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ЕРЕВАНСКИЙ ФИЗИЧЕСКИЙ ИНСТИТУТ
YEREVAN PHYSICS INSTITUTE

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ON THE WASTE OF FREE ENERGY FOR THE
CHOICE OF VACUUM UNDER PHASE TRANSITIONS



ЕРЕВАНСКИЙ ФИЗИЧЕСКИЙ ИНСТИТУТ

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Դիտարկվում է վիճակագրական գումարի լոգարիթմի ասիմպտոտիկ տրորոհման մասին՝ ըստ անսահմանության ձգտող հանգույցների թվի: Ստացվում է, որ ասիմպտոտիկ շարքի ծավալից անկախ, անդամը խզվում է փոլային փոխարկման կետում:

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Д. Б. СААКЯН

О ЗАТРАТАХ СВОБОДНОЙ ЭНЕРГИИ ДЛЯ ВЫБОРА ВАКУУМА
ПРИ ФАЗОВЫХ ПЕРЕХОДАХ

Рассматривается асимптотическое разложение логарифма статсуммы по числу стремящемуся в бесконечность числу узлов решетки. Получается, что член асимптотического разложения, независимый от объема, терпит разрыв при прохождении через точку перехода.

Ереванский физический институт
Ереван 1991



D.B. SAHAKYAN

ON THE WASTE OF FREE ENERGY FOR THE CHOICE
OF VACUUM UNDER PHASE TRANSITIONS

An asymptotic expansion of the logarithm of statistical sum in the number of lattice sites N tending to infinity is considered. It turns out, that the term of the asymptotic series independent of the volume has a discontinuity when passing through the transition point.

Yerevan Physics Institute
Yerevan 1991

Last years the properties of models of phase transitions, considered as specific field theoretical renormalizations (regularized by means of the introduction of lattice), are most frequently subject to scrutiny.

The property of phase transition models (of all the orders) to make a decision at the violation of symmetry was discussed in Ref. /1/.

When a system makes a decision, then there appears a macroscopic order. How does that affect the microscopic entropy?

It is noteworthy that since the phase transition proceeds only asymptotically when the number of lattice sites tends to infinity, $N \rightarrow \infty$, we shall confine to the asymptotical form of the logarithm of statistical sum $Z(N, B)$, $B \sim 1/T$

$$\ln Z(N, B) = N f_0(B) + \dots + f_1(B) + O(1) \quad (1)$$

The intermediate terms (with fractional powers in N or $\ln N$), that could occur between f_0 and f_1 in (1), are of no interest to us.

In Ref. /1/ it was proposed to consider the behaviour of $f_1(B)$ in the critical point B_c as an indicator of symmetry

breaking. To be exact, if the symmetry characterized by the group of order Q is broken, then we expect that

$$\lim_{\varepsilon \rightarrow 0} f_1(B_c + \varepsilon) - f_1(B_c - \varepsilon) = \text{const} \cdot \ln Q \quad (2)$$

For Ising model on the solid regular lattice it was obtained that in (2) $\text{const} = 1$.

Numerical calculations of $d2$, $Q=3$; $d2$, $Q=5$ Potts models and $d3$ Ising model on the solid regular lattice with the topology of torus have shown, that in (2) $\text{const}=1$ everywhere within the accuracy of calculations.

In Ref. /2/ some statistical physics models were introduced and the summation here for the calculation of statistical sum was not only over the spin configurations, but also over the lattices (the choice of neighbors), This greatly simplified the calculations.

Using the method of Ref./2/, I have calculated the statistical sum of Ising models on such dynamical lattices on the surfaces with an arbitrary genus of the surface g .

It turned out that instead of (2) with $\text{const}=1$ we had

$$\lim_{\varepsilon \rightarrow 0} f_1(B_c + \varepsilon) - f_1(B_c - \varepsilon) = g \ln 2 \quad (3)$$

One can interpret the result (3) as follows: when the configuration space is complicated and has large topological number g , then to increase the macroscopic order by $\ln Q$, the system increases the entropy to $g \ln Q$ in order that the balance of entropy be provided. It is very important to check (3) for Ising models on a solid lattice with genus g by means of numerical methods. For surfaces different from torus ($g \neq 1$), the function

$f_1(B)$ is, generally speaking, singular in B_c . Hence, it is necessary that the tending $\varepsilon \rightarrow 0$ on the left and on the right of B_c be the same.

Calculations for the model of Yang-Lee singularities (the Ising model in an imaginary magnetic field) on the torus were carried out in much the same way. The discontinuity of $f(B)$ proved to be similar to that occurring in the Ising model, as the same symmetry group $Z(2)$ is violated.

In both the models it is obtained that

$$f_1(B_c + 0) = f_1(B_c) = 2f_1(B_c - 0) \quad (4)$$

It is interesting to study the situation with multicritical points.

Analogous effect is produced in the phenomenon of cycle doubling of Feigenbaum. If instead of (1) we consider asymptotical expansion of the Logarithm of Kolmogorov K. entropy, we shall have the discontinuity again.

This effect must be present wherever the dynamical system (statistical physics model, mapping or catastrophe model) makes a decision, the effect being more pronounced, the more topologically complex is the phase space, or the more is violated the symmetry group.

If we considered $d2$ statistical physics model in which the number of sites and the genus of surface (on which the lattice is constructed) proportionally tended to infinity, then the obtained effect should have simply changed the character of transition.

It is reasonable to expect that the discontinuity of $f_1(\theta)$ is independent of defects in the system, large as they are, if the asymptotical expansion of the type (1) is obtained.

At last, it is also interesting to study this effect for the turbulence.

The effect in question resembles the uncertainty principle in quantum mechanics. The choice of vacuum is in a sense a measurement of the state of a quantum system by means of a classical instrument, the rise of entropy corresponding to the disturbance of the quantum state at the measurement.

References

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