Giant dipole resonance in ^{88}Mo from phonon damping model's strength functions averaged over temperature and angular momentum distributions[†]

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Many theoretical and experimental studies in nuclear structure during the last three decades were devoted to the giant dipole resonance (GDR) in highly excited nuclei. The GDR line shape and its full-width at half maximum (FWHM) Γ_{GDR} are experimentally extracted from the statistical calculations by using the Lorentzian strength function to reproduce the γ-ray spectra detected from the decay of the highly-excited compound nucleus (CN) at the excitation energy E^*. They are often compared with the theoretical predictions, which are obtained at a given values of nuclear temperature T and/or angular momentum J.

The extraction of T and J is crucial for a meaningful comparison between experiment and theory because the initial temperature T_{max} and/or angular momentum J_{max} at the first step in the decay of the CN are significantly higher than the mean values $\overline{T}$ and $\overline{J}$, obtained by averaging over all daughter nuclei in the decay process. Moreover, while the theoretical GDR strength function is calculated at a fixed value of T and/or J, its experimental counterpart is extracted by fitting the spectrum, which is generated by a multistep cascade decay, where the nucleus undergoes a cooling down from T_{max} (and/or J_{max}). Because of this mechanism, the authors of Ref.[1] have proposed to incorporate the theoretical strength functions into the full statistical decay calculations and compare the results obtained with the experimental data. This method was applied to test the validity of several theoretical models in Refs.[1,2], including the phonon damping model (PDM)[3], which describes the broadening of the GDR width at finite T and J via coupling of the GDR to non-collective particle-hole (ph), particle-particle (pp) and hole-hole (hh) configurations. However it is not clear if the GDR line shape obtained by averaging the GDR strength functions in the whole interval of T and/or J is equivalent to the GDR strength function obtained at the mean values $\overline{T}$ and $\overline{J}$ in these intervals.

In the present paper the PDM is employed to calculate the strength functions for the GDR in the statistical decays after the fusion-evaporation reaction ^{48}Ti + ^{40}Ca, which produces the CN ^{88}Mo* at various excitation energies E^*[4]. The calculations use the empirical probability distributions for T and J to produce the GDR average strength functions $\overline{S}(\omega, E^*)$ as well as $\overline{T}$ and $\overline{J}$ at each energy E^*. The calculations show that, while the GDR width increases with E^*, it approaches a saturation at high $T = 4$ MeV when $J > 50\hbar$. At a larger $J \geq 70\hbar$, the width saturation shows up at any T. The GDR strength function $\overline{S}(\omega, E^*)$ obtained by averaging the individual strength functions $S(\omega, T, J)$ over the empirical T- and J-probability distributions turns out to be almost identical to $S(\omega, \overline{T}, \overline{J})$ calculated at $\overline{T}$ and $\overline{J}$ (Fig. 1). Therefore, once $\overline{T}$ are $\overline{J}$ are known, one may compare the theoretical prediction for the individual strength function $S(\omega, T, J)$ and its width, obtained at $\overline{T}$ and $\overline{J}$, with the data, without the need of generating and averaging the strength functions over the whole T and J distributions.

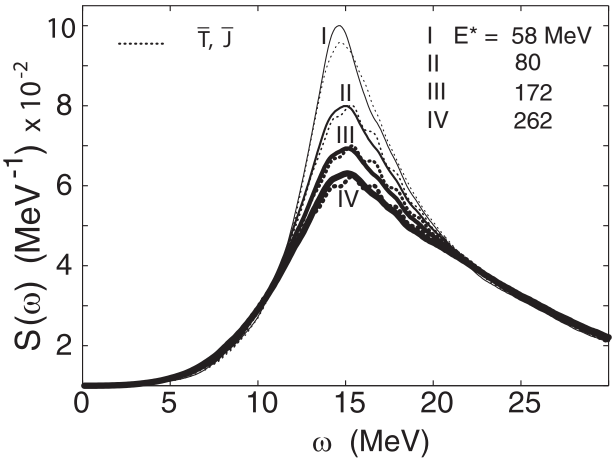

Fig. 1. GDR average strength function $\overline{S}(\omega, E^*)$ for ^{88}Mo at different excitation energies E^* obtained by using the T- and J-probability distributions. The dotted lines are the strength functions $S(\omega, T, J)$ obtained at the corresponding $T = \overline{T}$ and $J = \overline{J}$.

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