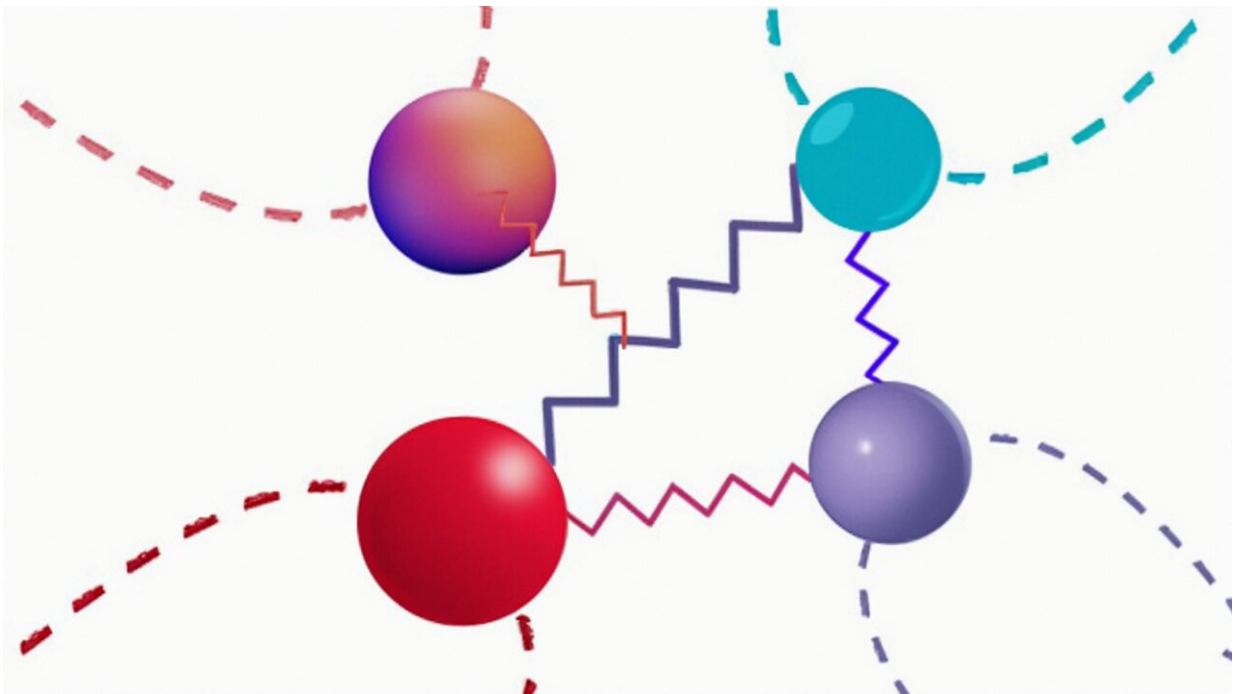


Many-body interactions feel the heat: Introducing thermal field theory

August 2 2023, by Robert Lea



A many-body process at zero temperature which becomes much more complicated when temperature is a factor. Credit: Robert Lea

Quantum field theory is a framework used by physicists to describe a wide range of phenomena in particle physics and is an effective tool to deal with complicated many-body problems or interacting systems.

Conventional [quantum field theory](#) describes systems and interactions at

zero [temperature](#) and zero chemical potential, and interactions in the [real world](#) certainly do occur at non-zero temperatures. That means scientists are keen to discover what effects may arise as a result of non-zero temperature and what new phenomena could arise due to a thermal background. In order to understand this, physicists turn to a recipe for quantum field theory in a thermal background — thermal field theory.

In a paper in *The European Physical Journal Special Topics*, Munshi G. Mustafa, Senior Professor at the Saha Institute of Nuclear Physics, Kolkata, India, introduces a thermal field theory in a simple way weaving together the details of its mathematical framework and its application.

"The goal of thermal field theory is to describe a large ensemble of multiple interacting particles, including gauge interactions, in a thermal environment," Mustafa says. "It also describes the creation and annihilation of new processes in a thermal system that are not present in vacuum or conventional field theory. Thermal field theory is a useful tool by which a complicated many-body system can be addressed only through the thermal averaged properties observed over a long period of time."

Mustafa explains that thermal field theory brings together the well-established realm of statistical mechanics supplemented with conventional quantum field theory to make problems manageable and allow observable characteristics to be expressed in terms of temperature and chemical potential.

"For a better understanding of the matter produced in high energy heavy-ion collisions at the Large Hadron Collider (LHC) and in future experiments, one needs the prescription of thermal field theory in particle and [nuclear physics](#). It is also required for a better understanding of phase transition in condensed matter physics and the evolution of the

universe at early times," Mustafa concludes.

"This pedagogical review will serve as a primer to those who are interested to learn thermal field theory from the basics."

More information: Munshi G. Mustafa, An introduction to thermal field theory and some of its application, *The European Physical Journal Special Topics* (2023). [DOI: 10.1140/epjs/s11734-023-00868-8](https://doi.org/10.1140/epjs/s11734-023-00868-8)

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