The maximum of general happiness will be at equal numbers of white buyers and black sellers, $x = 0.5$. Figure 2B shows the *ABAB* order of white buyers at the tables of the black sellers for $x = 0.5$.

## *Disorder, integration and indifference, $\varepsilon = 0$*

### Alloys

$\varepsilon = 0$ is the condition for ideal solubility, there is no interaction between neighbors. Figure 3A shows the (negative) free enthalpy of an ideal solution, e.g. silicon (Si) and germanium (Ge). Figure 3B shows the distribution of $A$ and $B$ atoms in an ideal solution, e.g. Si and Ge. The arrangement of Si and Ge atoms is random, we have complete disorder.

### Societies

$\varepsilon = 0$ is obtained for two possibilities:

a) Equal partners are as attractive or repellent as different partners, $E_{AB}+E_{BA}-E_{AA}-E_{BB} = 0$, this leads to indifference.

b) If the attraction of all partners is zero, $E_{AB} = E_{BA} = E_{AA} = E_{BB} = 0$, this may be called apathy.

1. Figure 3A gives the general happiness for an ideal mixture, $\varepsilon = 0$. Figure 3B shows boys and girls standing in line for refreshments after dancing: For thirsty dancers a drink is more important than a male or female neighbor. The

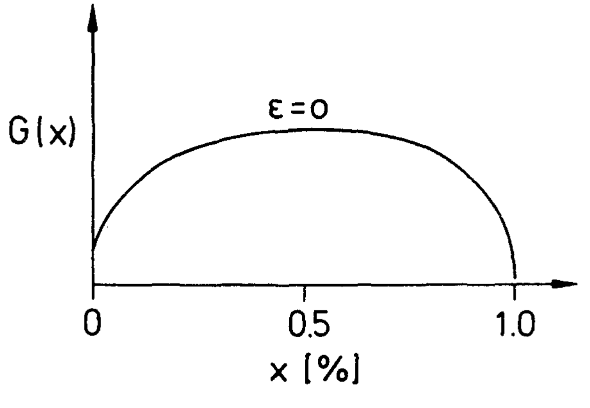


**Fig. 3A** 1. Negative free enthalpy of an ideal alloy;
2. General happiness of a binary society at indifference

resulting value of ε will be zero and corresponds to indifference, boys and girls are mixed by chance, which means they are completely integrated.

2. Figure 3B shows blacks and whites is a supermarket in Washington, DC. We will find a random distribution or complete integration of blacks and whites in the cashier lines, due to indifference of blacks and whites at shopping.

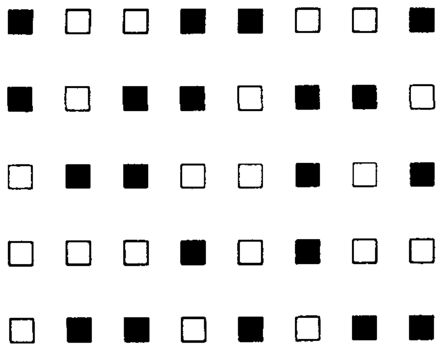

**Fig. 3B** 1. The disordered alloy: silicon and germanium in a crystal;
2. The disordered society: girls and boys waiting in line

## *Segregation and antipathy, ε<0*

If the attraction between equal partners is stronger than the attraction between different partners, the value of ε will become negative, ε<0. This leads to a different form of the function $G(x,T)$, Fig. 4A. In contrast to Figs 2A and 3A we now find two maxima instead of one. The first maximum is obtained at small values, the second at large values of $x$.

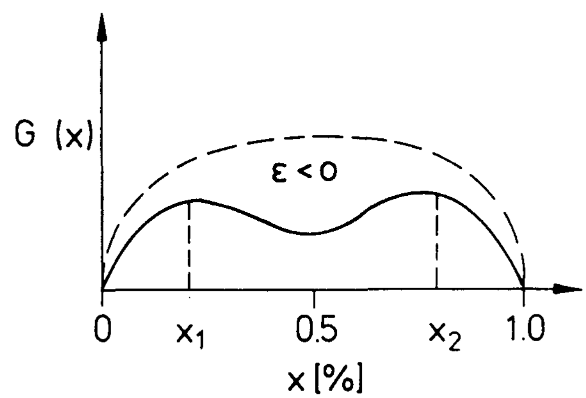


**Fig. 4A** 1. Negative free enthalpy $G(x,T)$ of an Au–Pt alloy at low temperature;
2. General happiness of girls and boys talking about sports as function of percentage of girls

## Alloys

An alloy of gold (Au) and platinum (Pt) will segregate into two different phases. The (negative) free enthalpy in Fig. 4A will have two maxima, one for Au with few Pt atoms, the other with Pt and few Au atoms. Figure 4B shows the two corresponding separated phases of the alloy.

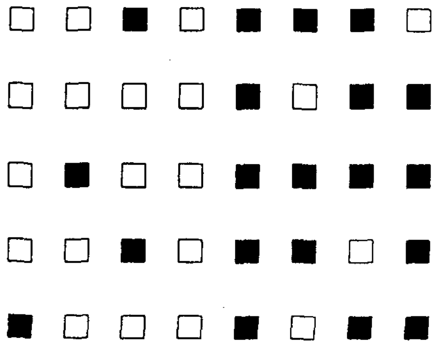

**Fig. 4B** 1. The segregated alloy: gold and platinum atoms at low temperature;
2. The segregated society: boys and girls talking sports

## Societies

Figure 4A shows general happiness $G(x,T)$ – Eq. (1) – as a function of percentage $x$ of a minority B for negative values of $\varepsilon$. The maximum of general happiness $G(x,T)$ can be obtained for small values of $x$ or for large values of $x$.

1. Figure 4B shows a group of boys and girls after dancing and refreshments in conversation about sports: A neighbor of the same sex now is more attractive than a partner of different sex. Boys and girls will segregate, a group of mainly boys will talk about recent sport events and the rest, mainly girls will talk about non-sports, perhaps fashion. Both groups are happy to arrange according to the two maxima of general happiness. The groups in Fig. 4B are not divided into only boys and only girls, but into boys with a few girls, who prefer talking sports – and girls with a few boys, who don't mind listening to fashion. The degree of partially mixing defines the mutual tolerance. Only if the mutual tolerance in talking about sports or fashion is zero, the party will split into boys or girls, only.

2. Figure 4A shows the general happiness of a society of black and white neighbors as a function of percentage $x$ of blacks: one maximum is obtained, if the percentage of black neighbors is low and the white people feel at home, the other maximum is obtained at a high percentage of black neighbors, where blacks feel at home.

Figure 4B shows the distribution of black and white neighbors in a town of 50% blacks. The maximum of happiness will be obtained by segregation into areas with mostly white and few black renters, and vice versa. This way blacks and whites feel at home.

Again it is important to notice, that the degree of segregation in black and white neighborhoods in general will not be 100%. Only if the tolerance between blacks and whites is zero, we will find black ghettos (homelands) and white ghettos. This aspect will be very important in the following discussion of tolerance in a society.

## Phase diagrams of alloys

At equilibrium the function $G(x,T)$ will always be at the maximum. The derivative of $G(x,T)$ will be zero.

$$\partial G / \partial x = - T[\ln x - \ln(1-x)] + 2\varepsilon(1-2x) = 0 \tag{3}$$

For $\varepsilon<0$ we may solve Eq. (3) for $T_m$ (*m* for maximum of *G*)

$$T_m(x) = 2\varepsilon(1-2x) / [\ln x - \ln(1-x)] \tag{4}$$

$T_m(x)$ is the temperature at which $G(x,T)$ will have its maximum for a given composition, and is called phase diagram of a regular *A–B* alloy with $\varepsilon<0$. Figure 5A shows the phase diagram $T_m(x)$ for a gold–platinum alloy as a function of Pt concentration $x$ according to Eq. (4). Above $T_m(x)$ Au and Pt are completely miscible. Below $T_m(x)$ is the miscibility gap. The alloy segregates into two phases, one contains platinum up to the solubility limit $x_1$, the other phase contains gold up to the solubility limit $x_2$. The values $x_1$ and $x_2$ depend on the temperature $T$ and correspond to the two maxima of $G(x,T)$ in Fig. 4A.

### *Probability of A–B pairs in integrated solutions/societies*

In order to apply the phase diagram to binary societies we will now compare the probability $P^{id}_{A-B}$ of *A–B* pairs for an ideal solution or integrated society to the percentage of pairs $P_{A-B}$ found in a segregated alloy or society. For ideal solutions the probability $P^{id}_{A-B}$ of *A–B* pairs as a function of composition $x$ is given by

$$P^{id}_{A-B} = 2x(1-x) \tag{5}$$

Equation (5) is a parabolic function of composition $x$.

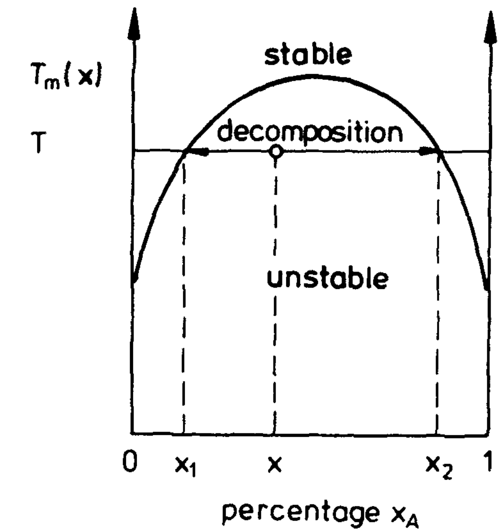


**Fig. 5A** Phase diagram $T(x)$ of a regular alloy

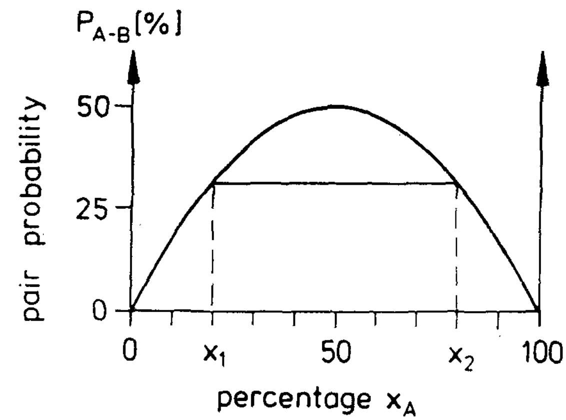


**Fig. 5B** Pair probability $P^{id}_{A\text{-}B}(x)$ for an ideal $A$–$B$ mixture as a function of composition $x$

## *Percentage of A–B pairs in segregated solutions/societies*

Figure 5B shows the percentage or probability of pairs $P_{A\text{-}B}$ as a function of composition corresponding to a segregated alloys or society. In gold – platinum alloys, according to Fig. 4B, we have ideal pair probability at low Pt percentage up to the solubility limit $x_1$. At a higher percentage of Pt the alloy segregates into two phases with a constant percentage of Au and Pt, and accordingly, the pair probability $P_{Au\text{-}Pt}$ also will be constant. Beyond $x_2$ we have again an ideal solution, the pair probability follows the parabola. Figures 5A and 5B look similar, the probability of pairs $P_{A-B}(x)$ is equivalent to the phase diagram $T_m(x)$.

## Population statistics and intermarriage

Marriage is a personal choice of single persons. Marriages within a certain period of time will reflect the social state of a society like votes of an election will show the political state of a society. The accuracy in predicting elections or marriages depends on the number of samples taken, this will restrict investigations to intermarriages in large cities, states or countries. On the other hand population statistics have been recorded in many societies in great detail, and we may expect a good accuracy in predicting the social state of a society from marriage statistics.

### *Black – non-black intermarriage*

In Table 1 and Fig. 6 statistical data of intermarriage of black and non-blacks in the USA (1988) are given for 33 reporting states. In states with a percentage of blacks below 0.6% (ID, ME, MT, NH) intermarriage follows the parabola for an integrated society indicated by a dashed line. For states with a percentage of blacks higher than 0.6% the percentage of intermarriage is generally constant, close to the mean US percentage $P_{B\text{-}NB}$ = 1.13%. This constant intermarriage rate is nearly independent of the percentage of blacks of a state.

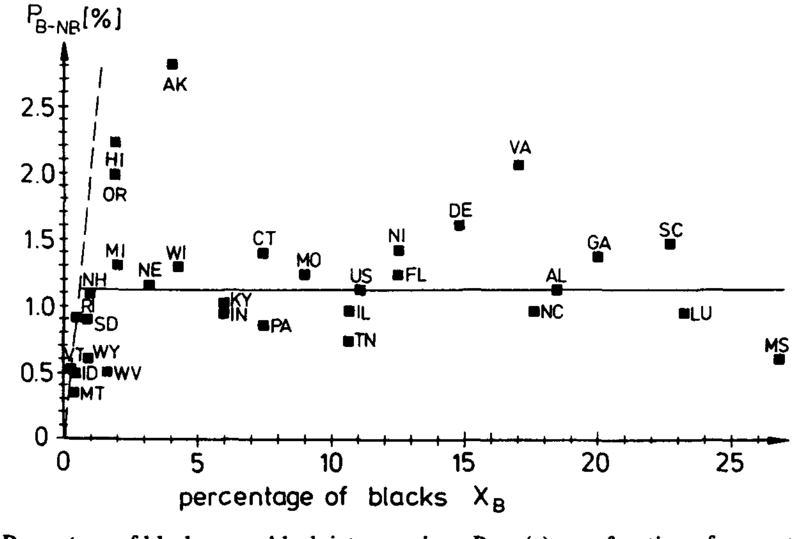


**Fig. 6** Percentage of black – non-black intermarriage $P_{B\text{-}NB}(x)$ as a function of percentage $x$ of blacks in 1988 for 33 reporting states of the USA [4]

**Table 1** Percentage of blacks $x_B$ (90) [3] and percentage of interracial marriages $P_{B\text{-}NB}$ of blacks and non-blacks in 1988 [4] for 33 reporting states in USA

| No. | State | St. | $x_B(90)$ % | $x_B$ % | $P_{B\text{-}NB}$ % |
|---|---|---|---|---|---|
| 1. | Alabama | AL | 23.3 | 18.4 | 1.13 |
| 2. | Alaska | AK | 4.2 | 5.3 | 2.80 |
| 3. | Connecticut | CT | 8.6 | 7.4 | 1.40 |
| 4. | Delaware | DE | 17.0 | 14.8 | 1.60 |
| 5. | Florida | FL | 13.7 | 12.5 | 1.24 |
| 6. | Georgia | GA | 27.0 | 19.9 | 1.37 |
| 7. | Hawaii | HI | 2.5 | 2.1 | 2.20 |
| 8. | Idaho | ID | 0.4 | 0.4 | 0.50 |
| 9. | Illinois | IL | 15.0 | 10.6 | 0.97 |
| 10. | Indiana | IN | 7.8 | 6.0 | 0.96 |
| 11. | Kansas | KS | 5.8 | 6.0 | 1.75 |
| 12. | Kentucky | KY | 7.2 | 6.1 | 1.03 |
| 13. | Louisiana | LA | 30.9 | 23.3 | 0.95 |
| 14. | Maine | ME | 0.4 | 0.4 | 0.49 |
| 15. | Minnesota | MI | 2.2 | 2.0 | 1.30 |
| 16. | Mississipi | MS | 35.6 | 26.7 | 0.60 |
| 17. | Missouri | MO | 10.7 | 8.9 | 1.25 |
| 18. | Montana | MT | 0.3 | 0.4 | 0.34 |
| 19. | Nebraska | NE | 3.7 | 3.2 | 1.16 |
| 20. | N.Hampshire | NH | 0.7 | 1.1 | 0.96 |
| 21. | N. Jersey | NJ | 13.8 | 12.5 | 1.41 |
| 22. | N. Carolina | NC | 22.0 | 17.6 | 0.96 |
| 23. | Oregon | OR | 1.7 | 1.9 | 2.0 |
| 24. | Pennsylvania | PA | 9.3 | 7.4 | 0.83 |
| 25. | Rh. Island | RI | 4.3 | 4.6 | 0.91 |
| 26. | S. Carolina | SC | 29.9 | 22.7 | 1.46 |
| 27. | S. Dakota | SD | 0.5 | 0.8 | 0.90 |
| 28. | Tennessee | TN | 16.0 | 10.7 | 0.73 |
| 28. | Utah | UT | 0.7 | 0.5 | 0.48 |
| 29. | Vermont | VT | 0.4 | 0.3 | 0.56 |
| 30. | Virginia | VA | 18.9 | 17.1 | 2.07 |
| 31. | W. Virginia | WV | 3.1 | 1.6 | 0.54 |
| 32. | Wisconsin | WI | 5.0 | 4.3 | 1.03 |
| 33. | Wyoming | WY | 0.8 | 0.8 | 0.61 |
| | USA 1988 | US | 12.3 | 11.1 | 1.13 |
| | USA 1970 | | 12.0 | | 0.28 |

$x_B(90)$ %: Bureau of the Census 1990[3]; $x_B$ %, $P_{B\text{-}NB}$ %: National Center for Health Statistics 1988 [4]

(The higher values for AK and HI are due to a high black – non-white intermarriage rate, the black-white rate of intermarriage corresponds the mean US value.) According to Fig. 6 the integration limit for blacks in the US society is $x_B$=0.6%. A percentage below 0.6% will be integrated (ID, ME, MT, NH), in states with a percentage of blacks above 0.6% segregated neighborhoods will form.

In Table 1 the percentage of blacks in a state and in marriage are stated, separately. Apparently, the percentage $x_B$ [4] of blacks participating in marriage is generally smaller than the percentage $x_B(90)$ [3] of blacks according to the population statistics, are higher than $x_B$ indicating that blacks are married less than average.

## *Religious intermarriage*

Catholic – non-catholic intermarriage in Germany has been investigated for three locations, a town (Paderborn) of 130.000 inhabitants, a state of 10 million inhabitants (Nordrhein-Westfalen) and the country (Germany) of 60 million [5–7]. The results are shown in Fig. 7. The percentage of intermarriage for catholics and non-catholics is again lower than expected for an integrated society, it is about 30% in all three cases, independent of the percentage of catholics in the three locations. The integration limit is close to 20% of catholics (or 20% of non-catholics) in the German society. Again the data agree with a solubility limit according to the model of regular solutions in Fig. 5B.

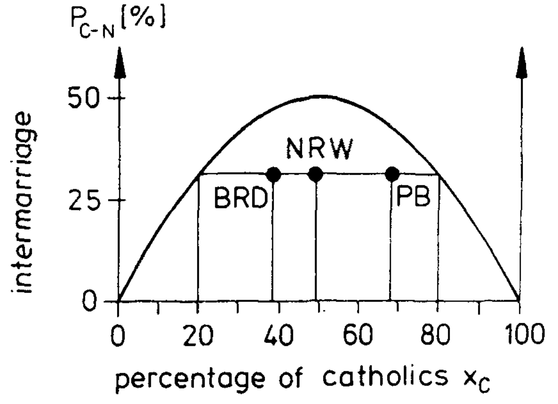


**Fig. 7** Percentage of catholic– non-catholic intermarriage $P_{C\text{-}NC}(x)$ as a function of percentage $x$ of catholics in 3 locations of Germany 1991 [5–7]

## *German–foreign intermarriage*

Intermarriage data of German and foreign citizen are presented in Fig. 8 for the same three locations [5–7]. The percentage of intermarriage is about 10%

in all three cases, the three locations have the same percentage of foreigners, about 8%. For this reason the three data points of German – foreign intermarriage appear as one single point in Fig. 8. Again the intermarriage data are constant in all three locations as predicted by the model of regular solutions in Fig. 5B. The integration limit according to the model is close to 5%.

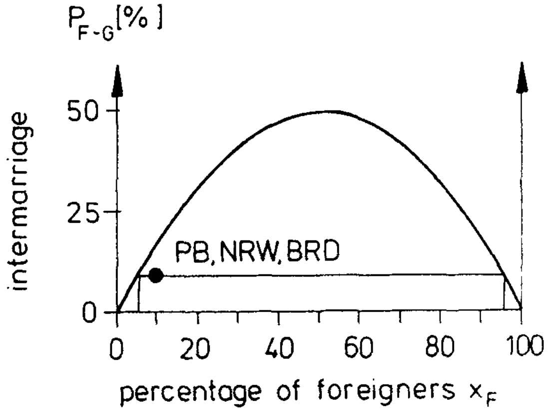


**Fig. 8** Percentage of foreign – citizen intermarriage $P_{F-C}(x)$ as a function of percentage $x$ of foreigners in 3 locations of Germany 1991 [5–7]

## *New statistical results*

The model of regular solutions leads to additional statistical information. The percentage of intermarriage $P_{A-B}$ and the percentage of a minority $x$ also reveal the distribution of people in the segregated society. The integration limit $x_1$, according to Figs 5B, 6–8, is given by

$$x_1 = 0.5 - (0.25 - P_{A-B} / 2)^{1/2} \tag{6}$$

In Figs 6–8 the minorities exceed the integration limit $x_1$, all societies segregate into sub-societies. The size $S(x)$ of a sub-society is

$$S(x) = (x - x_1) / (1 - 2x_1) \tag{7}$$

The percentage of blacks is 12.3% of the total US population. According to the model the percentage of blacks in a non-black neighbourhood is about $x_1$ = 0.6%, most blacks (or 11.7% of the US population) live in a 99.4% black environment. The size of the black ghettos (which includes 0.6% non-blacks) according to Eq. (7) is $S$ = 13.3%.

## Society and phase diagram

The intermarriage diagram $P_{A-B}(x)$ of societies corresponds to the phase diagram $T_m(x)$ of a metal. The good agreement of intermarriage data for three binary societies in Figs 6–8 with the pair probability $P_{A-B}(x)$ of a binary alloy in Fig. 5B is a strong indication that the model or regular solutions may be applied to societies, as well. Of course, the forces between different partners will not be governed by Coulomb interactions, as for atoms, but by social relations.

### *Tolerance of a society*

We now will discuss the meaning of temperature $T$ in societies. The above results indicate that $T_m(x)$ may be interpreted as tolerance of the society: $T_m(x)$ is proportional to $P_{A-B}$, and a high probability $P$ of pairing of different antipathetic people ($\varepsilon<0$) shows a high tolerance of the whole society.

Tolerance of a society is expressed and promoted by common schools, laws and rights to vote and to be voted and is also influenced by the economic situation. However, these interactions are outside of the scope of physics and have to be investigated by means of social science.

### *Integration*

At a tolerance above $T_m(x)$ in Fig. 5A any percentage of a minority may be integrated. A typical example is the integration of European immigrants in the US during the last century. Many US citizen are proud of having a mixture of European grandparents. This complete integration is, however, accompanied by a loss of specific European customs, heritage or language aside from English.

### *Segregation*

Below $T_m(x)$ the society segregates according to the two maxima of general happiness of Fig. 4A into two (integrated) sub-societies. Segregation is due to:

1. limited tolerance and
2. negative value of $\varepsilon$.

However, according to Eq. (2) the negative value of $\varepsilon$ is not necessarily due to negative feelings between two groups. Segregation will also result for positive feelings between different partners, if the attraction between equal partners is still stronger, $(E_{AB}+E_{BA}<E_{AA}+E_{BB})$.

Small values of $E_{AB}$, $E_{BA}$ mean limited friendship or trust in different people. Large positive values of $E_{AA}$, $E_{BB}$ will be the most frequent reason for segregation. In marriage, communities, parties or other social interactions persons of the same back-ground will often be preferred to different person. According to the model 'positive' $E_{AA}$, $E_{BB}$ values like heritage, tradition, dialect, religion will always promote segregation in a society.

In a segregated society people will marry within each sub-society. A low degree of integration will stabilize a multicultural society for generations or centuries. This may be observed for ethnic groups in the US like blacks or chinese as well as for religious groups like Amish people.

### *Ghettos and violence*

A very low integration will lead to the formation of ghettos. It is a result of:

1. intolerance or very low tolerance,
2. large negative values of $E_{AB}$, $E_{BA}$ or hate and distrust between different people,
3. very large positive values of $E_{AA}$, $E_{BB}$ or racism, national or religious extremists.

In addition the complete segregation of east and west by the iron curtain, the separation of Serbic, Croatian and Moslemic people in Yugoslavia or the separation of Germans and Jews by the Nazi-regime has been achieved only by violence. We may conclude that low tolerance and nearly total separation are closely related to violence. It may be of interest to obtain intermarriage data for areas of violence in order to investigate the relationship of a low rate of intermarriage and violence between different groups in more detail.

### *Functions and feelings*

The above discussion has demonstrated, that functions of natural science may be translated into terms of social sciences:

#### Alloys

In alloys a society of atoms with composition $x$ will be governed by functions of thermodynamics, like free enthalpy $G$, temperature $T$ and attractive or repellent energy $E$. These functions will determine the state of integration or segregation of the compound.

#### Societies

A society of black and white voters, national and foreign citizen, or male and female worker of composition $x$ will be governed by feelings like happiness, tolerance, sympathy, apathy and indifference. These feelings will determine the state of peace and integration or segregation and even violence of the society.

Table 2 sums up the terms translated from natural to social science.

**Table 2** Translatlon of terms of thermodynamics to social science according to the model of regular mixtures

| Abbr. | Natural Sience | Social Sience |
|---|---|---|
| A-B | Alloys | Societies |
| AuPt | gold-platinum | black-white renters |
| Si-Ge | silicon-germanium | cathol.-protestant citizen |
| CuZn | beta-brass | citizen-foreign neighbors |
| NaCl | rock salt crystal | male-female dancers |
| x | atom. percentage | size of minority (%) |
| | Functions | Feelings |
| $G$ | neg. free enthalpy | general happiness |
| $T$ | temperature | tolerance |
| $E_{AA}$ | cohesive energy | tradition, heritage |
| $E_{AB}>0$ | cohesive energy | curiosity, love |
| $E_{AB}<0$ | repelling energy | distrust, hate |
| $E=0$ | no cohesion | apathy |
| $\varepsilon>0$ | attractive interaction | sympathy |
| $\varepsilon=0$ | ideal solution | indifference |
| $\varepsilon<0$ | repelling interaction | antipathy |
| | State of alloys | State of Society |
| | disorder, solubility | integration |
| | solubility limit | segregation |
| | phase diagram | intermarriage diagram |

## Conclusions

Finally, in spite of the good agreement of phase diagrams and intermarriage data we have to be aware of limits of the model. People in certain situations may act similar to atoms, but unlike atoms each person will be different. The above results can only reflect a simplifying model and account for mean values. In contrast to functions in thermodynamics feelings will be time depending. This change with time may be observed comparing the data of black intermarriage in the US in 1970 and 1988. The percentage of black – non-black intermarriage or the mutual tolerance has risen by a factor of 4 in 18 years. However, more detailed studies of social interactions have to be carried out in order to see how far the present model may be applied to social sciences.

## References

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**Zusammenfassung** — Das Modell regulärer Lösungen, was bei binären Legierungen (z.B. Au-Pt, Si-Ge) angewendet werden kann, wurde mit binären Gesellschaften verglichen: Farbige-Nichtfarbige in den USA, Katholiken-Nichtkatholiken, Ausländer-Deutsche Staatsbürger. Die ausgezeichnete Übereinstimmung von Phasendiagrammen und Mischehen-Angaben ermuntern zu einer Berechnung von multikulturellen Gesellschaften mittels Funktionen aus der Thermodynamik: Löslichkeit entspricht Integrierung, Mischungslücken entsprechen der Segregation, freie Enthalpie dem Glück und die Temperatur der Toleranz der Gesellschaft. Freiheit führt nicht unbedingt zu Frieden. Nur ein hohes Toleranzniveau integriert Gettos und führt zu einer friedliebenden multikulturellen Gesellschaft.