Relativistic Thermodynamics and Angualr Momentum

Tadas Nakamura[1]

[1] FPU

http://mira.bio.fpu.ac.jp/tadas

The equilibrium state of an isolated system is characterized by the conserved quantities of the system. The total energy and particle number are usually taken into account in thermodynamics, however, angular momentum was often overlooked. In the present paper, relativistic thermodynamics has been generalized by introducing a new kind of temperature corresponding to angular momentum. The resulting equilibrium is different from the one without angular momentum, especially in relativistic regime.

Attempts to generalize thermodynamics to accommodate relativity have been made right after the establishment of the relativistic physics. In 1960s, there had been heated controversy on how to define thermodynamical values, such as temperature or heat, in a covariant way. The discussion came to a general agreement that there can be several different theories, each of which has self-consistent definitions of thermodynamical quantities within its framework. Then the choice of the theory can be based on aesthetics or convenience.

The author of the present paper prefers the theory proposed by van Kampen (1968), though its interpretation is somewhat different from the original. The interpretation here is based on the concept of multiple temperatures suggested by Jaynes (1957). When establishing his ``Maximum Entropy Principle", Jaynes pointed the conventional temperature is a consequence of the energy conservation law. Then, he ponders, there is no reason to deny the existence of temperatures corresponding to other kind of conserved quantities.

Once we accept this point of view, we can introduce three temperatures corresponding to three components of momentum. These ``momentum temperatures" result nothing new but trivial rewriting of equations in non-relativistic thermodynamics. However, they have a significant meaning in relativity. There are three temperatures for momentum and one temperature for energy, and the reciprocal temperatures of these four form a covariant vector. The resulting expression is identical to the one introduced by van Kampen (1968). Provided there exist temperatures for momentum, it is natural to think about another kind of temperatures for another kind of conserved quantities: angular momentum. The basics of the angularmomentum as a thermodynamical parameter will be presented.

References

Jaynes, E. T., Phys. Rev., vol 108 (1957), 620.
van Kampen, N. G., Phys. Rev., vol 173 (1968), 295.