spectrometer. The amount of CO_2 was much less than that of CO. The desorption spectrum of partial pressure change of CO vs. temperature contained three maxima which appeared at about 200, 400 and 600°C, respectively. These maxima are associated with the desorption of the amorphous structure, the unidentified structure containing half-order beams in the (310) azimuth, and the c(2× 2)-CO, respectively. LEED observations taken at intervals during the desorption procedure confirm this association.

No desorption of O or O_2 was observed even when heating a CO-covered {100} nickel surface which had also been exposed to oxygen prior to the heating. In addition, no strong H peak, as reported by Lichtman et al. was observed during heating of the crystal.

Conclusions. The above observations confirm and extend those previously reported by Park and Fransworth [2] that CO does adsorb on clean {100} nickel. Further, they show that a small amount of contamination decreases the sticking coefficient of CO on this surface. Any {100} nickel crystal which is cleaned by heating in vacuum probably has sufficient surface contamination to prevent an observable amount of CO adsorption. These observations indicate that conclusions from mass spectrometric observations of this type may be in error without concomitant observations on the surface with LEED equipment. They also suggest that, in general, cleaning a solid surface by high temperature heating alone may completely alter its chemical properties, due to diffusion of bulk contaminant to the surface.

References

1. D. Lichtman, T.R. Kirst and R.B. McQuistan, Phys. Letters 20 (1966) 129.
2. R.L. Park and H.E. Farnsworth, J. Chem. Phys. 43 (1965) 2351.
3. H.E. Farnsworth, R.E. Schlier, T.H. George and R.M. Burger, J. Appl. Phys. 26 (1955) 252; 29 (1958) 1150.

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ABSENCE OF PHASE TRANSITIONS IN ONE-DIMENSIONAL SYSTEMS WITH HARD CORES

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Conditions are given under which a one-dimensional classical system undergoes no phase transition.

It has been shown by Van Hove [1] that one-dimensional systems of particles with hard cores and finite range interactions have no phase transitions. Recently, one of us [2] has proved the absence of phase transitions for a large class of one-dimensional lattice gases with infinite range forces. In this note we state a theorem on continuous one-dimensional systems with hard cores, which again implies the absence of phase transitions for a large class of interactions with infinite range. Our conditions cover in particular a model due to Kac [3], see especially [4].

We consider classical systems of particles on the line which interact through a pair potential Φ satisfying the following conditions.

$$\Phi(r) = +\infty \quad \text{for} \quad |r| < R\,, \quad \text{where} \quad R > 0\,. \tag{1}$$

For $r \geq R$, $\Phi(r)$ is continuous and $|\Phi(r)| \leq h(r)$, where $h \geq 0$ is a decreasing function such that

$$\int_0^\infty (R+r)h(r)\,\mathrm{d}r < +\infty\,.$$

The conditions on Φ imply that if a system of particles on the line have compatible positions

x_i (i.e. $|x_j - x_i| \geq R$ if $i \neq j$) then the interaction energy between particles to the left of some point ξ and particles to the right of ξ is bounded:

$$\sum_{x_i \leq \xi} \sum_{x_j > \xi} |\Phi(x_j - x_i)| \leq \tfrac{1}{2} R^2 \int_0^\infty (R + r) h(r)\, \mathrm{d}r\,.$$

It is believed that in the absence of such a condition phase transitions might occur (and would occur if $\Phi \leq 0$ [5]).

If $z > 0$ is the activity and $\beta = 1/kT$, we define the grand partition function and correlation functions corresponding to the interval (a, b) by

$$Z_{a,b} = \sum_{n=0} \frac{z^n}{n!} \int_a^b \mathrm{d}x_1 \ldots \int_a^b \mathrm{d}x_n \exp[-\beta \sum_{1 \leq i < j \leq n} \Phi(x_j - x_i)]$$

$$\rho_{a,b}(x_1, \ldots, x_m) = (Z_{a,b})^{-1} \sum_{n=0} \frac{z^{m+n}}{n!} \int_a^b \mathrm{d}x_{m+1} \ldots \int_a^b \mathrm{d}x_{m+n} \exp[-\beta \sum_{1 \leq i < j \leq m+n} (x_j - x_i)]\,.$$

Theorem. Let Φ satisfy the conditions (1) and (2)

(i) The following limit exists

$$p(z, \beta) = \beta^{-1} \lim_{b-a \to \infty} \frac{1}{b-a} \log Z_{a,b}\,,$$

and has continuous first-order derivatives with respect to z and β.

(ii) There exist infinite volume correlation functions $\rho(x_1, \ldots, x_m)$ such that, if $f(x_1, \ldots, x_m)$ is any continuous function vanishing for $|x_1| + \ldots + |x_m|$ large enough, we have

$$\lim_{a \to -\infty, b \to \infty} \int \mathrm{d}x_1 \ldots \mathrm{d}x_m\, \rho_{a,b}(x_1, \ldots, x_m) f(x_1, \ldots, x_m) = \int \mathrm{d}x_1 \ldots \mathrm{d}x_m\, \rho(x_1, \ldots, x_m) f(x_1, \ldots, x_m)\,.$$

The right-hand side of this equation is a continuous function of z and β.

We interpret the continuity of the correlation functions as functions of β, z, to mean that phase transitions do not occur. Van Hove [1] on the other hand porved the absence of phase transitions (for finite range potentials) by showing that $p(z, \beta)$ is an analytic function of z. It should be remarked that the two criteria are not necessarily equivalent.

The above theorem can be proved by analogy with the corresponding property of lattice gases [2]. A general and detailed analysis will be published elsewhere [6].

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References

1. L. Van Hove, Physica 16 (1950) 137.
2. D. Ruelle, Statistical mechanics of a one-dimensional lattice gas, I.H.E.S. preprint (1967).
3. M. Kac, Phys. Fluids 2 (1959) 8.
4. M. Kac, G.E. Uhlenbeck and P.C. Hemmer, J. Math. Phys. 4 (1962) 216.
5. M.E. Fisher, Physics 3 (1967) 255.
6. G. Gallavotti and S. Miracle-Sole, to be published.

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