Works on the Foundations of Statistical Physics.

Nikolai Sergeevich Krylov. Princeton, N.J.: Princeton University Press, 1979. xxviii + 283 pp. $19.50 ($7.50 paperback).

When Nikolai Sergeevich Krylov died in 1947 at the age of 29, the world lost one of its most promising young theoretical physicists. The translators and commentators have done a difficult job well in readying this unfinished work for publication. It concerns what is termed in the USSR "laying the foundations of statistical mechanics." That is, before the serious mathematics begins, some conceptual matters relating the mathematics to the real world call for discussion. This cannot be done once and for all, however, since no two workers in statistical mechanics (or for that matter, in any statistical or physical theory) completely agree on the "foundations."

So laying the foundations of a theory remains a personal matter, which each of us must do separately. Even if we eventually come to use the same mathematics, there will remain differences in viewpoint that are sometimes held to be unimportant. But—and this is the reason why Krylov's work is still important and relevant today—those private viewpoints determine the direction in which one looks for generalizations of a theory.

This can be explained more specifically. Since the beginnings of statistical mechanics in the last century, two different streams of thought have been competing for that foundation status. The "ergodic" view, associated with James Clerk Maxwell, sees it as a part of mechanics, the goal being to deduce the probability distributions for systems of many molecules by application (albeit rather sophisticated) of Newton's laws of motion.

A very different view, associated with J. Willard Gibbs, sees the goal merely as making the best predictions possible of observable facts, from incomplete information; that is, it is just a branch of statistical inference, not essentially different from what is needed in econometrics or engineering. (Ludwig Boltzmann can be quoted on both sides).

With this background, we can explain that Krylov's work is a deeply thoughtful (and, in view of the accompanying endorsements from current prominent workers, authoritative) statement of the foundations of the ergodic approach, not duplicated in more recent literature.

The name "Statistical Mechanics" was coined by Gibbs for his program, but it has been adopted by everybody and so today two theories, totally different in outlook and purpose, coexist under that same name. To reduce confusion, this reviewer has proposed that we borrow a term from Seymour Geisser and call Gibbs's theory "Predictive Statistical Mechanics," since his "ensembles" are really predictive distributions.

Krylov and his followers regard probabilities as in principle determined, as are velocities and accelerations, by the laws of mechanics (but in a more complicated way, not yet fully carried out). They view the predictive method as nonrigorous and provisional, since its distributions are not derived from the laws of mechanics.

Advocates of the predictive view see the ergodic program as not only unnecessary but in principle impossible, because the necessary information is lacking. That is, Newton's laws of motion can tell us only how probabilities change with time, and not what probabilities should be assigned at the start.

At the present time, the ergodic view enjoys great favor with the mathematically minded, but it has not led to useful applications. The Gibbs methods have raced far ahead, yielding virtually all of the useful results and extending to new areas, such as spectral analysis and image reconstruction, far beyond the original purview of statistical mechanics. It seems that all the prestige is on one side, all the success on the other.

Although (or perhaps because) the ergodic program is today active and developing, it appears too early for the eventual major treatise. Therefore, Krylov's work may serve as its definitive foundation statement for some time to come.

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