1. Direct application of the Matsubara Green's functions for calculating operator and mass operator shows a promising results since it gives the correct definition of finite temperature operator and mass operator. It is observed that it gives the correct limit for $\Theta$.

Thermal continuum quasiparticle-random-phase approximation (TQPRPA) is one of the models which attempt to explain this phenomenon. The deficiency of TQPRPA is the absence of quasiparticle vibration coupling (QVC) mechanism, which is already included in relative time-blocking approximation (RTBA).

In this paper, we provide the brief description of RTBA and present the preliminary results of the finite temperature generalization of RTBA using the Matsubara Green's function formalism.

**ABSTRACT**

We study the nuclear excitation spectra in the two energy domains: the low energy region (below 10 MeV) and giant resonance (GR) region (10-30 MeV). In the low energy region, we experimentally discovered a feature of the radiative dipole strength function which is important as it has an impact on the rapid neutron capture cross sections, which are used, in particular, for the process of nucleosynthesis.

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**BACKGROUND**

We can make "fast models" using various ways:

- Photorecitrization
- Heavy ion collisions
- Nuclear Photonics

Experimental Results in Low Energy Region

**RESEARCH OBJECTIVES**

1. To formulate finite temperature RTBA model.
2. To obtain the E1 and M1 strength functions from the finite temperature RTBA model.
3. To calculate the gamma strength function, rapid neutron capture reaction rates, proton Gamow-Teller strengths, and beta decay rates relevant for r-process nucleosynthesis.

**RESEARCH DESIGN**

Matsubara Green's Function

- Time Representation

- Free Fermion

- Free Photon

- Particle Vibration Coupling (PVC)

- Dyson Equations:

\[
\Sigma_E(e) = \sum_{\epsilon} \frac{\epsilon}{\epsilon - E + \Sigma_E(\epsilon)}
\]

\[
\sum_{\epsilon} \frac{\epsilon}{\epsilon - E + \Sigma_E(\epsilon)}
\]

Deficiency: The absence of quasiparticle vibration coupling (QVC) mechanism, which is included in relative time-blocking approximation (RTBA).

**PRELIMINARY RESULTS**

Finite temperature $B$ operator:

\[
B_{\alpha\beta}(E, T) = \delta_{\alpha\beta} \alpha(E) \beta(E) \ln(1 - e^{-E/T})
\]

Finite temperature mass operator:

\[
M_{\alpha\beta}(E, T) = - T \sum_{\epsilon} \frac{\epsilon}{\epsilon - E + \Sigma_E(\epsilon)} \delta_{\alpha\beta} \alpha(E) \beta(E) \ln(1 - E/T)
\]

Zero temperature mass operator:

\[
\sum_{\epsilon} \frac{\epsilon}{\epsilon - E + \Sigma_E(\epsilon)} \delta_{\alpha\beta} \alpha(E) \beta(E) \ln(1 - E)
\]

**STATUS**

1. Direct application of the Matsubara Green's function for calculating operator $B$ and mass operator shows a promising results since it gives approximately the correct limit of $T = 0$.

2. There are still some unanswered questions related to the correct definition of finite temperature operator $B$, such as the origin of factor 1/8 and the requirement to add minus sign so that it gives the correct limit for $T = 0$.

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